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**The pervasive impact of social isolation and loneliness in young people
An epidemiological, longitudinal and genetically-sensitive study**

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**The pervasive impact of social isolation and
loneliness in young people: An epidemiological,
longitudinal and genetically-sensitive study.**

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PhD Thesis, 2016

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Abstract

Several decades of research attest to the importance of social relationships for mental and physical health. Social isolation and loneliness have often been considered adversities associated with aging. However, dissatisfaction with one's quality or quantity of social relationships is particularly common among young people. This thesis comprises four studies investigating the experiences of social isolation and loneliness in children and young adults, using a longitudinal, genetically-sensitive study design. Data were drawn from the Environmental Risk (E-Risk) Longitudinal Twin Study, a birth cohort of 2,232 twins born in 1994 and 1995. The first empirical chapter investigates associations between social isolation and mental health in the early school years. Longitudinal data from childhood to preadolescence is used to test whether social isolation predicts increases in mental health problems over and above pre-existing difficulties, and vice-versa. The second empirical chapter examines the relationship between social isolation, loneliness and depression in young adults. Behavioural genetic modelling using twin data is used to test the relative contributions of genetic and environmental influences to these associations. The third empirical chapter investigates childhood antecedents of loneliness, and broadly documents the profile of lonely young adults in multiple domains of functioning, including mental health, coping strategies, career prospects and interpersonal perceptions. The fourth empirical chapter analyses the associations between loneliness and aspects of sleep quality in young adults, using the monozygotic twin-differences method to control for familial sources of confounding. A potential exacerbating role of past exposure to violence victimisation on the association between loneliness and sleep is tested. Together, the findings underscore the pervasive role of loneliness in the well-being of young adults, and reinforce the importance of early intervention to prevent its persistence.

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Publications

Published articles

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Caspi, A., Moffitt, T. E., & Danese, A. (2016). Childhood bullying victimization and overweight in young adulthood: A cohort study. *Psychosomatic Medicine*, 78(9), 1094-1103.

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E., & Arseneault, L. (2016). Parental monitoring and knowledge: Testing bidirectional associations with youths' antisocial behaviour. *Development and Psychopathology*, 28(3), 623-638.

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Arseneault L. (2016). Social isolation, loneliness and depression in young adulthood: A behavioural genetic analysis. *Social Psychiatry and Psychiatric Epidemiology*, 51(3), 339-348.

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Wertz, J., Zavos, H., **Matthews, T.**, Harvey, K., Hunt, A., Pariante, C. M., & Arseneault, L. (2014). Why some children with externalising problems develop internalising symptoms: Testing two pathways in a genetically sensitive cohort study. *Journal of Child Psychology and Psychiatry*, 56(7), 738-746.

Articles in press

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Declaration

I confirm that this thesis and the research presented therein is my own original work, including conceptualisation, planning, data analysis and writing. All help received, and all published sources consulted, are acknowledged in the appropriate manner. No part of this thesis has previously been submitted towards any other degree or qualification. Those parts which have been published or submitted for publication are noted as such in the text.

Chapter 1: Introduction

1.1 The significance of social relationships

The importance of social relationships for development and well-being has long been recognised in the behavioural sciences. Influential models of human development, such as Erikson's (1968) psychosocial theory and Bowlby's (1969) attachment theory, emphasised the role of children's relationships with others in shaping their identity and social adjustment. Social relationships provide sources of support, companionship and intimacy, and opportunities to share common interests, activities and goals (Berkman, Glass, Brissette & Seeman, 2000; Cohen, 2004; Rook, 1987; Weiss, 1974). Peer relationships in the early years influence long-term trajectories of behavioural development, with implications for educational achievement and employment (Parker & Asher, 1987; Rubin, Coplan & Bowker, 2009; Woodward & Ferguson, 2000). Across the lifespan, the quality of social connections is robustly associated with mental and physical health (Hawkley & Cacioppo, 2010; Umberson & Montez, 2010). There is therefore strong evidence that social relationships play a ubiquitous role in everyday life. This thesis aims to examine how deficits in social relationships emerge among young people, and their implications for psychological and emotional well-being.

Baumeister and Leary (1995) propose that the pursuit of stable and rewarding social relationships is a fundamental psychological need (the *belongingness hypothesis*). In a broad review of the literature, they summarise the premises underlying this hypothesis:

- Individuals form social connections easily and willingly, under a variety of different circumstances.
- Individuals are motivated to preserve existing social ties and experience distress when these ties are broken.

- Social relationships influence cognitive processing, such that information pertaining to friends and partners is prioritised over information relating to strangers.
- Individuals' degree of perceived belongingness is associated with emotional responses, both positive and negative.
- Inadequacy of social relationships is associated with poorer mental and physical health.
- The mere existence of social connections is not sufficient to support well-being; these connections must also be characterised by positive and satisfying interactions.
- The motivation to form further social connections reduces when individuals' optimal level of belongingness is satiated, and when an existing social connection is lost, individuals readily form a new connection to substitute for it.
- An innate tendency to seek out and form social relationships may be advantageous from an evolutionary perspective.

To the extent that social connection is an inherent human need, difficulties in fulfilling this need would be expected to be an aversive experience. Importantly, however, individuals require more than social contact alone. Of equal importance are the qualitative properties of social relationships: they must be meaningful and provide a sense of companionship (Wheeler, Reis & Nezlek, 1983; Rook, 1987). Social relationships that lack these properties could still be experienced as unsatisfying. Thus, the perceived quality of social relationships is a separate matter from the material presence or quantity of these relationships. This distinction gives rise to the two related, but conceptually separate constructs of social isolation and loneliness.

1.2 Defining and measuring social isolation and loneliness

Social isolation refers to a state in which social relationships and interactions are limited or absent. This can arise involuntarily; for example, through peer exclusion or bereavement, or alternatively by voluntary withdrawal from social contact. Importantly, it refers to the factual circumstances in which individuals are placed (de Jong Gierveld & Havens, 2004). *Loneliness*, by contrast, is often referred to as ‘perceived social isolation’ (Cacioppo & Hawkley, 2009; Cacioppo, Hawkley & Thisted, 2010), to emphasise that it is a subjective experience rather than a direct reflection of an individual’s objective amount of social contact. Loneliness is most commonly defined as a distressing feeling that arises when individuals perceive their quality or quantity of social connection to be insufficient (de Jong Gierveld, 1987; Peplau & Perlman, 1982). Conceptually, social isolation and loneliness are related in that they both concern the estrangement of individuals from those around them. However, their separateness rests upon the distinction between *being* alone and *feeling* alone.

Although socially isolated people may feel lonely, the correlation between these constructs is modest (Coyle & Dugan, 2012), indicating that loneliness is influenced by factors other than the availability of social contact. Indeed, loneliness may be experienced by individuals who live with a spouse and have a large number of social connections, and conversely, some individuals may be satisfied with relatively little social contact (de Jong Gierveld, van Tilburg, & Dykstra, 2006; Hawkley, Hughes, Waite, Masi, Thisted, & Cacioppo, 2009). Solitude is not necessarily an aversive experience: in some instances it may confer benefits, such as providing opportunities for reflection and creativity (Long & Averill, 2003). Furthermore, some relationships can be characterised by conflict and stress (Walen & Lachman, 2000), underscoring the fact that not all forms of social contact are inherently desirable. Thus, loneliness relates more to the quality of social connections rather than their quantity (Pinquart & Sorensen, 2001).

The separateness of social isolation and loneliness is also reflected in the different methods by which these constructs are measured. Social isolation is typically assessed using numerous different indicators, such as social network size, frequency of social activity, marital status, cohabitation, and social support (Cacioppo et al, 2010; Caspi, Harrington, Moffitt, Milne & Poulton, 2006; Cornwell & Waite, 2009; Coyle & Dugan, 2012; Hughes, Waite, Hawkley & Cacioppo, 2004; Shankar, Hamer, McMunn & Steptoe, 2013; Steptoe, Shankar, Demakakos & Wardle, 2013). The variety in measurement approaches reflects the multifaceted nature of social connection, and each provides unique information about individuals' circumstances (Valtorta, Kanaan, Gilbody & Hanratty, 2016). Furthermore, the nature of social isolation may vary with age, with implications for measurement: for instance, indicators such as living alone or marital status may be appropriate for adult populations but would not be applicable to school-aged children. Studies of childhood social isolation often use measures of peer rejection or withdrawn behaviour in the school environment, which is the context in which many of children's earliest social relationships are formed (Hymel, Rubin, Rowden & LeMare, 1990; Laird, Jordan, Dodge, Pettit & Bates, 2001; Parker & Asher, 1987; Rubin et al, 2009).

Loneliness is sometimes assessed with a single questionnaire item, simply asking respondents how often they feel lonely (Pinquart & Sorensen, 2001). However, as individuals' social relationships are nuanced and multifaceted, so too are their perceptions of these relationships (Hawkley, Browne & Cacioppo, 2005), and therefore the full complexity of loneliness may be better captured using more elaborate lists of questions. The most widely used and well validated of such measures are the UCLA Loneliness Scale (Russell, 1996; Russell, Peplau & Cutrona, 1980; Russell, Peplau & Ferguson, 1978) and the de Jong Gierveld Loneliness Scale (de Jong Gierveld & Kamphuis, 1985). Examples of items used in these scales are "I feel as if nobody really understands me",

“My social relationships are superficial”, “I miss having a really close friend”, and “I often feel rejected”. Conspicuously, the word ‘lonely’ is not mentioned in any items, in order to reduce the potential for response bias due to individuals’ reluctance to admit feeling lonely. Both the UCLA and de Jong Gierveld scales have also been adapted into short forms for inclusion in large-scale interview assessments (de Jong Gierveld & van Tilburg, 2006; Hughes et al, 2004). Although these scales are typically administered to adults, children as young as 5 have been shown to have a conceptual understanding of loneliness (Cassidy & Asher, 2008), and instruments also exist for the measurement of childhood loneliness, such as the Children’s Loneliness Scale (Asher, Hymel & Renshaw, 1984) and the Loneliness and Aloneness Scale for Children and Adolescents (Marcoen, Goossens & Caes, 1987).

Because social isolation is an objective concept, measurement approaches can incorporate data from different informants in order to build a comprehensive picture of individuals’ degree of social contact. For example, teacher reports can provide valuable information about children’s peer relationships at school. Loneliness, as a more intimate experience, is more typically measured via self-report. However, informant ratings of loneliness have been shown to correspond moderately with self-reports, particularly when the informant is a romantic partner (Luhmann, Bohn, Holtmann, Koch & Eid, 2016). Multi-informant approaches therefore have potential utility in the measurement of both social isolation and loneliness.

1.3 A brief history of theoretical approaches to loneliness

Loneliness has been the subject of literature, art and philosophy throughout human history. However, scientific approaches to loneliness did not emerge until the second half of the 20th century. The earliest accounts of loneliness in the academic literature were put forth by psychoanalysts (e.g. Fromm-Reichmann, 1959; Sullivan, 1953), who attributed loneliness to a failure to form intimate attachments to caregivers in infancy and early

childhood. These psychodynamic perspectives were based primarily on observations of patients in clinical contexts. However, their emphasis on attachment processes and the need for intimacy was influential on subsequent conceptualisations of loneliness in the wider population. Broadly, the study of loneliness in the latter half of the 20th century was characterised by two predominant approaches: the *social needs* approach and the *cognitive* approach.

The social needs approach to loneliness was described by Robert S. Weiss (1973). This approach was influenced by Bowlby's (1969) attachment theory, and posits that loneliness arises when an individual's fundamental need for social connection is thwarted. Weiss (1974) further identified six specific *provisions* that are bestowed by different types of social relationships: attachment, social integration, guidance, reassurance of worth, reliable alliance, and opportunity to provide nurturance. Deficits in any of these provisions would give rise to loneliness. Weiss also differentiated between two forms of loneliness, each associated with shortfalls in different types of social provision. The first, *social loneliness*, refers to a lack of integration; for example, with a group of friends. The second, *emotional loneliness*, concerns the absence of an intimate, emotionally-supportive relationship.

An implication of the social needs approach is that loneliness is directly linked to the actual presence or absence of specific social provisions. It does not consider that individuals may differ in the social relationships that they desire, or that two individuals may respond differently to the same deficits in social provisions. The cognitive approach to loneliness addresses this by emphasising the role of individuals' perceptions and attributions in mediating the association between social relationships and loneliness (Peplau & Perlman, 1982; Perlman & Peplau, 1981). Whereas the social needs approach conceptualises social relationships in terms of the fulfilment of intrinsic emotional needs, the cognitive approach concerns itself with how individuals appraise their social

relationships. Specifically, it proposes that loneliness arises when individuals perceive a mismatch between their desired and actual degree of social connection. Individuals vary in their ideal quality and quantity of social contact, and a discrepancy can occur either when social relationships are insufficient to meet this level or, conversely, when they exceed it.

Although the social needs and cognitive approaches differ in their accounts of the mechanisms underlying loneliness, they have several key properties in common. First, they agree that loneliness arises in response to qualitative shortcomings in social relations. Second, they emphasise that loneliness is a subjective, individual experience. Third, this experience is considered inherently distressing (Perlman & Peplau, 1981). These premises remain key to the conceptualisation and investigation of loneliness in the present day.

More recent research has framed loneliness in the context of evolutionary theory. Weiss (1973) speculated that the impetus to connect with others may serve an adaptive purpose in social species. An evolutionary model of loneliness was formalised by John T. Cacioppo and colleagues (Cacioppo, Hawkley, Ernst, Burleson, Berntson, Nouriani & Spiegel, 2006), linking human social relationships to Dawkins' (1989) notion of the 'selfish gene'. According to this model, membership of a close social group enables cooperation, protection and sharing of resources, all of which are conducive to the rearing of healthy offspring. Estrangement from the social group therefore threatens individuals' ability to proliferate their genetic material. An individual who finds social disconnection aversive would have greater impetus to pursue social integration, in turn advantaging their contribution to the gene pool. Thus, whereas Weiss described loneliness as an experience devoid of redeeming features, Cacioppo and colleagues argue that sensitivity to loneliness promotes evolutionary fitness by motivating the individual to rebuild damaged social connections.

The rapid growth in research into loneliness, spanning developmental, cognitive and biological disciplines, has allowed this once-overlooked phenomenon to be understood in rich detail. Originally regarded as unremarkable from a scientific perspective, loneliness is now understood to be a complex, multifaceted experience, which has served an important role in the evolutionary heritage of human beings. As theoretical accounts of loneliness have developed, its distinction from social isolation has become more explicit: loneliness does not arise simply from an absence of social connections, but instead is shaped by how individuals think about and perceive their social relationships. Research has therefore moved away from treating these two constructs as interchangeable, in favour of studying their differential effects on health and behaviour. Empirical research on the effects of social isolation and loneliness are presented in the following sections.

1.4 The experience of loneliness

Loneliness has been described as a form of psychological pain which, like the physical experience of pain, alerts individuals that their circumstances are harmful and incentivises them to relieve themselves of the source of harm (Cacioppo & Hawkley, 2009). Some neuroimaging studies have even suggested that the experience of social exclusion activates regions of the brain which are implicated in processing physical pain, such as the dorsal anterior cingulate cortex and anterior insula (Eisenberger, 2012; Eisenberger & Cole, 2012). Loneliness is also painful in a metaphorical sense, and has been described as “the distressing, depressing, dehumanising, detached feelings that a person endures when there is a gaping emptiness in their life” (Killeen, 1998, p. 764).

The experience of loneliness is accompanied by a diverse range of negative emotional states, including low mood, anger, anxiety, pessimism and low self-esteem (Cacioppo, Hawkley et al, 2006). Loneliness is highly correlated with depression (Russell et al, 1980), to the extent that some instruments used to assess depressive symptoms, such as the Center for Epidemiological Studies Depression Scale (CES-D; Radloff, 1977), have

even included items about feeling lonely. However, these two constructs are conceptually and empirically separable (Cacioppo, Hawkley et al, 2006; Weeks et al, 1980). Longitudinal evidence shows that loneliness is prospectively associated with increases in depressive symptoms (Cacioppo et al, 2010; Cacioppo, Hughes et al, 2006; Heikkinen & Kauppinen, 2004; Vanhalst, Klimstra, Luyckx, Scholte, Engels & Goossens, 2012; Vanhalst, Luyckx, Teppers & Goossens, 2012).

Lonely individuals perceive their own social relationships in a more negative light than they do other people's relationships (Duck, Pond & Leatham, 1994). Compared to non-lonely individuals, they are more fearful of being perceived harshly by others, and have more negative expectations about the outcomes of their social interactions (Cacioppo, Ernst, Burleson, McClintock, Malarkey, Hawkley, Kowalewski, Paulsen, Hobson, Hugdahl, Spiegel & Berntson, 2000; Jones, Freeman & Goswick, 1981). Findings from eye tracker studies suggest that lonely individuals show an attentional bias towards threatening social stimuli (Bangee, Harris, Bridges, Rotenberg & Qualter, 2014; Qualter, Rotenberg, Barrett, Henzi, Barlow, Stylianou & Harris, 2013). Neuroimaging studies further support a link between loneliness and biased processing of social information. In one such study, lonely participants showed different patterns of activation in the ventral striatum and visual cortex in response to social stimuli compared to non-lonely participants, suggesting that lonely individuals may find positive social stimuli less rewarding and devote more attention to negative social stimuli (Cacioppo, Norris, Decety, Monteleone & Nusbaum, 2009). Similarly, in an EEG study using an adapted Stroop task, lonely individuals showed an unconscious attentional bias towards negative social words, in contrast to non-social or positive social words, whereas no such differences were observed in non-lonely participants (Cacioppo, Balogh & Cacioppo, 2015).

The evolutionary account of loneliness provides an explanation for the pattern of cognitive changes observed in lonely individuals. As membership of a closely-knit group

provides protection for its members, the loss or absence of these protective social bonds places the individual in a vulnerable position. Thus, loneliness is an unsafe feeling, and triggers a state of heightened vigilance for social threats (Cacioppo & Hawkley, 2009). Increased sensitivity to negative social information and biased expectations about others could serve a self-protective purpose for individuals in this situation, by preparing them to anticipate potential attacks or betrayals. However, these cognitive traits can manifest in behaviour with counterproductive results. Lonely individuals are less trusting and more guarded in their dealings with others (Cacioppo, Hawkley et al, 2006; Rotenberg, 1994). Therefore, the anticipation of negative social interactions can become a self-fulfilling prophecy, sabotaging opportunities to form close and meaningful relationships (Cacioppo & Hawkley, 2005). In spite of this, lonelier individuals are more likely to attribute shortcomings in their social relationships to factors beyond their control (Newall, Chipperfield, Clifton, Perr, Swift & Ruthig, 2009). Consequently, feelings of loneliness and the pattern of maladaptive cognitions and behaviour that arise from them can form a vicious cycle.

In summary, the experience of loneliness is not only unpleasant in its own right, but goes hand-in-hand with pervasive changes in mood and cognition. These can have implications for mental health, and potentially for many areas of everyday functioning, such as employment, coping with stress, and overall life satisfaction. Further, loneliness can negatively bias not only individuals' own perceptions, but also the way they are perceived by others. These difficulties may, in turn, contribute to the persistence of loneliness over time.

1.5 Health outcomes of social isolation and loneliness

In the literature on social isolation and loneliness, particular focus has been placed on elderly populations. One reason for this is that common life changes in older age, such as bereavement, moving into residential care and declining mobility can make people

particularly vulnerable to loneliness (Savikko, Routasalo, Tilvis, Strandberg & Pitkälä, 2005). A second reason is that social relationships have long been recognised to have a powerful influence on trajectories of physical health across the lifespan, with implications for longevity (Umberson & Montez, 2010). Deficits in social relationships are not only associated with psychological distress in the immediate present, but also have effects on health that accrue over time to increase the risk of disease in later life (Caspi et al, 2006). The study of social relationships and health has broadly consisted of two parallel approaches, emerging from the disciplines of sociology and psychology, with the former focusing on the objective and functional aspects of social connection and the latter on the subjective experience of loneliness (Cornwell & Waite, 2009). The combined evidence from these studies indicate that deficiencies in social relationships, whether actual or perceived, are associated with an increased risk for mortality of a magnitude comparable to other well-studied risk factors such as smoking and obesity (House, Landis & Umberson, 1988; Holt-Lunstad, Smith, Baker, Harris & Stephenson, 2015; Holt-Lunstad, Smith & Layton, 2010; Luo, Hawkey, Waite & Cacioppo, 2012; Steptoe et al, 2013). In older adults, social isolation is associated with elevated blood pressure and inflammation, and declines in cognitive functioning (Shankar et al, 2013; Shankar, McMunn, Banks & Steptoe, 2011). Similarly, childhood social isolation predicts increased risk of inflammatory and metabolic risk markers for age-related disease in adulthood (Danese, Moffitt, Harrington, Milne, Polanczyk, Pariante, Poulton & Caspi, 2009), and chronic social isolation from childhood to adulthood has been found to predict risk markers for cardiovascular disease in a dose-response manner (Caspi et al, 2006). Studies of loneliness have found similar associations with health outcomes: loneliness is associated with increases in blood pressure (Hawkey, Masi, Berry & Cacioppo, 2006; Hawkey, Thisted, Masi & Cacioppo, 2010), impaired immune functioning (Pressman, Cohen, Miller, Barkin, Rabin & Treanor, 2005), obesity (Lauder, Mummary, Jones &

Caperchione, 2006), impaired physical functioning (Perissinotto, Stijacic Cenzer & Covinsky, 2012) and cognitive decline (Shankar et al, 2013; Wilson, Krueger, Arnold, Schneider, Kelly, Barnes, Tang & Bennett, 2007).

That social isolation and loneliness are both associated with similar health outcomes raises several possibilities. On the one hand, loneliness may be the ‘active ingredient’ through which deficiencies in social relationships exert effects on downstream physiological processes. Alternatively, loneliness and other aspects of social connection may be independently associated with health outcomes, or exert their effects together in an additive manner. However, disentangling the respective effects of social isolation and loneliness on health has proven complicated. Relatively few studies have directly compared their differential associations with mortality, and those which have done so have yielded mixed findings. One longitudinal study of older adults found that loneliness, but not social isolation, predicted an increased risk for mortality (Holwerda, Beekman, Deeg, Stek, van Tilburg, Visser, Schmand, Jonker & Schoevers, 2012). Another found that social isolation predicted mortality, but no effect was found for loneliness after controlling for baseline health (Stephoe et al, 2013). However, a recent meta-analysis of 70 studies suggests that both isolation and loneliness independently predict mortality to a similar extent (Holt-Lunstad et al, 2015).

Although the clinical manifestations of social isolation and loneliness may not become apparent until mid-life or old age, risk indicators for future health problems may be detectable in younger people. One such example is impaired sleep, which is hypothesised to be one of the mechanisms through which loneliness affects health (Cacioppo, Hawkley, Crawford, Ernst, Burleson, Kowalewski, Malarkey, Van Cauter & Berntson, 2002). The link between loneliness and sleep can be explained in terms of the evolutionary model of loneliness: as being embedded within a social group conferred protection for human ancestors, particularly during vulnerable states such as sleep, feeling cut off from others

would be expected to heighten awareness of threats in the environment, compromising the restfulness of sleep. Furthermore, because it is perceived isolation (rather than isolation in itself) that feels unsafe, it would be expected that feelings of loneliness, rather than merely sleeping alone, would be most strongly associated with sleep problems. Consistent with this prediction, loneliness has been shown to be associated with sleep fragmentation, poorer subjective sleep quality and greater daytime dysfunction (Cacioppo, Hawkley, Berntson, Ernst, Stickgold & Hobson, 2002; Cacioppo, Hawkley, Crawford et al, 2002; Harris, Qualter & Robinson, 2013; Hawkley, Preacher & Cacioppo, 2010; Hawkley, Thisted et al, 2010; Kurina, Knutson, Hawkley, Cacioppo, Lauderdale & Ober, 2011). Deficiencies in sleep predict numerous health problems, including hypertension (Gangwish, Heymsfield, Boden-Albala, Buijs, Kreier, Pickering, Rundle, Zammit & Malaspina, 2006), impaired immune function (Irwin, 2002), obesity (Patel & Hu, 2008) and mortality (Cappuccio, D'Elia, Stazzullo, & Miller, 2010). Therefore, if loneliness impairs sleep among otherwise healthy young people, this may have significant implications for future health outcomes.

1.6 Aetiology of social isolation and loneliness

If loneliness is transmitted via evolutionary mechanisms, it would be expected that significant genetic influences on loneliness would be detectable, as genes coding for traits that promote survival and reproductive success (such as an aversion to social disconnection) are passed down across generations (Cacioppo, Cacioppo & Boomsma, 2014). Consistent with this, behavioural genetic studies have estimated the heritability of loneliness to be approximately 40-50% (Boomsma, Willemsen, Dolan, Hawkley & Cacioppo, 2005; Goossens, van Roekel, Verhagen, Cacioppo, Cacioppo, Maes & Boomsma, 2015; McGuire & Clifford, 2000). Heritability reflects the proportion of variance in a trait that is explained by genes; that is, it indicates the extent to which genetic differences between people (as opposed to differences in environmental exposures)

explain why some individuals are more susceptible to feeling lonely than others. Heritability estimates are specific to the population being studied, and can vary with age. In particular, the heritability of loneliness reduces from early childhood to preadolescence, before rising again by young adulthood, a finding that may be attributable to changes in the dynamics of social relationships corresponding with puberty (Bartels, Cacioppo, Hudziak & Boomsma, 2008).

There is reason to suspect that social isolation may also be heritable. Although isolation is superficially a circumstance that is imposed by the environment, a robust finding in the field of behavioural genetics is that exposures which are ostensibly environmental in nature show some degree of genetic influence (Kendler & Baker, 2007; Plomin & Bergeman, 1991; Plomin, DeFries, Knopik & Neiderhiser, 2016). This has been shown to be the case with measures of social support and integration (Kendler, 1997). Thus, there may be heritable characteristics, such as personality traits, that increase individuals' vulnerability to becoming isolated. Furthermore, it is possible that social isolation and loneliness may share some of the same genetic influences, and that this genetic overlap contributes to the association between them.

The fact that genetic influences account for no more than half of the variance in loneliness indicates that this construct is also subject to substantial influence from the environment. As would be expected, those with fewer social contacts are lonelier in general; however, the quality of social relationships rather than the quantity is more important in this regard (Pinquart & Sorensen, 2001). Among adolescents, loneliness is associated with absent or poor-quality friendships and peer problems such as low acceptance and victimisation (Vanhalst, Luyckx & Goossens, 2013). Towards adulthood, the quality of romantic relationships becomes increasingly significant (Qualter, Vanhalst, Harris, van Roekel, Lodder, Bangee, Maes & Verhagen, 2015). Living alone, divorce and the death of a spouse are associated with greater loneliness, particularly among the elderly (Dykstra,

van Tilburg & de Jong Gierveld, 2005; Savikko et al, 2005; Victor, Scambler, Bowling & Bond, 2005). This implies a protective effect of marriage; however, this is only the case if the spouse provides companionship and support (Hawkley et al, 2009). Further risk factors for loneliness emerge in late life, such as declining health and mobility, which can impose limitations on social relationships and activities (Savikko et al, 2005).

1.7 The significance of social isolation and loneliness in young people

Much of the research on social isolation and loneliness has placed emphasis on old age, when risk factors such as bereavement and ill health become more prominent. However, while loneliness is indeed common among those aged 80 and older, it is not the case that loneliness increases with age in a linear fashion (Dykstra, 2009). Instead, the prevalence of loneliness follows a U-shaped distribution across the lifespan, with the highest rates of loneliness observed in younger people (aged under 25 years) as well as the elderly (Luhmann & Hawkley, 2016; Mental Health Foundation, 2010; Pinquart & Sorensen, 2001; Victor & Yang, 2012). By contrast, the size of individuals' social networks is at its highest in adolescence and early adulthood, reducing gradually thereafter across the lifespan (Wrzus, Hänel, Wagner & Neyer, 2013). Thus, young people are characterised by a marked disparity between the quantity of their social relationships and their perceived satisfaction with those relationships.

Individuals' social needs go through a series of shifts across development from early childhood to the onset of adulthood. For younger children, having the company of a friend is of primary importance, while feeling accepted by a peer group gains in value towards adolescence, followed by a desire for intimate relationships with friends and romantic partners (Parkhurst & Hopmeyer, 1999; Qualter et al, 2015). These shifts take place against the backdrop of other significant transitions, such as advancement through education, the onset of puberty, and changes in social cognition (Blakemore & Mills, 2014). Social isolation and loneliness may therefore be substantively different

experiences for young people compared to adults, and specific attention towards this age group is merited when investigating the antecedents and outcomes of these experiences.

1.8 Aims and research questions

The aim of this thesis is to study the experiences of social isolation and loneliness in young people, their associations with mental health and other domains of functioning, and their aetiology. Four specific research questions are considered:

Social isolation and mental health in childhood

One question of interest is the association between social integration and mental health in the early school years. Peer relationships in school-aged children have long-lasting implications for functional outcomes in adult life (Parker & Asher, 1987; Woodward & Ferguson, 2000). Children who are socially isolated early in their schooling may be at risk for developing mental health problems, and conversely, children with emotional or behavioural difficulties at school entry may find themselves increasingly isolated in subsequent years. These problems could become exacerbated as children progress through adolescence, as those who have experienced difficulties in their early social adjustment may face even greater challenges in the increasingly complex social environment of secondary school.

Longitudinal studies have reported that childhood social isolation predicts increased internalising and externalising problems (Hymel et al, 1990; Prinstein & La Greca, 2004; Rubin et al, 2009). However, it is important to ascertain whether these associations are accounted for by the continuity of pre-existing mental health difficulties. Furthermore, as well as testing for increases in symptoms of individual disorders, such as internalising or externalising problems, it is important to consider the role of comorbidity. For instance, the emergence of internalising problems (such as depression and anxiety) in preadolescence is often predicted by externalising problems (such as aggressive and antisocial behaviour) earlier in childhood (Wertz, Zavos, Matthews, Harvey, Hunt,

Pariante & Arseneault, 2014). Therefore, for example, if social isolation co-occurs with externalising problems in early childhood, this may account for the longitudinal association between social isolation and later internalising problems.

Associations and aetiological overlap between social isolation, loneliness and depression

It is possible that social isolation *per se* is not substantively associated with mental health problems in young people, but rather that the experience of loneliness is the more important factor. While social isolation may be correlated with affective disorders such as depression, it is plausible that the experience of loneliness, as a distressing emotional response to social disconnection, would explain a large proportion of this association. It is therefore important to model loneliness and social isolation simultaneously, in order to avoid conflating these constructs and to discriminate between their respective associations with mental health.

The use of genetically-sensitive designs such as the classical twin study has provided evidence for the heritable component of loneliness (Bartels et al, 2008; Boomsma et al, 2005; McGuire & Clifford, 2000). This indicates that individuals' propensity to feel lonely varies in the population due, in part, to genetic differences. Furthermore, it is possible that the experience of social isolation is also influenced by heritable characteristics. Evidence of genetic influences on social isolation would be suggestive of a gene-environment correlation (rGE), whereby individuals' heritable characteristics influence the environment to which they are exposed. For instance, heritable personality and behavioural traits may isolate individuals by evoking rejection from others (an *evocative* rGE), or by promoting withdrawal from social contact (an *active* rGE).

If social isolation and loneliness are both genetically-influenced, a further question is the extent to which these experiences, and related experiences such as depression, are influenced by the same genetic and environmental origins. Correlations between psychological traits and disorders are often found to be genetically-driven; for instance,

the comorbidity between depression and anxiety is partly explained by genes shared by the two disorders (Middeldorp, Cath, Van Dyck & Boomsma, 2005). Loneliness is robustly associated with depressive symptoms (Cacioppo, Hughes et al, 2006; Cacioppo et al, 2010), and this association may be explained in part by a common genetic vulnerability associated with, for example, personality traits such as neuroticism (Boomsma et al, 2005). Multivariate genetic analyses using twins are a valuable tool with which to study the genetic overlap between loneliness and other states associated with it. However, such approaches have yet to be exploited.

Correlates and predictors of social isolation among young people

The burden of loneliness may be a risk factor not only for mental health problems such as depression, but also for broader impairments in many domains of functioning. This could be particularly true for young adults, given the high prevalence of loneliness in this group and the life changes that take place at this age, such as entering the labour market and leaving the family home. The burden of loneliness may undermine young people's confidence in their employment prospects, or lead them to adopt maladaptive coping strategies and behaviours detrimental to later health. Furthermore, in view of the hypothesis that lonely individuals adopt self-protective patterns of behaviour, loneliness may influence the way their personality and behaviour are perceived by others, a possibility that can be explored through multi-informant approaches.

As well as examining the profile of loneliness in terms of its correlates in adulthood, it is important to consider individuals' childhood history and experiences that may shape individuals' vulnerability to loneliness. On the one hand, loneliness is likely to be an adversity that can befall people from a diverse range of socioeconomic and family backgrounds. On the other hand, emotional problems in the childhood years, or difficulties with peer relationships such as bullying or social isolation, may foreshadow greater feelings of loneliness in young adulthood.

Loneliness and sleep problems in young adulthood

Loneliness has previously been shown to be associated with impaired sleep (Cacioppo, Hawkley, Berntson et al, 2002; Cacioppo, Hawkley, Crawford et al, 2002; Harris et al, 2013; Hawkley, Preacher & Cacioppo, 2010; Kurina et al, 2011). This is consistent with an evolutionary model which posits that loneliness increases vigilance for threat. However, to further advance this as a causal hypothesis, more stringent tests are required to control for unmeasured confounds, such as genetic influences. Sleep quality, like loneliness, is substantially heritable (Barclay, Eley, Buysse, Rijdsdijk & Gregory, 2010; Heath, Kendler, Eaves & Martin, 1990). The fact that correlations between phenotypes are often mediated by common genetic origins indicates that the strength and putative causality of associations may be spurious if genetic influences are not controlled for. An analysis that allows this to be tested is the monozygotic twin differences method: by measuring differences between siblings who are matched for their genetic profiles and home environment, these familial confounding effects are held constant. This permits a robust test for environmentally-mediated associations between loneliness and sleep quality.

1.9 Thesis structure

This thesis comprises four studies investigating antecedents and correlates of social isolation and loneliness in young people, using a prospective, genetically-sensitive methodology. The data are drawn from a twin cohort of 2,232 individuals living in the United Kingdom, interviewed via home visits at ages 5, 7, 10, 12 and 18. Data collected at multiple time points are used to test longitudinal and cross-sectional associations between social isolation, loneliness and other adversities. By exploiting the twin design of the study, genetic and environmental influences on these associations are disentangled. The sample, main measures and statistical approaches used are described in Chapter 2.

Chapter 3 investigates associations between social isolation and mental health in childhood and preadolescence. Data from children's mothers and teachers are combined in order to measure social isolation and emotional and behavioural problems both in and outside of the school environment. Longitudinal analyses are used to test for bidirectional associations between social isolation and mental health between primary and secondary school entry. This study has been published in the *Journal of the American Academy of Child and Adolescent Psychiatry* (Matthews, Danese, Wertz, Ambler, Kelly, Diver, Caspi, Moffitt & Arseneault, 2015).

Chapter 4 studies the differential associations of social isolation and loneliness with depression in young adults. Twin modelling is used to examine the relative contributions of genetic and environmental influences on these traits and the associations between them. This is the first multivariate behavioural genetic study to investigate the aetiological overlap between loneliness and other constructs. This study has been published in *Social Psychiatry and Psychiatric Epidemiology* (Matthews, Danese, Wertz, Odgers, Ambler, Moffitt & Arseneault, 2016).

Chapter 5 takes an integrative approach to examine the broader experience of loneliness in young people. Cross-sectional analyses test loneliness' association with multiple domains of functioning in young adulthood, including mental and physical health, coping and functioning, and employment prospects. Data provided by informants about participants' personality and behaviour are used to examine how lonely individuals are perceived by others. Using longitudinal data, childhood predictors of young adult loneliness are examined, including family factors, mental health, victimisation and peer problems.

Chapter 6 investigates the association between loneliness and sleep quality in young adults, one of the pathways through which loneliness is believed to predict ill health later in life. Loneliness' association with overall sleep quality is tested, as well as the profile

of impairments across different domains of sleep. Building on previous findings, the robustness of the association between loneliness and sleep quality is tested by using the MZ twin differences design, controlling for familial sources of confounding. The revision of this study is currently under review at *Psychological Medicine*.

The thesis concludes with a general discussion of the findings, methodological limitations and clinical implications (Chapter 7).

Chapter 2: Sample, measures and methods

2.1 The Environmental Risk Longitudinal Twin Study

The data used in this thesis are drawn from the Environmental Risk (E-Risk) Longitudinal Twin Study, which investigates how genetic and environmental factors shape children's development. The sampling frame from which the E-Risk families were drawn consists of two consecutive birth cohorts (1994 and 1995) in the Twins' Early Development Study (TEDS), a birth register of twins born in England and Wales (Trouton, Spinath, & Plomin, 2002). Of the 15,906 twin pairs born in 1994-1995, 71% joined the TEDS register. The sampling frame for the E-Risk study included only same-sex dizygotic twin pairs (i.e. it did not include opposite-sex dizygotic twin pairs) in order to give a better comparison to monozygotic twin pairs who are necessarily of the same sex, i.e. avoiding confounding twin similarity with brother-sister dissimilarity. The E-Risk study therefore began with the 73% of TEDS register families with same-sex twins.

Families were recruited to represent the UK population of families with newborns in the 1990's, based on (1) residential location throughout England and Wales and (2) mother's age (i.e., older mothers having twins via assisted reproduction were under-selected and teen-aged mothers with twins were overselected). This sampling was used to (1) replace high-risk families who were selectively lost to the register via non-response and (2) ensure sufficient numbers of children growing up in high-risk environments. Age at first childbearing was used as the risk-stratification variable because data were present for virtually all families in the register, it is relatively free of measurement error, and early childbearing is a known risk factor for children's problem behaviours (Maynard, 1997; Moffitt & E-Risk Study Team, 2002). The study sought a sample of 1,100 families to allow for attrition in future years of the longitudinal study while retaining statistical power. An initial list of families who had same-sex twins was drawn from the register to target for home visits, with a 10% over-sample to allow for non-participation. Of the

1,203 families from the initial list who were eligible for inclusion, 1,116 (93%) participated in home-visit assessments when the twins were 5 years of age, forming the base sample of the study: 4% of families refused, and 3% were lost to tracing or could not be reached after many attempts. Research workers visited each home for 2.5 to 3 hours, in teams of two. While one research worker interviewed the mother, the other tested the twins in sequence in a different part of the house. Families were given Marks & Spencer or Kingfisher vouchers for their participation, and children were given colouring books and stickers. All 16 research workers had university degrees in behavioural science, and experience in psychology, anthropology or nursing. Each research worker completed a formal 15-day training programme on either the mother interview protocol or the child assessment protocol, to attain certification to a rigorous reliability standard. Home visits helped to insure complete non-missing data that was uncompromised by a parent's reading skills, from families that represent the full population range of risk circumstances.

With parent's permission, questionnaires were posted to children's teachers, and teachers returned questionnaires for 94% of cohort children. Zygosity was determined using a standard zygosity questionnaire, which has been shown to have 95% accuracy (Price, Freeman, Craig, Petrill & Ebersole, 2000). Ambiguous cases were zygosity-typed using DNA. The sample includes 54% monozygotic (MZ) and 46% dizygotic (DZ) twin pairs. Sex is evenly distributed within zygosity (49% male).

Follow-up home visits were conducted when children were 7 years (98% of the E-Risk Study families, N = 2,191), 10 years (96%, N = 2,143), 12 years (96%, N = 2,143), and most recently in 2012-2014, at 18 years (93%, N = 2066). Follow-up visits followed the same procedures, and research workers were trained in the same way. Home visits at ages 5, 7, 10, and 12 years included assessments with participants as well as their mother (or primary caretaker); the home visit at age 18 included interviews only with the

participants. Each twin was assessed by a different interviewer. With the parent's permission, questionnaires were mailed to the children's teachers when children were 7 years (93% response rate), 10 years (90%) and 12 years (80%). At the age 18 interview, each twin was asked to nominate two co-informants who knew them well (typically their co-twin and a parent) to complete a questionnaire about them. At least one completed questionnaire was returned for 2,052 (99%) of the twins seen, and both questionnaires were returned for 1,698 twins (82%).

At follow up, the study sample represents the full range of socioeconomic conditions in the U.K., as reflected in the families' distribution on a neighbourhood-level socioeconomic index (ACORN [A Classification of Residential Neighbourhoods], developed by CACI Inc. for commercial use in Great Britain) (Odgers, Caspi, Russell, Sampson & Arseneault, 2012). ACORN uses census and other survey-based geodemographic discriminators to classify enumeration districts (~150 households) into socioeconomic groups ranging from "wealthy achievers" (Category 1) with high incomes, large single-family houses, and access to many amenities, to "hard pressed" neighbourhoods (Category 5) dominated by government-subsidized housing estates, low incomes, high unemployment, and single parents. ACORN classifications were geocoded to match the location of each E-Risk study family's home (Odgers, Caspi, Bates, Sampson, & Moffitt, 2012). E-Risk families' ACORN distribution closely matches that of households nation-wide: 25.6% of E-Risk families live in "wealthy achiever" neighbourhoods compared to 25.3% nationwide; 5.3% vs. 11.6% live in "urban prosperity" neighbourhoods; 29.6% vs. 26.9% live in "comfortably off" neighbourhoods; 13.4% vs. 13.9% live in "moderate means" neighbourhoods; and 26.1% vs. 20.7% live in "hard-pressed" neighbourhoods. E-Risk underrepresents "urban prosperity" neighbourhoods because such households are likely to be childless.

At age 18, the proportions of MZ (55%) and male same-sex (47%) twins were almost identical to those found in the original sample at age 5. The average age of the twins at the time of the assessment was 18.4 years (SD = 0.36); all interviews were conducted after their 18th birthday. There were no differences between those who did and did not take part at age 18 in terms of socioeconomic status (SES) assessed when the cohort was initially defined ($\chi^2 = 0.86$, $p = 0.65$), age-5 IQ scores ($t = 0.98$, $p = 0.33$), or age-5 emotional or behavioural problems ($t = 0.40$, $p = 0.69$ and $t = 0.41$, $p = 0.68$, respectively). High participation rates were achieved using several measures. At each phase, study families provided details of four persons (e.g. grandparents, aunts) who would be able to provide contact information, and also gave consent to contact their GP. Study members were sent a newsletter twice per year and each twin received a birthday card each year. If newsletters or cards were returned undelivered, tracing procedures were immediately initiated. Home visits also helped to achieve high participation rates.

Parents gave informed consent at each wave of assessment, and twins gave assent between 5-12 years and then informed consent at age 18. Ethical approval was granted by the Joint South London and Maudsley and the Institute of Psychiatry NHS Ethics Committee for each phase of the study.

2.2 Main measures

Childhood social isolation

Social isolation was assessed via mother and teacher reports of social withdrawal when children were 5 and 12 years old. The measure was based on 6 items selected from the Children's Behavior Checklist (Achenbach, 1991a), and the corresponding 6 items from the Teacher's Report Form (Achenbach, 1991b): "complains of loneliness", "doesn't get along with other children/pupils", "feels or complains that no-one loves him/her", "would rather be alone than with others", "not liked by other children/pupils" and "withdrawn, doesn't get involved with others". Mothers provided data in face-to-face interviews and

teachers responded by postal questionnaire, when children were aged 5 and 12. Items were coded 0 (not true), 1 (somewhat/sometimes true) and 2 (very often true). At each age, items were summed within respondent to create two social isolation scales. The mother and teacher scales were moderately correlated both at age 5 ($r = 0.27$) and at age 12 ($r = 0.31$). This level of agreement is consistent with previous findings of parent and teacher ratings of children's behaviour, and may be partly accounted for by situational specificity (Achenbach, McConaughy & Howell, 1987). Hence, mothers' and teachers' reports were averaged in order to integrate observations both in the classroom environment and outside of school. The Cronbach's alpha for the combined scale was $\alpha = 0.68$ at age 5, and $\alpha = 0.78$ at age 12.

A categorical social isolation variable was created to identify three groups of children. Those with scores of 1 or lower were classified as 'low' isolated, those with scores greater than 1 and less than or equal to 2 were classified as 'moderate', and those with scores greater than 2 were classified as 'high'. At age 5, 14% of children were moderately isolated and 9% were highly isolated. At age 12, 14% of children were moderately isolated and 12% were highly isolated. 80% of individuals classified as low at age 5 were also low at age 12, while 36% of those who were highly isolated at age 5 remained so at age 12. The continuity of social isolation across age points was tested using the kappa statistic, indicating slight stability between ages 5 and 12 ($\kappa = 0.17$, $p < 0.001$).

Social isolation in young adulthood

When participants were age 18, social isolation was measured using the Multidimensional Scale of Perceived Social Support (Zimet, Dahlem, Zimet & Farley, 1998), which assesses individuals' access to supportive relationships with family, friends and a significant other. The 12 items in the MSPSS consist of statements such as "There is a special person who is around when I am in need" and "I can count on my friends when things go wrong." Participants rated these statements as not true (0), somewhat true (1)

or very true (2). The scoring of the items was reversed, so that higher scores reflected disagreement with the statements. Scores were then summed to produce a scale with high scores reflecting greater social isolation (Cronbach $\alpha = 0.88$).

Low social support was chosen as an indicator of social isolation for a number of reasons. First, certain other indicators such as marital status or living alone were not applicable to the 18 year-olds in the E-Risk sample, as the vast majority of participants were living either in the family home or with flatmates. Second, while counting numbers of social contacts or interactions is a feasible alternative approach, the pervasive use of smartphones and social media in modern society (particularly in this age group) may introduce bias to such measures. For instance, an individual may have many social media ‘contacts’ with whom they seldom communicate, and a ‘social interaction’ could refer to a relatively trivial act such as sending an email. Social support, on the other hand, reflects more proximal and meaningful social connections, and therefore low social support was considered to reflect the extent to which participants were embedded in a social network. The strengths and limitations of this measurement approach are discussed further in Chapter 7.

Loneliness in young adulthood

Loneliness at age 18 was measured using four items from the UCLA Loneliness Scale, Version 3 (Russell, 1996). This revised form of the original scale simplifies the wording of items in order to increase its comprehensibility across different populations. Items are presented as questions beginning with “How often do you feel...” with a choice of four responses: “never”, “rarely”, “sometimes” and “often”. The selection of items from the original set of 20 was based on the three-item short form of the UCLA scale, developed by Hughes et al (2004). The items included in this scale are “How often do you feel you lack companionship?”, “How often do you feel left out?”, and “How often do you feel isolated from others?” The measure used in the E-Risk study adds a fourth item from the

original UCLA scale, “How often do you feel alone?” This item was included for its face validity and to boost the variance captured by the measure. A study of the factor structure of the full UCLA scale showed that this item loads onto the same latent factor as the other three items used (Hawkley et al, 2005). In line with the three-item scale, response choices were restricted to “hardly”, “some of the time”, and “often”. These responses were coded 0, 1 and 2 respectively and summed to produce a scale with range 0-8 ($M = 1.57$, $SD = 1.94$). The four-item scale showed good internal consistency (Cronbach $\alpha = 0.83$).

2.3 Statistical analyses

Each empirical chapter includes a detailed description of the analyses used for each separate study. This section reviews two methods for using twin data, and some of the conceptual issues related to these methods.

The classical twin study

Twin studies aim to quantify the extent to which individual differences in a phenotype (such as loneliness) are explained by differences in genes or environmental exposures. In the classical twin study, the total variance in a phenotype is separated into three latent explanatory factors. The first, additive genetic influences (A), refers to the summed effects of all individual genes. The proportion of variance in a trait explained by additive genetic influences is referred to as the *narrow-sense heritability* (h^2). This is in contrast to *broad-sense heritability* (H^2), which also includes dominance effects and gene-gene interactions. The second factor, called the shared or common environment (C), refers to environmental effects which are experienced by all siblings within a family, and which make them more similar to each other. The third factor is the non-shared shared or unique environment (E), and refers to environmental effects that are individual-specific and make siblings different from one another.

In order to isolate the effects of these three factors, the twin study exploits the difference in genetic relatedness of monozygotic (MZ) and dizygotic (DZ) twin pairs. MZ twins

share all of their segregating genes; DZ twins, by contrast, share only half on average. Furthermore, as twins grow up together in the same family home, the influence of the shared environment is assumed to be the same for MZ and DZ twins (the *equal environments assumption*). This premise allows three inferences to be drawn. Firstly, if the similarity between MZ twins on a given phenotype is greater than the similarity between DZ twins, this indicates the presence of genetic influences. Secondly, if the similarity of DZ twins is exactly half that of MZ twins, this difference is attributable entirely to their 50% difference in genetic relatedness. On the other hand, if DZ twins' similarity is greater than half that of MZ twins, this indicates other influences, over and above genes, which contribute to their similarity (i.e. shared environment). Thirdly, any dissimilarity between MZ twins, who are matched for their genes and shared environment, can only be explained by environmental experiences unique to individuals (Neale & Cardon, 1992).

The ACE model

The relative contributions of genes, shared environment and non-shared environment to a trait can be roughly calculated using Falconer's formula (Falconer & Mackay, 1996). This is based on comparing the within-twin pair correlations of MZ and DZ twin scores for a given phenotype. The correlation between MZ twins is the sum total of all genetic and shared environmental influences ($r_{MZ} = A + C$). The correlation between DZ twins consists of 50% of genetic influences plus all shared environment influences ($r_{DZ} = \frac{1}{2}A + C$). Therefore, given that the total variance in a trait is the sum of the A, C and E effects, the proportions of the variance accounted for by each factor can be calculated as follows:

$$A = 2 \times (r_{MZ} - r_{DZ}).$$

$$C = r_{MZ} - A$$

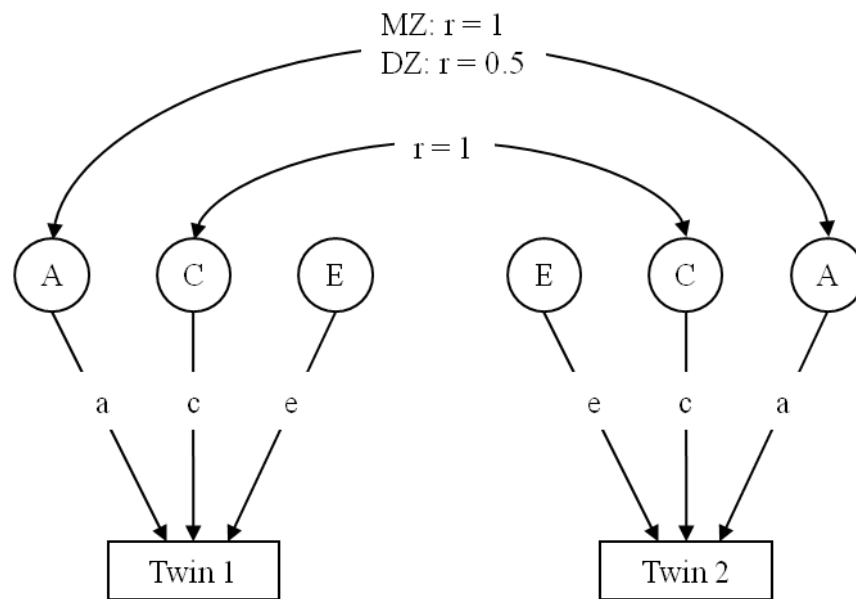
$$E = 1 - r_{MZ}$$

Typically, however, twin data is analysed using structural equation modelling (SEM), which permits the computation of confidence intervals, goodness-of-fit tests, and multivariate analyses (Rijsdijk & Sham, 2002). In a SEM framework, additive genetic, shared environmental and non-shared environmental influences are modelled as latent factors which load onto the observed phenotypic variables. Figure 2.1 represents the basic ACE twin model in path diagram form. The within-twin pair correlation between the additive genetic (A) factors is fixed at 1 for MZ twins and 0.5 for DZ twins. The correlation between the shared environment (C) factors is fixed at 1 for both MZ and DZ twins. The non-shared environment (E) factors, by virtue of being specific to individuals, are assumed not to correlate. Because the E factors capture all residual variance not explained by A and C, they also include all measurement error.

The ACE model is fitted to the observed covariance structure of the data in order to estimate the proportion of variance explained by the latent A, C and E factors. In this thesis, modelling is carried out using the OpenMx package for R, which estimates model parameters using maximum likelihood estimation (Boker, Neale, Maes, Wilde, Spiegel, Brick, Spies, Estabrook, Kenny, Bates, Mehta & Fox, 2011).

After fitting the ACE model to the data, more parsimonious submodels can be tested by imposing constraints on the model parameters. For instance, by constraining the paths from the C factors to take a value of zero, shared environmental effects can be omitted from the model and only additive genetic and non-shared environment effects are estimated. The fit of this AE model is compared against that of the ACE model by calculating the difference in their goodness-of-fit statistics, given as -2 times the log-likelihood ($-2LL$). The difference in $-2LL$ follows a chi-squared distribution, permitting a test of statistical significance. A non-significant difference between the AE and ACE models would indicate that the C factor can be dropped without substantive deterioration in model fit. Similarly, the paths from the A factor can be constrained to test the fit of a

Figure 2.1. Univariate twin model



Circles represent latent genetic (A), shared environment (C) and non-shared environment (E) factors. Rectangular boxes represent observed variables. Single-headed arrows represent the loadings of the latent factors onto the observed variables. Double-headed arrows represent the correlations between the latent factors.

CE model. The E factor cannot be excluded, as it contains the error variance.

The univariate ACE model can also be extended to multiple phenotypes. As is the case with twin correlations for a single trait, correlations between twins across two different traits can be compared by zygosity to infer the contribution of genetic and environmental influences to their co-occurrence. Multivariate twin models estimate the extent to which genetic and environmental influences on one trait are shared by a second trait. This can be used to calculate the proportion of the phenotypic correlation between the two traits that is explained by these overlapping influences. A trivariate twin model of social isolation, loneliness and depression is described in Chapter 4.

The twin differences method

An impediment to testing causal hypotheses using non-experimental methods is the fact that associations between environmental risk factors and outcomes can be confounded by other, unobserved causes, such as genes and shared environmental influences. An

example of genetic confounding is when the same heritable characteristics that influence an outcome also increase individuals' exposure to the putative risk factor, via gene-environment correlation (Plomin, DeFries, McClearn & McGuffin, 2008). An example of shared environmental confounding is when family-wide experiences such as socioeconomic status and neighbourhood factors contribute both to the exposure and the outcome. Without controlling for these potential confounds, the observed effect of a risk factor may therefore be spurious. The twin study design offers a means of methodologically controlling for genetic and shared environmental confounding, known as the discordant or twin differences method (Pike, Reiss, Hetherington & Plomin, 1996; Vitaro et al, 2009). This approach is based on the same assumptions as the classical twin study. However, rather than comparing the similarity of MZ versus DZ twin pairs in order to partition the variance in a trait, this method uses zygosity as a means of controlling for specific sources of variance in bivariate associations between traits.

The first step in this analysis involves subtracting each twin's score from that of their co-twin for each variable. The resulting value reflects the degree of dissimilarity between members of a twin pair. Among DZ pairs, this dissimilarity is attributable to the non-shared environment plus some genetic differences. Among MZ twins, any dissimilarity is explained only by the non-shared environment. Therefore, if the association with an outcome were explained by unique environmental experiences rather than familial factors, it would be expected that a MZ twin who is exposed to these experiences to a greater extent than their co-twin would also score higher on the outcome variable. This hypothesis is tested by correlating twin differences in the risk factor with twin differences in the outcome. By carrying out this analysis in a sample of MZ and DZ twins, shared environmental influences are held constant. By restricting the sample to MZ twins only, genetic influences are also controlled for. A significant association between MZ twin differences in two traits indicates an environmentally-mediated association. The MZ twin

differences design is therefore a powerful means of controlling comprehensively for many sources of confounding. In Chapter 6, this method is used to test the robustness of the association between loneliness and sleep quality.

Non-independence of twin observations

The twin design has implications for analyses conducted at the individual (rather than twin pair) level. As data are collected from two children from each family, observations are correlated within families, thereby violating the assumption of independent residuals in regression analysis. While this does not bias the regression coefficients, standard errors may be over- or underestimated. To correct for this, all individual-level tests in this thesis are based on the Huber-White or sandwich estimator (Williams, 2000), which adjusts the estimated standard errors to account for the clustered data.

Chapter 3: Social isolation and mental health at primary and secondary school entry: a longitudinal cohort study

3.1 Abstract

Objective: We tested whether children who are socially isolated early in their schooling develop mental health problems in early adolescence, taking into account their mental health and family risks at school entry. **Method:** We used data from the Environmental Risk (E-Risk) Longitudinal Twin Study, a birth cohort of 2,232 children born in England and Wales in 1994 and 1995. We measured social isolation using mothers' and teachers' reports at ages 5 and 12. We assessed mental health symptoms via mothers' and teachers' ratings at age 5 and self-report measures at age 12. We collected mother-reported information about the family environment when children were 5 years. We conducted regression analyses to test concurrent and longitudinal associations between early family factors, social isolation and mental health difficulties. **Results:** At both primary and secondary school, children who were socially isolated experienced greater mental health difficulties. Children with behavioural problems or ADHD symptoms at age 5 had an elevated risk of becoming more socially isolated at age 12. However, children who were isolated at age 5 did not have greater mental health symptoms at age 12, over and above pre-existing difficulties. **Conclusions:** Although social isolation and mental health problems co-occur in childhood, early isolation does not predict worse mental health problems later on. However, children who exhibit problematic behaviours may struggle to cope with the social challenges that accompany their progression through the early school years.

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3.2 Introduction

Intimacy and belongingness are intrinsic human needs (Baumeister & Leary, 1995). Interpersonal connections offer many benefits; they provide a frame of reference for social identity, as well as being a source of support and relief in times of stress (Cohen & Wills, 1985). Relationships may be particularly important in childhood, when identity is developing and lifetime trajectories of emotional and behavioural problems are shaping (Moffitt & Caspi, 2001; Woodward & Ferguson, 2000). To the extent that positive social relationships are rewarding and desirable, the absence or loss of such relationships may be detrimental to individuals' well-being. Furthermore, children with emotional or behavioural disorders could experience difficulties integrating in social environments. The aim of this study was to examine the associations between social isolation and mental health difficulties at primary and secondary school entry, two important transitions in children's lives and key periods for the formation of social connections.

The majority of studies on social isolation have focused on the latter years of life, when bereavement becomes more common and declining health imposes limitations on social activities. It is also at this stage of life that the long-term impact of social isolation is most evident: Isolation in middle to late adulthood is associated with an increased risk of mortality that is comparable to the risks associated with smoking (Holt-Lunstad et al, 2010; House et al, 1988). A number of mechanisms have been proposed to explain how the distressing experience of social isolation negatively impacts on health, including altered cardiovascular activity (Hawkey, Burleson, Berntson & Cacioppo, 2003; Hawkey et al, 2006), increased activation of the hypothalamic-pituitary-adrenal axis (Cacioppo et al, 2000; Eisenberger & Cole, 2012), inflammation (Cole, Hawkey, Arevalo, Sun, Rose & Cacioppo, 2007; Danese et al, 2009), and less restorative sleep (Cacioppo, Hawkey, Berntson et al, 2002; Hawkey, Preacher & Cacioppo, 2010).

Although the health outcomes of social isolation have been extensively studied in adults, there is increasing evidence from longitudinal studies that these long-term effects have their origins much earlier in life. Findings from a birth cohort study in New Zealand show that social isolation measured in childhood is associated with an increased risk of depression, high inflammation levels and other markers of cardiovascular disease in adulthood (Danese et al, 2009). Furthermore, multiple periods of isolation from childhood to adulthood predict poorer adult health outcomes in a dose-response manner (Caspi et al, 2006). This underscores the importance of early intervention to forestall the long-term effects of social isolation, and indicates a need for research to examine this phenomenon from a developmental perspective. Moreover, it is unclear how isolation emerges and persists in childhood. Understanding the role of isolation for children's development may provide clues as to how it exerts an effect on adult health outcomes.

Research on childhood social isolation has typically focused on the school environment, as it is in this context that children acquire many of their early social experiences and develop peer relationships (Hymel et al, 1990; Laird et al, 2001; Laursen, Bukowski, Aunola & Nurmi, 2007; Parker & Asher, 1987; Pedersen, Vitaro, Barker & Borge, 2007; Prinstein & La Greca, 2004; Rubin, Chen & Hymel, 1993; Rubin et al, 2009). This socialising process can be hindered in different ways; for instance, children may experience rejection by classmates, or they may themselves withdraw from social activities, in both cases consigning them to the margins of their peer groups. These isolating experiences may in turn have an impact on mental health. Studies of peer acceptance indicate that rejected children go on to show increases in externalising problems (Hymel et al, 1990; Laird et al, 2001, Prinstein & La Greca, 2004; Rubin et al, 1993), whilst childhood withdrawal is associated with later symptoms of depression and anxiety (Prior, Smart, Sanson & Oberklaid, 2000; Rubin et al, 2009). However, the relationship between isolation and later psychopathology may not be straightforward.

Pre-existing mental health difficulties could play a role, and social isolation may itself be a dynamic phenomenon that co-occurs with poor mental health without necessarily predicting a worsening of mental health symptoms over time. To comprehensively understand the relationship between isolation and mental health, it is important to consider both cross-sectional and bi-directional associations across time.

The onset of adolescence may be particularly challenging for children who did not successfully socialise in their early years of schooling. The transition to secondary school signals a period of upheaval, requiring children to adapt to a larger and unfamiliar social environment. Peer relationships become more complex and nuanced in adolescence (Hartup & Stevens, 1997), and solitary behaviour could come to be perceived more negatively (Rubin, 1985). Friendships and interactions with peers provide children with cues from which they can learn etiquette and social norms; therefore, children who are excluded from social interactions in the early years may fail to acquire these skills sufficiently, and go on to display more problematic behaviour later in their schooling. However, it is also possible that pre-existing emotional or behavioural problems can alienate children from friendship groups and activities, and thus predict increases in social isolation over time. If this is the case, the association between social isolation and later adjustment outcomes could be largely accounted for by the continuity of these pre-existing problems.

In the present study, we investigated the developmental associations between social isolation and mental health difficulties (emotional problems, behavioural problems and ADHD symptoms) at ages 5 and 12 in a longitudinal, nationally-representative cohort of children living in the United Kingdom (UK). First, we tested for concurrent associations between social isolation and mental health difficulties at both ages. Second, we examined bi-directional associations between social isolation and emotional or behavioural problems over time. We controlled for family factors when testing the associations

between social isolation and mental health, because factors in the family environment such as low SES and physical maltreatment could also make children more vulnerable to social isolation (Elliot, Cunningham, Linder, Colangelo & Gross, 2005; Schneider, Richard, Younger & Freeman, 2000).

3.3 Method

Participants

Participants were members of the Environmental Risk (E-Risk) Longitudinal Twin study, described in Chapter 2.

Measures

The measure of childhood social isolation is described in Chapter 2.

Measures of family factors and mental health problems are described in Table 3.1. Four of the items used to construct the social isolation measure are included in the emotional problems subscales of the CBCL and TRF; these items were therefore omitted when deriving the emotional problems scale.

Statistical analyses

We examined associations between family factors and social isolation using a series of multinomial logistic regressions. We entered family factors into separate univariate regressions, firstly with social isolation at age 5 and secondly at age 12 as the dependent variable. As all family factors were significantly associated with social isolation at both age points, we then analysed them simultaneously in combined models to identify factors independently associated with social isolation.

To test concurrent associations between social isolation and mental health difficulties at ages 5 and 12, we also used multinomial logistic regressions. In the first step, we regressed social isolation on each mental health variable separately (emotional problems, behavioural problems and ADHD symptoms). In the second step, we entered these variables simultaneously into one model to test for independent effects. In the final step,

Table 3.1: Measures of age-5 family factors and age-5 and age-12 mental health

Measure	Informant	Description	Instrument	M (SD) or %	Reference
<u>Age 5</u>					
SES	Parents	3 groups (split by tertile) based on a standardised composite of income, parents' education, and social class.	N/A	33.2% (low)	Trzesniewski, Donnellan, Moffitt, Robins, Poulton & Caspi (2006)
Maternal depression	Mother	Lifetime diagnosis of a major depressive episode.	Diagnostic Interview Schedule; Diagnostic and Statistical Manual IV	35.0%	Robins, Cottler, Bucholz & Compton (1995); American Psychiatric Association (1994)
Parental antisocial behaviour	Mother	Lifetime presence of symptoms of conduct disorder and antisocial personality disorder. Children were coded as having an antisocial parent if either parent had 3 or more antisocial personality symptoms.	Young Adult Self-Report; DSM-IV	27.6%	American Psychiatric Association (1994); Achenbach (1997)
Physical maltreatment	Mother	Standardised clinical interview. Children were coded as having experienced maltreatment based on mothers' report of the severity of discipline, her concerns that someone else may have harmed the child, and the interviewer's rating of the likelihood that the child had been maltreated.	Interview protocol from the Multisite Child Development Project	13.8%	Dodge, Bates & Pettit (1990); Dodge, Bates, Pettit & Valente (1995); Lansford, Dodge, Pettit, Bates, Crozier & Kaplow (2002)
Emotional problems	Mother and teacher	Sum of items on withdrawn/depressed and somatic subscales. Total scores standardised and averaged across raters.	CBCL; TRF	0 (1)	Achenbach (1991a; b)
Behavioural problems	Mother and teacher	Sum of items on delinquency and aggression subscales, summed across raters and standardised.	CBCL; TRF	0 (1)	Achenbach (1991a; b)
ADHD symptoms	Mother and teacher	Sum of items on inattentive, impulsive and hyperactivity scales, summed across raters and standardised.	CBCL; TRF	0 (1)	Achenbach (1991a; b)
<u>Age 12</u>					
Depression	Self-report	Total score of 27 items.	Children's Depression Inventory	3.11 (5.32)	Kovacs (1995; 1992)
Anxiety	Self-report	Total score of 10-items	Multidimensional Anxiety Scale for Children	7.62 (3.04)	March (1997)
Conduct problems	Self-report	Self-report survey administered via computer. Questions were designed to map onto the diagnostic criteria for conduct disorder.	DSM-IV	2.46 (2.94)	American Psychiatric Association (1994)

we controlled for those family factors which were previously shown to be associated with social isolation at ages 5 and 12.

We tested longitudinal associations between age-5 social isolation and age-12 mental health difficulties using linear regressions. For each mental health outcome (depression, anxiety and conduct problems), we first entered social isolation as the only predictor. In the second step, we controlled for emotional problems, behavioural problems and ADHD symptoms at age 5. In the third step, we controlled for family factors associated with age-5 social isolation. To examine longitudinal associations between age-5 mental health and age-12 social isolation, we used multinomial logistic regressions. In the first step, we entered predictors individually, then in the second step we entered them simultaneously into a combined model. In the third step, we controlled for family factors associated with age-12 social isolation. Finally, in the fourth step, we controlled for prior social isolation. We did not detect gender interactions for any of the associations investigated. However, because of known gender differences in the prevalence of mental health problems, all analyses were adjusted for gender. We conducted all regression analyses in Stata 11 (StataCorp, 2009).

3.4 Results

Are early family factors associated with childhood social isolation?

Not all family factors were independently associated with social isolation (Table 3.2). Five year-old children from low SES families were at increased risk of being moderately or highly isolated. Children whose mothers had a lifetime diagnosis of depression were at increased risk of high social isolation, whilst those who had experienced physical maltreatment were at increased risk for being moderately but not highly isolated. When looking at age 12, children from lower SES families, children exposed to maltreatment and children with antisocial parents were at increased risk of being isolated. Children with depressed mothers were not at risk of being socially isolated at age 12. When controlling

Table 3.2: Multivariate analysis of associations between family factors and social isolation at age 5 and 12

	Age-5 social isolation¹		Age-12 social isolation¹	
	Moderate RRR (95% CI) ²	High RRR (95% CI)	Moderate RRR (95% CI)	High RRR (95% CI)
Age-5 family factors				
SES				
Moderate	0.93 (0.67, 1.29)	0.98 (0.64, 1.51)	1.42 (1.01, 1.99)	1.59 (1.07, 2.38)
Low	1.45 (1.06, 2.00)	1.61 (1.06, 2.44)	1.67 (1.17, 2.37)	2.40 (1.62, 3.56)
Maternal depression	1.17 (0.89, 1.54)	1.75 (1.25, 2.46)	1.22 (0.92, 1.60)	1.10 (0.80, 1.51)
Parental antisocial behaviour	1.26 (0.93, 1.71)	1.38 (0.95, 2.00)	1.58 (1.17, 2.13)	1.45 (1.02, 2.05)
Physical maltreatment	1.47 (1.04, 2.08)	1.36 (0.90, 2.06)	1.20 (0.85, 1.69)	1.50 (1.01, 2.22)

All analyses adjusted for gender

¹ Social isolation base category: Low

² RRR: Relative risk ratio; CI: Confidence interval

for baseline social isolation, SES and parental antisocial behaviour continued to predict age-12 social isolation, but maltreatment did not.

Are social isolation and mental health concurrently associated?

Social isolation was concurrently associated with mental health difficulties when children were 5 years old (Table 3.3, Panel A). Children with emotional or behavioural problems, or ADHD symptoms, all had an increased risk for being moderately or highly isolated. These effects remained significant when controlling for other mental health difficulties and family factors, with the exception of ADHD symptoms which remained significantly associated with increased risk of high social isolation only.

Social isolation and mental health difficulties were also concurrently associated when children were aged 12 (Table 3.3, Panel B). Children with depression, anxiety and conduct problems were at increased risk for being isolated. When controlling for other mental health difficulties and age-5 family factors, these effects remained significant except for anxiety, which remained associated with an increased risk of moderate but not high social isolation.

Does social isolation in primary school predict mental health difficulties at secondary school entry?

Age-5 social isolation failed to predict age-12 mental health difficulties once baseline mental health problems were taken into account (Table 3.4, Panel A). In the first step, children who were moderately and highly isolated reported increased symptoms of depression, anxiety and conduct problems at age 12. However, these effects did not remain significant after controlling for age-5 emotional and behavioural problems and ADHD symptoms.

Table 3.3: Concurrent associations between social isolation and mental health at ages 5 and 12

Panel A	Age-5 social isolation ¹	
	Moderate RRR (95% CI) ²	High RRR (95% CI) ²
Age-5 mental health problems		
Emotional problems (unadjusted)	3.81 (3.18, 4.57)	7.91 (6.23, 10.05)
Adjusted for age-5 behavioural problems and ADHD	3.33 (2.76, 4.03)	6.43 (5.01, 8.24)
Adjusted further for family factors ³	3.33 (2.75, 4.03)	6.53 (5.04, 8.46)
Behavioural problems (unadjusted)	1.92 (1.69, 2.20)	2.73 (2.34, 3.19)
Adjusted for age-5 emotional problems and ADHD	1.51 (1.26, 1.82)	1.41 (1.11, 1.79)
Adjusted further for family factors ³	1.50 (1.24, 1.81)	1.42 (1.12, 1.81)
ADHD symptoms (unadjusted)	1.65 (1.45, 1.88)	2.86 (2.45, 3.34)
Adjusted for age-5 emotional and behavioural problems	1.08 (0.90, 1.30)	1.89 (1.50, 2.39)
Adjusted further for family factors ³	1.09 (0.91, 1.31)	1.94 (1.54, 2.44)
Panel B	Age-12 social isolation ¹	
	Moderate RRR (95% CI) ²	High RRR (95% CI) ²
Age-12 mental health problems		
Depression (unadjusted)	1.05 (1.02, 1.07)	1.12 (1.10, 1.14)
Adjusted for age-12 anxiety and conduct problems	1.03 (1.00, 1.05)	1.09 (1.07, 1.11)
Adjusted further for and age-5 family factors ⁴	1.03 (1.00, 1.05)	1.09 (1.07, 1.11)
Anxiety (unadjusted)	1.09 (1.05, 1.14)	1.13 (1.07, 1.19)
Adjusted for age-12 depression and conduct problems	1.07 (1.02, 1.12)	1.05 (0.99, 1.11)
Adjusted further for age-5 family factors ⁴	1.07 (1.02, 1.11)	1.04 (0.99, 1.10)
Conduct problems (unadjusted)	1.10 (1.05, 1.15)	1.19 (1.14, 1.24)
Adjusted for age-12 depression and anxiety	1.08 (1.04, 1.13)	1.14 (1.09, 1.19)
Adjusted further for age-5 family factors ⁴	1.06 (1.01, 1.12)	1.12 (1.07, 1.17)

All analyses adjusted for gender

¹ Social isolation base category: Low

² RRR: Relative risk ratio; CI: Confidence interval

³ SES, maternal depression and physical maltreatment

⁴ SES, parental antisocial behaviour and physical maltreatment

Table 3.4: Longitudinal associations between social isolation and mental health at ages 5 and 12

Panel A	Age-12 mental health problems		
	Depression (B, 95% CI) ¹	Anxiety (B, 95% CI) ¹	Conduct problems (B, 95% CI) ¹
Age-5 social isolation²			
Moderate (unadjusted)	1.18 (0.39, 1.98)	0.45 (0.04, 0.85)	0.56 (0.16, 0.97)
Adjusted for age 5 emotional and behavioural problems and ADHD	0.49 (-0.24, 1.23)	0.24 (-0.18, 0.66)	0.30 (-0.10, 0.71)
Adjusted further for family factors ⁴	0.50 (-0.24, 1.24)	0.25 (-0.17, 0.67)	0.29 (-0.11, 0.69)
High (unadjusted)	2.09 (0.95, 3.23)	0.84 (0.31, 1.36)	0.50 (0.03, 0.98)
Adjusted for age 5 emotional and behavioural problems and ADHD	0.58 (-0.75, 1.92)	0.35 (-0.24, 0.94)	-0.06 (-0.61, 0.48)
Adjusted further for family factors ⁴	0.64 (-0.70, 1.97)	0.40 (-0.19, 0.98)	-0.02 (-0.57, 0.53)
Panel B	Age-12 social isolation ²		
	Moderate RRR (95% CI) ³	High RRR (95% CI) ³	
Age-5 mental health problems			
Emotional problems (unadjusted)	1.47 (1.26, 1.72)	2.01 (1.71, 2.37)	
Adjusted for age-5 behavioural problems and ADHD	1.25 (1.06, 1.48)	1.47 (1.23, 1.75)	
Adjusted further for family factors ⁵	1.21 (1.02, 1.43)	1.42 (1.19, 1.69)	
Adjusted further for social isolation	1.12 (0.93, 1.36)	1.13 (0.93, 1.37)	
Behavioural problems (unadjusted)	1.57 (1.38, 1.79)	2.19 (1.92, 2.50)	
Adjusted for age-5 emotional problems and ADHD	1.31 (1.10, 1.56)	1.43 (1.20, 1.70)	
Adjusted further for family factors ⁵	1.24 (1.05, 1.48)	1.38 (1.16, 1.66)	
Adjusted further for social isolation	1.22 (1.02, 1.46)	1.31 (1.10, 1.57)	
ADHD symptoms (unadjusted)	1.51 (1.33, 1.71)	2.29 (2.00, 2.63)	
Adjusted for age-5 emotional and behavioural problems	1.21 (1.02, 1.43)	1.67 (1.39, 2.00)	
Adjusted further for family factors ⁵	1.19 (1.00, 1.41)	1.64 (1.37, 1.97)	
Adjusted further for social isolation	1.18 (0.99, 1.39)	1.55 (1.29, 1.87)	

All analyses adjusted for gender

¹ Regression coefficient (95% confidence interval)

² Social isolation base category: Low

³ RRR: Relative risk ratio; CI: Confidence interval

⁴ SES, maternal depression and physical maltreatment

⁵ SES, parental antisocial behaviour and physical maltreatment

Do mental health difficulties in primary school predict social isolation in secondary school?

Age-5 mental health difficulties were associated with higher levels of social isolation at age 12 (Table 3.4, Panel B). Children with behavioural problems or ADHD symptoms at age 5 were at greater risk for being isolated at age 12 than children without mental health problems. These effects remained significant when controlling for family factors and social isolation at age 5. Age-5 emotional problems did not remain significantly associated with social isolation after baseline isolation was controlled for.

3.5 Discussion

The present study shows that social isolation is associated with mental health problems in both primary and secondary school-aged children. Furthermore, children who exhibit problematic behaviours such as aggression or hyperactivity in the early school years are at risk of experiencing increasing levels of isolation by the start of secondary school. Children with early emotional problems, on the other hand, do not appear to be at greater risk of increased isolation later on. Mental health symptoms reported by secondary school children who had experienced earlier social isolation are partly accounted for by the continuity of pre-existing problems.

One first key finding indicates that a number of early family factors are associated with social isolation, both concurrently and across time. Children from low SES families were more isolated, as were children of antisocial parents. These findings are consistent with previous research on predictors of social isolation (Elliott et al, 2005; Schneider et al, 2000). Financial hardship may limit children's access to social activities, depriving them of opportunities to integrate with their peers. Antisocial behaviour on the part of parents, meanwhile, may lead to the family being ostracised by the local community. The children of antisocial parents could also go on to exhibit more behavioural problems themselves and place them at greater risk of becoming isolated. A stable family environment may not

only be protective against the risk of social isolation, but may also support the social development of children who are isolated by their peers (Cohn, Patterson & Christopoulos, 1991).

Our second key finding shows that children with early behavioural problems or symptoms of ADHD were at greater risk of becoming more isolated over time than children without these problems. This is consistent with previous findings that aggressive children tend to be rejected by their peers (Parker & Asher, 1987; Pedersen et al, 2007). Prosocial behaviour and minimal conflict are valued qualities in children's friendships (Berndt, 2002). Therefore, children who are disruptive or aggressive may become excluded from social circles. Interestingly, ADHD symptoms were the strongest predictor of social isolation, a finding which may have important implications for parents, teachers and practitioners with respect to the early identification and treatment of this disorder. Previous research on children with ADHD suggests that difficulties with self-monitoring and cue-taking can hamper their social interactions, which may contribute to their risk of isolation (Hoza, 2007). In contrast, although children with emotional problems tend to be socially isolated in primary and secondary school, they did not show increases in social isolation over time.

A third key finding indicates that children who were socially isolated at age 5 did not show greater depression, anxiety or conduct problems at age 12 once pre-existing mental health problems were controlled for. This implies that being socially isolated early in life may be an adverse situation that is subsequent to children's ongoing mental health problems, rather than being a unique precursor to psychopathology. This is surprising given previous studies showing poor mental health outcomes in rejected and withdrawn children (Hymel et al, 1990; Laird et al, 2001; Laursen et al, 2007; Prinstein & La Greca, 2004; Prior et al, 2000; Rubin et al, 1993, 2009). A possible explanation for this discrepancy is that the models used in this study controlled more comprehensively for

comorbid mental health problems. It is possible that the association between social isolation and mental health outcomes is explained by other psychiatric symptoms, or by heterotypic continuity between behavioural and later emotional problems (Dougherty, Smith Bufferd, Stringaris, Leibenluft, Carlson & Klein, 2013; Stringaris, Cohen, Pine & Leibenluft, 2009). Another potential explanation is that social isolation was measured differently in this study compared to several prior investigations: Rather than focusing specifically on rejection or withdrawal, the items used for our measure of social isolation were broader in scope, comprising a range of difficulties including rejection, peer problems and social anxiety. Furthermore, we used both mother and teacher ratings, meaning that unlike many prior studies of social isolation, our assessments were not confined to behaviour observed during school hours.

An additional explanation for the observed results is that the association between social isolation and mental health may depend upon children's own perceptions of their social relationships. Social isolation and loneliness are related, but distinct constructs, one being an objective state and the other a subjective, psychological state (de Jong Gierveld & Havens, 2004; Perlman & Peplau, 1981; Qualter & Munn, 2003). It may be that feelings of loneliness are a stronger predictor of mental health outcomes than objective social isolation (Coyle & Dugan, 2012). Longitudinal data on loneliness was not available for this study; nonetheless, it would be advantageous for further research on childhood social isolation to incorporate self-report data as well as teacher, parent or peer ratings.

A number of limitations to this study warrant acknowledgement. Firstly, the correlational design prohibits any inferences of causality. The aetiological association between social isolation and mental health problems is complex and warrants further investigation. Secondly, age-5 mental health and age-12 social isolation were both based on mother and teacher reports. It is therefore possible that the associations between these measures were inflated due to shared-method variance. Since the children in this study had different

teachers at each age, we repeated the analysis using only teachers' report of social isolation at age 12. This yielded the same pattern of results, with behavioural problems and ADHD uniquely predicting increases in social isolation. Future research could investigate whether the longitudinal associations observed in this study can be replicated using different measures and informants.

Thirdly, the categorisation of social isolation into groups was based on an arbitrary choice of cut-off points, rather than an established precedent. However, similar findings were observed when the analyses were repeated with social isolation analysed as a linear scale. Finally, as the sample was drawn from a twin study, each of the participants had a sibling by definition. Children with socially anxious or withdrawn behaviours may be protected from social isolation through their sibling relationships (East & Rook, 1992). It is therefore possible that our twin data may underestimate the effects of social isolation.

Findings from this study suggest a number of avenues for further investigation. Examining childhood and adolescent social isolation and its associations with mental health in later life will help to build a more comprehensive picture of social isolation from a developmental standpoint. Furthermore, measures of physical health in late adolescence and early adulthood may prove useful to determine whether the negative effects of childhood social isolation on later health (Caspi et al, 2006; Danese et al, 2009) can be detected as early as the teenage years. Finally, investigating subjective ratings of loneliness will help to reveal whether the relationship between social isolation and mental health is modified by individuals' own feelings about their social lives.

3.6 Conclusion

The present study has identified a number of early factors involved in the emergence of social isolation in children. At both primary- and secondary-school entry, children who are socially isolated experience greater mental health difficulties than their non-isolated peers. However, social isolation in young children did not appear to modify change in

their mental health over time; rather, the later problems experienced by these children appear to reflect the stability of pre-existing difficulties. Taken together, our findings suggest that timely intervention to address behavioural problems and ADHD symptoms in early childhood, whilst being expedient in its own right, may also yield the benefit of preventing children's social isolation worsening later in their schooling.

Chapter 4: Social isolation, loneliness and depression in young adulthood: a behavioural genetic analysis

4.1 Abstract

Objective: To investigate the association between social isolation and loneliness, how they relate to depression, and whether these associations are explained by genetic influences. **Method:** We used data from the age-18 wave of the Environmental Risk (E-Risk) Longitudinal Twin Study, a birth cohort of 1,116 same-sex twin pairs born in England and Wales in 1994 and 1995. Participants reported on their levels of social isolation, loneliness and depressive symptoms. We conducted regression analyses to test the differential associations of isolation and loneliness with depression. Using the twin study design, we estimated the proportion of variance in each construct and their covariance that was accounted for by genetic and environmental factors. **Results:** Social isolation and loneliness were moderately correlated ($r = 0.39$), reflecting the separateness of these constructs, and both were associated with depression. When entered simultaneously in a regression analysis, loneliness was more robustly associated with depression. We observed similar degrees of genetic influence on social isolation (40%) and loneliness (38%), and a smaller genetic influence on depressive symptoms (29%), with the remaining variance accounted for by the non-shared environment. Genetic correlations of 0.65 between isolation and loneliness and 0.63 between loneliness and depression indicated a strong role of genetic influences in the co-occurrence of these phenotypes. **Conclusion:** Socially isolated young adults do not necessarily experience loneliness. However, those who are lonely are often depressed, partly because the same genes influence loneliness and depression. Interventions should not only aim at increasing social connections but also focus on subjective feelings of loneliness.

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4.2 Introduction

Social relationships are a fundamental component of human life. A network of positive social relationships provides a source of support, meaning and guidance which can influence long-term trajectories of health outcomes (Umberson & Montez, 2010). The absence of these relationships – social isolation – is a situation that many people experience at some point in their lives, with potential implications for their health and well-being (Caspi et al, 2006; Victor, Scambler, Bond & Bowling, 2000). Furthermore, beyond the objective absence of social relationships are differences in the way people perceive their social environments. The feeling that one's desired quality and quantity of social connections are not being fulfilled – loneliness – constitutes an adversity in its own right. In the present study, we examined the separateness of social isolation and loneliness, and their differential associations with depressive symptoms. Further, using twin data, we investigated the underlying genetic and environmental influences that may account for some of these associations.

Social isolation is a state of estrangement, in which social connections are limited or absent. Loneliness, on the other hand, is a subjective feeling of distress, arising when social connections are perceived to be inadequate or unfulfilling (Coyle & Dugan, 2012; de Jong Gierveld & Havens, 2004; Tomaka, Thompson & Palacios, 2006). Crucially, although isolation and loneliness tend to co-occur, they can also be experienced independently of one another: it does not follow that isolated individuals necessarily feel lonely, nor does an abundance of social connections preclude one from experiencing loneliness (Golden, Conroy, Bruce, Denihan, Green, Kirby & Lawlor, 2009; Hawkley & Cacioppo, 2010). Thus, although there is overlap between these two constructs, there are important conceptual distinctions between them. It is therefore important to incorporate measures of both isolation and loneliness, without treating them as interchangeable (Coyle & Dugan, 2012).

Loneliness is a strong risk factor for depression, over and above measures of objective social connection (Cacioppo, Hawkley et al, 2006; Cacioppo, Hughes et al, 2006; Cacioppo et al, 2010; Cornwell & Waite, 2009; Heikkinen & Kauppinen, 2004; Heinrich & Gullone, 2006). Although the prevalence of loneliness varies with age, its association with depression remains stable across the lifespan (Nolen-Hoeksema & Ahrens, 2002; Victor & Yang, 2012). However, the nature of loneliness may vary at different stages of life as individuals' social needs shift in focus (Qualter et al, 2015). During the transition from adolescence to early adulthood, high value is attached both to close friendships and to romantic relationships. Loneliness is particularly prevalent at this stage of life (Hawthorne, 2008; Qualter et al, 2015; Victor & Yang, 2012), making young adulthood an interesting period in its own right for the study of loneliness and its association with social isolation and depression. We anticipate that feelings of loneliness will co-occur with greater social isolation, but that the separateness of these constructs will be reflected in only a modest association between the two. Further, based on the conceptualisation of loneliness as an emotional state, in contrast to the more circumstantial nature of isolation, we expect that loneliness will have the more robust association with depressive symptoms.

The associations between isolation and loneliness, and between loneliness and depression, may reflect common underlying genetic or environmental influences which contribute to the co-occurrence of these phenomena. Genetically-informative studies have estimated that approximately 40-50% of the variance in loneliness is accounted for by genetic factors (Bartels et al, 2008; Boomsma et al, 2005; Goossens et al, 2015; McGuire & Clifford, 2000). The genetic contribution to loneliness has been represented in an evolutionary framework, in which loneliness is an adaptive response to social disconnection that provides the impetus to re-integrate with social groups (Cacioppo, Hawkley et al, 2006). This suggests that social isolation is a situation that arises from the

environment, and that it is the individual's response that is genetically influenced. However, social isolation itself shows a similar degree of genetic influence to loneliness (Matthews et al, 2015), raising the possibility that some of the same heritable characteristics may be involved in both of these experiences. To date, however, no multivariate behavioural genetic studies have been carried out to estimate the extent to which the associations between isolation, loneliness and depression are explained by common genetic or environmental influences. Such evidence would be informative from a clinical practice point of view, as genetically-driven associations would suggest that interventions to reduce loneliness and associated depressive symptoms should take individuals' social perceptions into account rather than focusing efforts purely on increasing opportunities for social participation.

The perception of being cut off from social groups makes individuals feel vulnerable, triggering a range of cognitive, behavioural and physiological responses geared towards self-protection (Cacioppo, Hawkley et al, 2006). Thus, lonely individuals are inclined to be less trusting, to be more anxious and pessimistic, to perceive others around them more negatively and to approach social interactions in a defensive, hostile manner (Cacioppo & Hawkley, 2005; 2009). Although such cognitive biases and behavioural styles may serve the adaptive purpose of distancing individuals from potential threats, the corollary of this is that lonely individuals may become further isolated by sabotaging their opportunities to develop positive social relationships. It is therefore possible that a genetic predisposition to these defensive patterns of thought and behaviour, reflected in the heritability of loneliness, may also contribute to social isolation. Based on this, we would expect to find a genetic correlation between social isolation and loneliness, reflecting the presence of common underlying genetic contributions to these constructs. Similarly, in light of the negative emotional states associated with loneliness and evidence for a genetic

contribution to depression (Sullivan, Neale & Kendler, 2000), we expect to observe some genetic overlap between loneliness and depression.

The aim of the present study was to investigate the associations between social isolation and loneliness, and whether they differentially relate to depression, in a nationally-representative cohort of young people on the cusp of adult life. We examined the nature of these associations via three research questions: (1) To what extent are social isolation and loneliness separate constructs? (2) Are both social isolation and loneliness similarly associated with depression? (3) To what extent are the associations between isolation, loneliness and depression explained by genetic and environmental influences?

4.3 Method

Participants

Participants were members of the Environmental Risk (E-Risk) Longitudinal Twin study, described in Chapter 2.

Measures

The measures of social isolation and loneliness are described in Chapter 2.

We assessed current depressive symptoms using the Diagnostic Interview Schedule (Robins et al, 1995). The interview began with four screening questions to identify participants who had experienced at least two weeks of persistent low mood, anhedonia or irritability in the past year, or those who had been prescribed medication for depression. Participants who answered positively to any of the screening items were asked a further 24 questions designed to map onto the nine symptoms of a major depressive episode specified in the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV; American Psychiatric Association, 1994). We created a scale based on the total number of symptoms present. To identify participants with clinically significant depression we used a diagnostic cut-off based on the presence of at least 5 symptoms plus

interference in daily functioning. 20% of participants met these criteria for a major depressive episode at 18 years.

Data analysis

We tested the association between social isolation and loneliness using Pearson correlation. We used linear regression to test the respective associations of isolation and loneliness with depression. First, we regressed depressive symptoms separately on social isolation and loneliness. Secondly, we entered social isolation and loneliness simultaneously. We repeated these steps using logistic regression with a diagnosis of a major depressive episode as the dependent variable. All regression analyses were adjusted for sex and SES. As a further step in each analysis, we tested for an interaction effect between sex and the independent variables. Regression analyses were conducted in Stata 11 (StataCorp, 2009).

To test genetic and environmental contributions to the relationship between social isolation, loneliness and depression, we used the twin study methodology (Rijsdijk & Sham, 2002). By comparing the similarity of monozygotic (MZ) twin pairs versus dizygotic (DZ) pairs, the influences of additive genetic (A), shared environment (C) and non-shared environment (E) can be estimated. We used structural equation modelling in OpenMx (Boker et al, 2011) to fit a trivariate Cholesky decomposition in order to estimate the contributions of these influences to the covariance between social isolation, loneliness and depression. Variables were log-transformed to adjust for the non-normal distributions. The Cholesky decomposition entails a specific ordering of variables, such that each variable can be influenced by factors underlying the variables that precede it, but not vice-versa. This assumes an *a priori* rationale for the ordering of variables, such as observations made at different time points. As all variables were measured at the same time, this assumption was not justified; therefore, the results of the initial Cholesky

decomposition were transformed into the mathematically equivalent correlated factors solution (Loehlin, 1996).

4.4 Results

Differential associations between social isolation, loneliness and depression in young adults

Descriptive statistics are presented in Table 4.1. Males reported greater social isolation than females, while females reported higher levels of depression. No sex differences were found for loneliness. Social isolation and loneliness were significantly correlated ($r = 0.39, p < 0.001$). A significant sex interaction was detected ($B = 0.07, p = 0.001$), indicating that the association between isolation and loneliness was stronger among females ($r = 0.45, p < 0.001$) than males ($r = 0.35, p < 0.001$). Among those who scored in the top 25% range for isolation, only half (51%) were also in the top 25% range for loneliness. Similarly, of those who scored in the top 25% for loneliness, only 47% were also among the most isolated 25% of twins.

Depression was significantly correlated with social isolation ($r = 0.21, p < 0.001$) and loneliness ($r = 0.38, p < 0.001$). When social isolation and loneliness were entered simultaneously into a linear regression model (Table 4.2), the regression coefficient for social isolation remained significant but was reduced by 69% compared to the univariate estimate, while the coefficient for loneliness was minimally affected. No sex differences were detected in the associations tested.

These findings were replicated when we repeated the analyses using a clinical diagnosis of a major depressive episode as the outcome variable. When social isolation and loneliness were entered together into a logistic regression model (Table 4.2), the odds ratio for isolation reduced substantially although remained marginally significant, while the odds ratio for loneliness remained robust. This indicates that the association between

Table 4.1: Descriptive statistics of measures and mean differences by sex

Measure	Whole sample				Males				Females				Mean difference (Male-Female)	
	N	Range	Mean	SD	N	Range	Mean	SD	N	Range	Mean	SD	<i>t</i>	<i>p</i>
Social Isolation	2061	0-24	3.29	4.35	976	0-24	3.74	4.51	1085	0-24	2.87	4.15	4.56	< 0.001
Loneliness	2051	0-8	1.57	1.94	973	0-8	1.51	1.93	1078	0-8	1.62	1.95	-1.39	0.17
Depression	2063	0-9	1.81	2.97	979	0-9	1.44	2.70	1084	0-9	2.13	3.16	-5.32	< 0.001

N = Number, SD = Standard Deviation

Table 4.2: Social isolation, loneliness, and their associations with depression

	Depressive symptom scale (B, 95% CI)			Major depressive episode diagnosis (OR, 95% CI)		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Social isolation	0.16 (0.12, 0.19)	-	0.05 (0.02, 0.09)	1.11 (1.08, 1.13)	-	1.03 (1.00, 1.06)
Loneliness	-	0.61 (0.54, 0.69)	0.56 (0.48, 0.65)	--	1.51 (1.42, 1.60)	1.46 (1.37, 1.56)

B = Regression coefficient (unstandardised); OR = Odds Ratio, CI = Confidence Interval

Significant associations shown in bold

All analyses adjusted for sex, SES and non-independence of twin observations.

social isolation and depression is in large part accounted for by the shared variance with loneliness.

Genetic and environmental contributions to the associations between social isolation, loneliness and depression

When looking at the cross-twin within-trait correlations (Table 4.3), we found evidence for substantial additive genetic (A) influences on social isolation, loneliness and depression, reflected by higher correlations among MZ twins relative to DZ twins. MZ correlations well below 1 signify differences between genetically-identical individuals living in the same home, attributable to non-shared environment (E) influences on these traits. Conversely, the cross-twin correlations suggested only negligible shared environment (C) influences, which are indicated by a DZ correlation higher than half the MZ correlation. A similar pattern is observed when looking at the cross-twin cross-trait correlations, indicating a contribution of additive genetic and non-shared environment influences to the covariation between isolation, loneliness and depression.

The variances of social isolation, loneliness and depression were decomposed into genetic and environmental components using behavioural genetic modelling (Figure 4.1). The contribution of shared environment (C) influences could be omitted from the model without substantial loss of fit ($\Delta-2LL = 1.31$, $\Delta df = 6$, $p = 0.97$). Therefore, we present results for a more parsimonious AE model, estimating only additive genetic and non-shared environment influences. No sex differences were found for any of the estimates in the model.

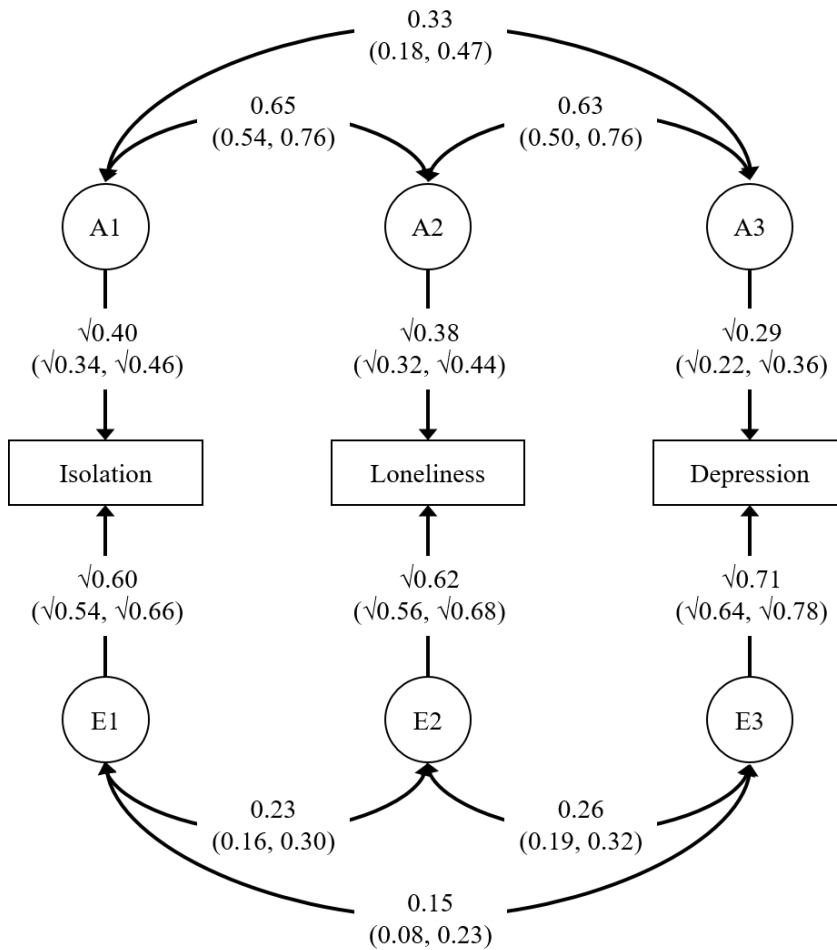
Genetic influences were similar for social isolation (40% of variance) and loneliness (38% of variance), and slightly smaller for depression (29% of variance). The genetic correlation between isolation and loneliness was 0.65, indicating strong overlap in the genetic influences on these constructs. The non-shared environmental correlation between isolation and loneliness was 0.23. For loneliness and depression, the genetic

Table 4.3: Cross-twin correlations for social isolation, loneliness and depression

		Isolation (Twin 1)	Loneliness (Twin 1)	Depression (Twin 1)
MZ Twins	Isolation (Twin 2)	0.41	0.25	0.17
	Loneliness (Twin 2)	0.25	0.37	0.21
	Depression (Twin 2)	0.08	0.22	0.31
DZ Twins	Isolation (Twin 2)	0.17	0.09	-0.01
	Loneliness (Twin 2)	0.15	0.21	0.09
	Depression (Twin 2)	0.01	0.08	0.11

Significant correlations shown in bold; MZ = monozygotic; DZ = dizygotic

Figure 4.1: Correlated factors model separating the covariance between social isolation, loneliness and depression in to additive genetic (A) and non-shared environment (E) components.



Vertical arrows indicate the proportions of variance accounted for by the A and E factors. Double-headed arrows indicate the aetiological correlations between variables. 95% confidence intervals are shown in brackets.

The proportion of the phenotypic association between two variables that is accounted for by genetic influences can be calculated by multiplying the paths connecting the variables via their respective A factors, and dividing by the phenotypic correlation. E.g. for isolation and loneliness this is calculated as $(\sqrt{0.40} * 0.65 * \sqrt{0.38}) / 0.39 = 0.65$.

correlation was 0.63 and the non-shared environmental correlation was 0.26, again indicating strong genetic overlap between these variables. The genetic and non-shared environmental correlations between isolation and depression were 0.33 and 0.15 respectively.

The proportion of the phenotypic correlation between variables that is accounted for by genetic and non-shared environmental factors can be calculated using path tracing: the product of the heritability estimates for two variables and their genetic correlation yields the part of the phenotypic correlation explained by genetic influences. This can be expressed as a percentage by dividing by the phenotypic correlation. The proportion of the association between social isolation and loneliness explained by genetic influences was 65%. When looking at loneliness and depression, genetic influences accounted for 55% of this association, with the remainder accounted for by the non-shared environment.

4.5 Discussion

In the present investigation we built on previous studies in disentangling the constructs of social isolation and loneliness, using data from a nationally-representative longitudinal cohort. Young adults who were socially isolated experienced greater feelings of loneliness, and were also more likely to grapple with depression, suggesting that social relationships confer benefits for mental health over and above subjective feelings of connectedness, such as reducing the effects of stress (Cohen & Wills, 1985). However, young adults' feelings of loneliness were more strongly associated with their experience of depressive symptoms than were reports of social isolation, a finding consistent with previous studies (Cacioppo, Hawkley et al, 2006; Cacioppo, Hughes et al, 2006; Cornwell & Waite, 2009). Using a genetically-sensitive design, we detected genetic contributions to social isolation, loneliness and depression, and a strong genetic overlap between these phenotypes.

We found a heritability estimate for loneliness which is in line with those found in previous behavioural genetics studies (Bartels et al, 2008; Boomsma et al, 2005; Goossens et al, 2015). The heritability of loneliness has been described as reflecting a genetic propensity to experiencing psychological pain in conditions of social disconnection (Cacioppo, Hawkley et al, 2006). However, we also found that social isolation itself – ostensibly an environmental exposure – showed a similar degree of genetic influence to loneliness. The presence of genetic influences on measures of the environment is a robust finding in behavioural genetics research (Kendler & Baker, 2007; Plomin & Bergeman, 1991), and in the case of social isolation may reflect heritable characteristics that predispose individuals to experience negative interactions with others, or to self-select into solitary patterns of behaviour. The absence of shared environment influences indicates that the environmental exposures contributing to isolation and loneliness are unique to individuals rather than experienced by multiple siblings within a family.

We expanded further on previous findings on the heritability of loneliness by using a multivariate behavioural genetic design to test the hypothesis that social isolation, loneliness and depression would share common underlying genetic influences. Consistent with our expectations, the heritabilities of isolation and loneliness were highly correlated, and this genetic correlation accounted for approximately two thirds of the phenotypic overlap between these two constructs, indicating that the co-occurrence of loneliness with social isolation is driven to a large extent by the same heritable characteristics. Some lonely individuals have a tendency to adopt negative perceptions and expectations of others, which in turn can harm their social interactions and drive others away, thus exacerbating their isolation (Cacioppo & Hawkley, 2005; 2009). Thus, the same heritable traits that can make individuals liable to becoming isolated in the first place may also dispose them to respond to their feelings of disconnection in maladaptive ways,

contributing to this self-reinforcing cycle between isolation and loneliness. A smaller part of the correlation was explained by environmental factors, which may reflect the influence of broader socioeconomic and cultural forces that shape the context in which social relationships are formed (Berkman et al, 2000).

Furthermore, we found that the association between loneliness and depression was explained both by genetic and non-shared environmental influences. Although heritable personality traits such as neuroticism are correlated with both of these phenomena, other research shows that they do not explain the association between them (Cacioppo, Hawkley et al, 2006; Vanhalst, Klimstra et al, 2012). Instead, the genetic overlap may reflect a heritable predisposition to cognitive biases and negative attributional styles that are characteristics of both loneliness and depression (Anderson, 1999). Non-shared environmental influences, meanwhile, may be reflective of peer influences or life events. The cross-sectional nature of the data does not allow the role of mediating variables to be tested; further longitudinal research will therefore be valuable in identifying potential mechanisms underlying the associations found in this study.

The latent factor approach in this study does not yield information about which genes play a role in the associations under investigation. However, a growing body of research in this area has yielded some promising findings (Goossens et al, 2015). Studies of gene-environment interactions have found that the associations between loneliness and measures of family support were moderated by variants of genes including the serotonin transporter (5-HTTLPR; van Roekel, Scholte, Verhagen, Goossens & Engels, 2010), the dopamine D2 receptor (DRD2; van Roekel, Goossens, Scholte, Engels & Verhagen, 2011), and the corticotrophin-releasing hormone receptor 1 (CRHR1; Chou, Cacioppo, Kumari & Song, 2014). Another study showed attenuation of the relationship between loneliness and depression in the presence of a specific apolipoprotein (APOE) allele (Chou, 2010). Replication of these findings in large samples and research in the growing

field of epigenetics will help to further elucidate the genetic underpinnings of social isolation and loneliness.

Although males were on average more isolated and females more depressed, no sex differences were found for loneliness. This is consistent with previous studies using the UCLA Loneliness Scale (Borys & Perlman, 1985). However, the association between isolation and loneliness was stronger among females. Previous studies suggest that friendships between females are characterised by greater amounts of emotional sharing in comparison to male friendships, which emphasise shared activities (Aukett, Ritchie & Mill, 1988; Caldwell & Peplau, 1982). To the extent that females invest more in the emotionally supportive qualities of social relationships, this may leave them particularly susceptible to feelings of loneliness in the absence of such relationships, while males may experience this to a somewhat lesser extent. Nonetheless, it is important to note that for both males and females the association between isolation and loneliness was well below unity, indicating that non-isolated individuals may still feel lonely. Furthermore, the association between loneliness and depression was equally strong for males and females, suggesting that loneliness is a similarly distressing experience for both males and females. In the present study, we operationalised social isolation as the lower end of a distribution of social support. Isolation has been measured in numerous other ways in different studies, including cohabitation, marital status, social network size and participation in social activities (Cacioppo et al, 2010; Cornwell & Waite, 2009; Coyle & Dugan, 2012, Hughes et al, 2004; Shankar et al, 2011; Tomaka et al, 2006). There is little consensus as to the best or most comprehensive measure of isolation, and some measures may be more appropriate than others depending on the age group under investigation. For example, data on living arrangements collected at age 18 indicated that nearly all of the participants in this study were cohabiting either with family members, partners or flatmates. We therefore did not consider living alone to be a suitable measure of isolation among this

age group. Other indicators of isolation were not available at age 18; however, in a previous study we derived a measure of childhood social isolation based on mother and teacher report when participants were aged 12 (Matthews et al, 2015). Repeating our analyses using this variable yielded much the same pattern of results, with 41% of variance in social isolation accounted for by genetic influences, and approximately three-quarters of its phenotypic association with age-18 loneliness accounted for by the genetic correlation. We are therefore confident in our selection of low social support as a proxy for isolation for the purpose of this study. Nonetheless, it should be acknowledged that social support is not the only feature of social relationships that may have implications for mental health outcomes (Berkman et al, 2000). Furthermore, there may be individual differences in the way participants rate the amount of support available to them, and therefore this measure cannot be assumed to be fully objective in nature. Future studies should therefore aim to replicate our findings using measures of isolation that take into account other aspects of social networks.

Some methodological limitations in our study merit acknowledgement. Firstly, as all data were measured at the same age, our results do not permit conclusions to be drawn about the direction of the associations. Social isolation and loneliness may reinforce one another via maladaptive appraisal and coping styles, and similarly, individuals with symptoms of depression may become withdrawn and isolate themselves, feeding back into feelings of loneliness; thus, the observed associations may be bidirectional in nature. A second limitation is the use of self-report for all measures in the present study. It is not possible to rule out the presence of a reporting bias, whereby individuals with low mood are more likely to rate their social relationships more negatively. Thirdly, measuring social isolation and loneliness in a sample of twins may be confounded by the fact that each participant, by definition, had a sibling. Consequently, social isolation and loneliness may be underestimated by twin data.

With regard to clinical implications, the shared genetic origins of loneliness and depression suggest potential targets for treatment and prevention. Although the cross-sectional nature of the data does not permit any developmental hypotheses to be drawn, our findings are consistent with prior studies suggesting that interventions to decrease feelings of loneliness can be important to reduce depressive symptoms (VanderWeele, Hawkley, Thisted & Cacioppo, 2011). Given that loneliness can be experienced even without social isolation, simply increasing individuals' amount of social contact may be insufficient for improving outcomes. Consistent with this, a meta-analysis of interventions suggests that addressing negative social cognitions shows greater promise as a strategy to reduce loneliness, compared to interventions focused on increasing social contact or support (Masi, Chen, Hawkley & Cacioppo, 2011). More broadly, relationship-based interventions such as interpersonal therapy are effective in reducing depressive symptoms in young people (Mufson, Weissman, Moreau & Garfinkel, 1999).

4.6 Conclusion

The present study provides new insights into the links between social connection and mental health. Isolation and loneliness are strongly related constructs, and both show similar degrees of heritability. However, from a research and clinical practice perspective, it is important not to treat these constructs as interchangeable. Lonely individuals are vulnerable to depression irrespective of their actual degree of social support. Furthermore, the aetiological influences underlying these associations point to the role of common genetic characteristics in driving the co-occurrence of these experiences. To further understand the mechanisms involved, future research should investigate the role of mediating variables and gene-environment interplay in the relationship between isolation, loneliness and psychopathology.

Chapter 5: Lonely young adults in modern Britain: findings from an epidemiological cohort study

5.1 Abstract

Objective: To build a detailed and integrative profile of young adults' experience of loneliness, in terms of their current health and functioning and their childhood experiences and circumstances. **Method:** Data were drawn from the Environmental Risk (E-Risk) Longitudinal Twin Study, a prospective, nationally-representative cohort of children born in 1994-1995. Regression analyses were used to test the cross-sectional associations between age-18 loneliness and mental health, physical health and health risks, coping and functioning, employment prospects and other people's perceptions of participants. Longitudinal analyses were used to investigate childhood factors associated with young adult loneliness, including family environment, child characteristics, mental health, victimisation and social relationships. **Results:** Lonelier young adults were more likely to experience a diverse range of mental health problems, to engage in physical health risk behaviours, and to use more negative coping strategies to deal with stress. They were less confident in their employment prospects and were more likely to be out of work and education. Ratings provided by informants, including interviewers and participants' family members, indicated that individuals' own feelings of loneliness are apparent to others. Furthermore, lonelier individuals' personality and behaviour were rated by others as less likeable and prosocial, and more suspicious and hostile. Lonelier young adults were, as children, more likely to have had mental health difficulties, and to have experienced bullying and social isolation. **Conclusion:** Young people's experience of loneliness co-occurs with a broad range of problems, with potential implications for health and functioning in later life. The findings underscore the importance of early intervention to prevent lonely young adults from becoming lonely older adults.

5.2 Introduction

Loneliness is a distressing and pervasive experience, with broad implications for mental and physical health. Among older people, it is associated with a diverse range of mental and physical health problems, including depression (Cacioppo et al, 2010; Heikkinen & Kauppinen, 2004), increases in blood pressure (Hawkley et al, 2006; Hawkley, Thisted et al, 2010), changes in gene expression (Cole et al, 2007), compromised sleep (Hawkley, Preacher & Cacioppo, 2010), cognitive impairments (Shankar et al, 2013), and increased activation of the hypothalamic-pituitary-adrenal axis (Adam, Hawkley, Kudielka & Cacioppo, 2006). A large body of epidemiological evidence has established loneliness as a strong predictor of premature death, with effect sizes similar to or greater than other well-established risk factors such as smoking and obesity (Holt-Lunstad et al, 2010; 2015; House et al, 1988; Luo et al, 2012). According to a cross-national study by the Office for National Statistics (2014), the percentage of the UK population with access to supportive social relationships is the third-lowest of all the 28 EU nations. This makes loneliness a public health concern of particular relevance to the UK.

Loneliness is defined as the feeling that one's desired quantity or quality of social connection is unfulfilled (Peplau & Perlman, 1982). Although widely studied from a gerontological perspective, it is not confined to old age, and is particularly prevalent among younger people (Dykstra, 2009; Luhmann & Hawkley, 2016; Pinqart & Sorensen, 2001; Qualter et al, 2015; Victor & Yang, 2012). A survey by the Mental Health Foundation (2010) indicates that the proportion of people in the UK who often feel lonely, worry about feeling lonely, and seek help for loneliness is highest among younger people (aged 18-34 years) compared to older age groups. Young adults today could therefore be particularly at risk for loneliness-related health outcomes in later life, and, with a view to intervention, this underscores the need for further research to understand how loneliness impacts young people's lives and the early factors that contribute to its emergence.

The relationship between loneliness and depression has been studied thoroughly (Cacioppo et al, 2010; Vanhalst, Luyckx et al, 2012; Vanhalst, Klimstra et al, 2012). However, the diverse emotional states associated with loneliness could have broader implications for mental health, beyond increasing symptoms of depression. For example, feelings of low worth may increase the risk of self-harm, suicidal ideation or substance abuse. Negative expectations about social interactions may elevate symptoms of anxiety, or arouse hostility towards others, potentially contributing to antisocial behaviours. In order to fully assess the extent of loneliness' implications for mental health, a multivariate approach is required to simultaneously test its associations with a variety of mental health disorders and the comorbidity between them.

Loneliness may have important implications not only for young adults' mental health but for other aspects of everyday functioning. One of the benefits of social relationships is that they serve to buffer against the effects of stressful events (Cohen & Wills, 1985). Conversely, feelings of loneliness may magnify individuals' sensitivity to stressful exposures (Cacioppo et al, 2000; Cacioppo, Hawkley & Berntson, 2003). In the absence of supportive social relationships, lonely individuals may cope with stress in maladaptive ways, such as withdrawing or obsessing about problems. They may also adopt health-damaging behaviours such as smoking, or negative attitudes towards physical activity (Lauder, Mummery, Jones & Caperchione, 2006). Particularly among young people, excessive use of the internet may be a further coping strategy used by individuals who feel cut off from others.

The burden of loneliness may also play a role in young adults' academic and career endeavours. A significant number of young adults in the UK are not in employment, education or training (NEET), and this group is characterised by more negative perceptions of their employability and the likelihood of succeeding in their careers, rather than by a lack of motivation or effort (Goldman-Mellor, Caspi, Arseneault, Ajala,

Ambler, Danese, Fisher, Hucker, Odgers, Williams, Wong & Moffitt, 2016). Negative self-perceptions arising from feelings of loneliness may make young people particularly at risk of falling into this group and, conversely, difficulties in finding employment or accessing further education may serve to make young people feel further isolated and marginalised.

According to an evolutionary model (Cacioppo, Hawkley et al, 2006), loneliness is experienced as a feeling of vulnerability, leading individuals to perceive others as hostile and adopt defensive patterns of behaviour. While such behaviours serve the adaptive benefit of distancing oneself from social threats, they could have the counterproductive effect of pushing away potential friends (Cacioppo & Hawkley, 2009). A recent study showed that individuals' loneliness is visible to those they interact with (Luhmann et al, 2016). However, less is known about how other characteristics of lonely individuals, such as their personality and behavioural styles, are perceived by others. The use of a multi-informant approach to study the impression lonely individuals make on others could help to identify patterns of behaviour which are informative for targeting interventions to break the cycle of loneliness.

Loneliness is not simply a function of individuals' objective amount of social contact. The subjective, psychological nature of loneliness means that individuals' propensity to experience it may be shaped by experiences earlier in life. For instance, adversities in the family home environment, such as parental psychopathology and domestic violence, could have long-term implications for children's social and emotional development and set in place an elevated vulnerability to feelings of loneliness. Mental health problems in childhood, particularly those of an internalising nature, may negatively bias how children appraise their social relationships later on life. Cognitive impairments such as low IQ and theory of mind deficits, and personality traits such as neuroticism, could lead to difficulties with social interactions during the formative childhood years, with a lasting

effect on the formation of positive social relationships later in life. Other adversities related to peer relationships, such as being a victim of bullying or social isolation, could similarly have a detrimental effect on children's socialisation and on the perceived quality of their social relationships later in life.

The aim of the present study is to broadly document the profile of lonely people in a prospective, contemporary and nationally-representative cohort of young adults living in the UK. Cross-sectional data are used to investigate the functioning of lonely young people in five domains: mental health, physical health and health risks, coping and functioning, career prospects, and how they are perceived by others. Longitudinal data were used to examine the childhood history of lonely individuals, in terms of family environment, child characteristics, mental health, and victimisation and social relationships.

5.3 Methods

Participants

Participants were members of the Environmental Risk (E-Risk) Longitudinal Twin study, described in Chapter 2.

Measures

Loneliness

The measure of loneliness is described in Chapter 2.

Adult correlates of loneliness

Functioning in adulthood was measured in terms of mental health, physical health and health risks, coping and functioning, and employment prospects (Table 5.1). Mental health measures comprised past year diagnoses of depression, anxiety, attention-deficit hyperactivity disorder (ADHD), conduct disorder, alcohol dependence and cannabis dependence, as well as any instances of self-harm or suicide attempts between ages 12 and 18. Participants also reported whether they had seen a GP, psychiatrist, counsellor or

Table 5.1: Measures

	Participant's age at measurement	Reporting period	Informant	Distribution	Reference
<u>Correlates in young adulthood</u>					
<i>Mental health and service use</i>				% (N)	
Depression diagnosis	18	Past year	Self-report	20.07 (414)	1
Anxiety diagnosis	18	Past year	Self-report	7.43 (153)	1
ADHD diagnosis	18	Past year	Self-report	7.67 (158)	1
Conduct disorder diagnosis	18	Past year	Self-report	15.05 (309)	1
Alcohol dependence diagnosis	18	Past year	Self-report	12.75 (263)	1
Cannabis dependence diagnosis	18	Past year	Self-report	4.31 (89)	1
Self-harm	18	Age 12-18	Self-report	13.52 (279)	
Suicide attempt	18	Age 12-18	Self-report	3.83 (79)	
Service use	18	Past year	Self-report	12.89 (266)	
<i>Physical health and health risks</i>				M (SD)	
BMI	18	Current	Objective measure	23.08 (4.86)	
CRP (mg/L)	18	Current	Objective measure	0.27 (0.67)	
Sleep quality	18	Current	Self-report	5.39 (3.17)	2
Physical activity	18	Current	Self-report	2.76 (1.06)	3
				% (N)	
Daily smoking	18	Current	Self-report	22.34 (461)	
<i>Coping and functioning</i>				M (SD)	
Life satisfaction	18	Current	Self-report	3.87 (0.73)	4
Coping with stress	18	Current	Self-report	8.95 (2.61)	
Technology use	18	Current	Self-report	4.54 (3.91)	5
<i>Employment prospects</i>				% (N)	
NEET	18	Current	Self-report	11.57 (239)	6
Low qualifications	18	Current	Self-report	21.88 (451)	
				M (SD)	
Job preparedness (skills)	18	Current	Self-report	4.97 (1.82)	6
Job preparedness (attributes)	18	Current	Self-report	16.98 (2.64)	6

Optimism	18	Current	Self-report	16.10 (3.20)	6
Attitudes towards work	18	Current	Self-report	9.74 (2.99)	6
Job search activities	18	Current	Self-report	5.03 (2.43)	6
<i>Interviewer ratings</i>	18				
Lonely	18	Current	Interviewer	0.67 (1.19)	
Likeable-prosocial	18	Current	Interviewer	7.00 (2.29)	
Suspicious-hostile	18	Current	Interviewer	1.18 (1.96)	
<i>Sibling ratings</i>	18				
Lonely	18	Current	Sibling	0.55 (1.09)	
Likeable-prosocial	18	Current	Sibling	6.39 (2.08)	
Suspicious-hostile	18	Current	Sibling	2.24 (2.37)	
<i>Parent ratings</i>	18				
Lonely	18	Current	Parent	0.55 (1.07)	
Likeable-prosocial	18	Current	Parent	7.24 (2.00)	
Suspicious-hostile	18	Current	Parent	1.71 (2.26)	
<u>Childhood predictors</u>					
<i>Family environment</i>					
Maternal warmth	5	Current	Interviewer	3.27 (1.00)	7
				% (N)	
Maternal depression	5	Past 5 years	Mother	35.01 (780)	1
Parental antisocial behaviour	5	Past 5 years	Mother	27.58 (614)	1
Domestic violence	5	Past 5 years	Mother	42.29 (938)	8
Low SES	5	Current	Mother	33.24 (742)	
<i>Child characteristics</i>					
Female gender	5	Current	Mother	51.08 (1140)	
				M (SD)	
IQ	5	Current	Test score	100 (15.00)	9
Theory of mind	5	Current	Test score	4.52 (3.28)	10
Openness to experience	12	Current	Interviewer	4.31 (2.76)	11
Conscientiousness	12	Current	Interviewer	8.52 (3.23)	11
Extraversion	12	Current	Interviewer	8.28 (3.54)	11

Agreeableness	12	Current	Interviewer	8.94 (1.70)	11
Neuroticism	12	Current	Interviewer	2.08 (1.84)	11
<i>Child mental health</i>					
Depression symptoms	12	Current	Self-report	3.11 (5.32)	12
Anxiety symptoms	12	Current	Self-report	7.62 (3.04)	13
Substance use	12	Age 5-12	Mother	0.04 (0.24)	14
				% (N)	
ADHD diagnoses	5, 7, 10, 12	Age 5-12	Mother	12.11 (247)	1
Conduct disorder diagnoses	5, 7, 10, 12	Age 5-12	Mother	15.76 (349)	1
<i>Victimisation and social relationships</i>					
Maltreatment	5, 7, 10, 12	Birth to age 12	Mother	21.15 (472)	15
Bullying	7, 10, 12	Age 5-12	Mother and self-report	44.49 (985)	16
Social isolation	5, 7, 10, 12	Age 5-12	Mother and teacher	33.67 (700)	17

¹ American Psychiatric Association (1994)

² Buysse, Reynolds, Monk, Berman & Kupfer (1989)

³ Taylor-Piliae, Fair, Haskell, Varady, Iribarren, Hlatky, Go, & Fortmann (2010)

⁴ Diener, Emmon, Larsen & Griffin (1985)

⁵ Meerkerk, Van Den Eijnden, Vermulst & Garretsen (2009)

⁶ Goldman-Mellor et al (2016)

⁷ Caspi, Moffitt, Morgan, Rutter, Taylor, Arseneault Tully, Jacobs, Kim-Cohen & Polo-Tomas (2004)

⁸ Strauss (1990)

⁹ Wechsler (1990)

¹⁰ Hughes, Adlam, Happe, Jackson, Taylor & Caspi (2000)

¹¹ Digman & Shmelyov (1996)

¹² Kovacs (1992)

¹³ March (1997)

¹⁴ Achenbach (1991a)

¹⁵ Jaffee, Caspi, Moffitt, Polo-Tomas & Taylor (2007)

¹⁶ Shakoor, Jaffee, Andreou, Bowes, Ambler, Caspi, Moffitt & Arseneault (2011)

¹⁷ Matthews et al (2015)

psychotherapist for mental health problems in the past year. The physical health and health risk domain comprised measures of body mass index (BMI), C-reactive protein (CRP, a marker of inflammation), sleep quality, day-to-day physical activity and daily smoking. The coping and functioning domain included life satisfaction, coping with stress and technology use. Coping was assessed by asking participants about which strategies they used when experiencing stress in relation to finances, relationships, college or work. Four positively-coded items (“talk with other people about it”, “talk with a therapist or counsellor”, “exercise” and “take steps to solve the problem”) and four negatively-coded items (“withdraw or spend more time alone”, “obsess about problems”, “ignore problems” and “give up”) were combined to create a scale with higher scores reflecting more negative coping strategies.

Participants were asked about their highest qualification level, and those with either no qualifications or GCSE’s at grades D-G were coded as having low qualifications. Those who were neither currently employed nor studying or completed a vocational qualification were coded as not in employment, education or training (NEET). Participants also completed questionnaires about their job search behaviour, attitudes towards work, optimism about opportunities to succeed in their career, and their perceived job preparedness in terms of technical skills (e.g. writing and computer programming) and personal attributes (e.g. communication and teamworking ability).

After the visit, interviewers completed a series of questions about their impressions of the participant. Participants were also asked to nominate two individuals who knew them well to complete informant questionnaires. Questionnaires were completed by 98.0% of the first nominated informants, of whom 99.8% were the participant’s co-twin or other sibling. Questionnaires were completed by 83.5% of the second nominated informants, of whom 98.1% were the participant’s parent. Three items from these questionnaires (“seems lonely”, “feels that no one cares for them” and “has trouble making friends”)

were selected to derive informant ratings of loneliness. Items were coded “No” (0), “A little/somewhat” (1) and “Yes” (2). For each informant, items were summed to create three loneliness scales based on interviewer ($\alpha = 0.70$), sibling ($\alpha = 0.72$) and parent reports ($\alpha = 0.73$). Agreement between informants was modest (r 's = 0.31 – 0.43). To measure informants' perceptions of participants' personality and behaviour, eleven additional items were selected from the informant questionnaires (e.g. “has a good sense of humour”, “gets jealous” and “thinks others are out to get them”). Items were coded “No” (0), “A little/somewhat” (1) and “Yes” (2). To identify latent constructs underlying these items, an exploratory factor analysis using geomin rotation was conducted on the interviewers' responses in Mplus (Muthen & Muthen, 2010). This yielded three factors with eigenvalues greater than 1. A comparison of the factor loadings when extracting two versus three factors suggested that a two-factor structure represented a more parsimonious and conceptually-meaningful model of the data. Based on the pattern of loadings, the factors were named *likeable-prosocial*, and *suspicious-hostile* (interviewer $\alpha = 0.76$, sibling $\alpha = 0.76$, parent $\alpha = 0.81$). Factor loadings are shown in Table 5.2.

Two confirmatory factor analyses were carried out to verify the fit of this factor structure to the responses provided by siblings and parents. The two-factor solution showed adequate fit both to the sibling ratings (RMSEA = 0.05; CFI = 0.96) and the parent ratings (RMSEA = 0.06; CFI = 0.96). Interviewer, sibling and parent scales were subsequently derived for each factor by summing the requisite items. Internal consistency was acceptable for all scales (*likeable-prosocial*: interviewer $\alpha = 0.73$, sibling $\alpha = 0.67$, parent $\alpha = 0.71$; *suspicious-hostile*: interviewer $\alpha = 0.76$, sibling $\alpha = 0.76$, parent $\alpha = 0.81$). There was modest agreement between informants on both scales (*likeable-prosocial* r 's = 0.27 – 0.35; *suspicious-hostile* r 's = 0.32 – 0.46).

Table 5.2: Rotated factor loadings of interviewer ratings

	Factor 1 (Likeable- prosocial)	Factor 2 (Suspicious- hostile)
Has a lot of common sense	0.75	-0.12
Is a leader	0.72	0.14
Shows initiative	0.90	0.00
Has a good sense of humour	0.55	-0.03
Is a good citizen	0.37	-0.40
Has a hot temper, gets angry	0.03	0.67
Thinks others are out to get them	0.06	0.98
Gets jealous	-0.03	0.71
Blames others for their own problems	-0.14	0.72
Is suspicious of other people	-0.03	0.86
Has unreasonable fears or worries	0.02	0.54

Childhood predictors of loneliness

Childhood measures were grouped in five domains: family environment, child characteristics, child mental health, experiences of victimisation and social relationships (Table 5.1). Family environment variables included parental socioeconomic status (SES), maternal warmth, maternal depression, parental antisocial behaviour and exposure to domestic violence. Child characteristics captured gender, IQ, theory of mind, and personality traits such as openness to experience, conscientiousness, extraversion, agreeableness and neuroticism. Child mental health variables were symptom counts of depression, anxiety, ADHD, conduct disorder and substance use (alcohol, tobacco and other drugs). Victimisation comprised measures of child maltreatment and bullying, while social relationships were indexed by social isolation.

Data analysis

Concurrent associations between loneliness and mental health diagnoses, self-harm, suicide attempts and service use in young adulthood were tested using logistic regressions. Associations between loneliness and measures of physical health and health

risks, coping and functioning, employment prospects and informant ratings were tested using linear and logistic regressions.

Longitudinal analyses were conducted using linear regression with age-18 loneliness as the outcome variable. Childhood predictors were entered individually, and the variables that were significantly associated with loneliness were then entered together in blocks by domain (family environment, child characteristics, child mental health, victimisation and social relationships). Significant predictors from each domain were then entered into a final model.

All regression analyses were conducted in Stata 14 (StataCorp, 2015).

5.4 Results

Prevalence of loneliness

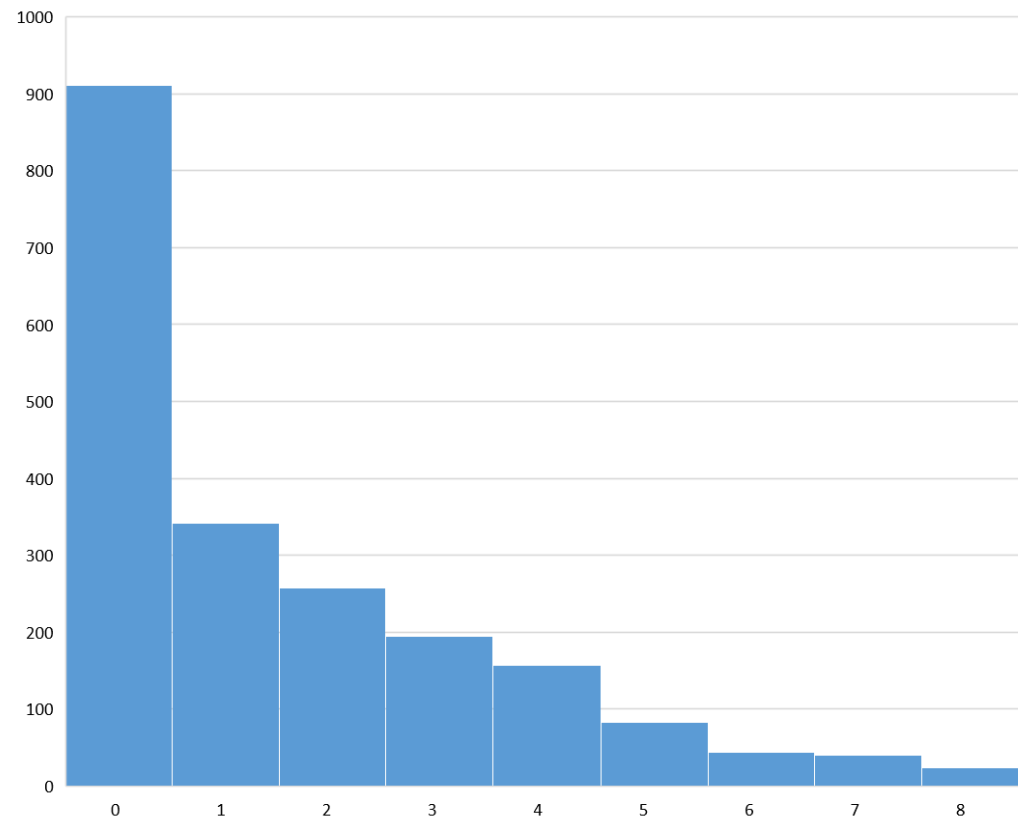
In response to the four items about feelings of loneliness, 23-31% reported experiencing these feelings “some of the time”, and 5-7% reported feeling them “often”. All subsequent analyses were conducted using the summed scale of these items. The distribution of the scores is shown in Figure 5.1.

Adult correlates of loneliness

Lonelier 18 year-olds were more likely to have clinically-significant depression, anxiety, ADHD, conduct disorder, alcohol and cannabis dependence, to have self-harmed, and to have attempted suicide (Table 5.3). Loneliness was most strongly associated with depression, anxiety, self-harm and suicide attempts, the odds of which more than doubled with a one standard deviation increase in loneliness. Lonelier individuals were also more likely to have sought help for mental health problems from a GP, psychiatrist, counsellor or psychotherapist in the past year.

Loneliness was not associated cross-sectionally with indicators of poor health, including BMI or CRP (Table 5.3). However, it was associated with risk indicators for future ill health: lonelier individuals had poorer sleep quality, engaged in less day-to-day physical

Figure 5.1: Histogram of loneliness scores



Mean = 1.57; standard deviation = 1.94

Table 5.3: Characteristics of lonely young adults

	Association with loneliness
<i>Mental health and service use</i>	OR (95% CI)
Depression diagnosis	2.22 (1.98, 2.48)
Anxiety diagnosis	2.45 (2.12, 2.84)
ADHD diagnosis	1.65 (1.45, 1.88)
Conduct disorder diagnosis	1.56 (1.40, 1.74)
Alcohol dependence diagnosis	1.29 (1.15, 1.45)
Cannabis dependence diagnosis	1.71 (1.42, 2.05)
Self-harm	2.22 (1.97, 2.50)
Suicide attempt	2.27 (1.90, 2.72)
Service use	1.88 (1.68, 2.11)
<i>Physical health and health risks</i>	β (95% CI)
BMI	0.02 (-0.03, 0.06)
CRP	-0.04 (-0.08, 0.01)
Sleep quality	0.28 (0.24, 0.33)
Physical activity	-0.11 (-0.15, -0.07)
	OR (95% CI)
Daily smoking	1.23 (1.10, 1.38)
<i>Coping and functioning</i>	β (95% CI)
Life satisfaction	-0.44 (-0.48, -0.39)
Coping with stress	-0.36 (-0.41, -0.32)
Technology use	0.28 (0.22, 0.33)
<i>Employment prospects</i>	OR (95% CI)
NEET	1.38 (1.21, 1.57)
Low qualifications	1.22 (1.09, 1.37)
	β (95% CI)
Job preparedness (skills)	0.00 (-0.45, 0.05)
Job preparedness (attributes)	-0.22 (-0.27, -0.17)
Optimism	-0.29 (-0.35, -0.24)
Attitudes towards work	-0.02 (-0.07, 0.03)
Job search activities	0.03 (-0.01, 0.08)
<i>Interviewer ratings</i>	
Lonely	0.45 (0.40, 0.51)
Likeable-prosocial	-0.17 (-0.21, -0.12)
Suspicious-hostile	0.34 (0.28, 0.39)
<i>Sibling ratings</i>	
Lonely	0.34 (0.28, 0.40)
Likeable-prosocial	-0.10 (-0.15, -0.06)
Suspicious-hostile	0.28 (0.23, 0.33)
<i>Parent ratings</i>	
Lonely	0.34 (0.27, 0.40)
Likeable/prosocial	-0.20 (-0.26, -0.15)
Suspicious/hostile	0.23 (0.17, 0.28)

β = Standardised regression coefficient (interpretable as equivalent to a correlation). OR = Odds Ratio. In logistic regression analyses, loneliness scores were standardised to obtain ORs based on a 1 SD increase in loneliness. CI = Confidence interval. NEET = Not in education, employment or training. All associations adjusted for gender and SES. Note: for sleep quality and coping with stress, higher scores reflect worse sleep and more negative coping strategies, respectively.

activity, and were more likely to be daily smokers. Lonelier young adults had lower overall life satisfaction, reported more compulsive technology use, and used more negative strategies to cope with stress, such as withdrawing and obsessing about problems rather than seeking help or taking pragmatic steps to rectify the situation. Loneliness was unrelated to individuals' attitudes towards work or their efforts to seek employment. Nonetheless, lonelier 18 year-olds were more likely to be out of work and education, and to have no higher qualifications than GCSE's at grades D-G. In terms of job market preparedness, lonelier individuals rated themselves lower in terms of their personal attributes (e.g. teamworking), but not their practical skills (e.g. computer programming). They also reported lower optimism about their ability to succeed in life.

Self-reported loneliness was associated with interviewers', siblings', and parents' ratings of participants' loneliness, indicating that individuals' loneliness is visible to those around them, whether it is someone they know well or someone they have met for the first time. Participants' loneliness was also associated with informants' perceptions of their personality and behaviour: lonelier individuals were rated lower on the likeable-prosocial dimension, and higher on the suspicious-hostile dimension.

Tests of independence

To test the direction of the associations between loneliness and each mental health disorder, each analysis was repeated while controlling for prior symptoms of the disorder in childhood. All associations remained significant (Table 5.4). As a further step, to test the independence of each association, all comorbid mental health problems in young adulthood were controlled for, as well as prior symptoms. Loneliness remained independently associated with depression, anxiety, ADHD, conduct disorder, self-harm and suicide attempts, but not with alcohol or cannabis dependence.

The independence of the associations between loneliness and life satisfaction, coping, technology use, job market preparedness and optimism were tested by controlling for

Table 5.4: Associations between loneliness and mental health problems in young adulthood

		Loneliness		Controlling incrementally for:		
		Diagnosis	No diagnosis	Sex and SES	Prior symptoms	Comorbid mental health problems
	% (N)	M (SD)		OR (95% CI)		
Depression	20.07 (414)	2.95 (2.35)	1.22 (1.65)	2.22 (1.98, 2.48)	2.19 (1.95, 2.46)	1.69 (1.47, 1.94)
Anxiety	7.43 (153)	3.70 (2.42)	1.40 (1.80)	2.45 (2.12, 2.84)	2.48 (2.13, 2.88)	1.89 (1.57, 2.28)
ADHD	7.67 (158)	2.70 (2.30)	1.48 (1.88)	1.65 (1.45, 1.88)	1.61 (1.41, 1.84)	1.31 (1.11, 1.54)
Conduct disorder	15.05 (309)	2.34 (2.24)	1.43 (1.85)	1.56 (1.40, 1.74)	1.53 (1.36, 1.71)	1.23 (1.07, 1.42)
Alcohol dependence	12.75 (263)	2.04 (2.07)	1.50 (1.91)	1.29 (1.15, 1.45)	1.29 (1.15, 1.44)	0.98 (0.84, 1.12)
Cannabis dependence	4.31 (89)	2.81 (2.46)	1.51 (1.90)	1.71 (1.42, 2.05)	1.73 (1.44, 2.08)	1.24 (0.97, 1.59)
Self-harm	13.52 (279)	3.18 (2.27)	1.32 (1.76)	2.22 (1.97, 2.50)	2.19 (1.94, 2.48)	1.60 (1.39, 1.85)
Suicide attempt	3.83 (79)	3.72 (2.48)	1.48 (1.86)	2.27 (1.90, 2.72)	2.20 (1.83, 2.65)	1.37 (1.07, 1.78)

OR = Odds ratio. CI = Confidence interval. Loneliness scores were standardised to obtain ORs based on a 1 SD increase in loneliness. All associations adjusted for gender and SES

mental health problems. All associations remained robust to these controls. Furthermore, the associations between loneliness and lower job market preparedness and optimism were not explained by being NEET.

Childhood predictors of loneliness in young adulthood

Loneliness occurred indiscriminately across SES and gender (Table 5.5). It was not associated with aspects of the early family environment, including maternal warmth, maternal depression, parental antisocial behaviour and domestic violence in the home. However, children who had higher levels of neuroticism, depressive or anxious symptoms, or who experienced bullying or social isolation in childhood were lonelier at age 18. When these predictors were considered together, they all remained independently associated with loneliness, although the effect sizes were small. IQ and theory of mind were associated with loneliness in the univariate analyses, but became non-significant when controlling for covariates. Childhood ADHD, conduct disorder and substance use did not predict loneliness over and above the effects of depression and anxiety. Maltreatment was not associated with loneliness after social isolation and bullying were accounted for.

5.5 Discussion

Principal findings

The findings of this study show that loneliness is a common experience in young people, and plays a pervasive role in their everyday lives. They show that loneliness affects individuals from all socioeconomic backgrounds, and is associated with a broad range of difficulties and health risks. Despite the high comorbidity of the mental health problems under investigation, loneliness was independently associated with each individual disorder, suggesting that loneliness' effect on psychopathology is pleiotropic in nature. Lonelier individuals' global satisfaction with their lives was markedly poorer, and they tended towards more negative ways of coping with stress. Despite being no less

Table 5.5: Childhood predictors of loneliness in young adulthood

	Baseline	Adjusted within domain	Final model
	β (95% CI)		
<i>Family environment</i>			
Low parental SES	0.04 (-0.00 , 0.09)		
Maternal warmth	-0.04 (-0.09 , 0.01)		
Maternal depression	0.05 (-0.00 , 0.10)		
Parental antisocial behaviour	0.01 (-0.04 , 0.06)		
Domestic violence	0.00 (-0.05 , 0.05)		
<i>Child characteristics</i>			
Female gender	0.03 (-0.02 , 0.08)		
IQ	-0.05 (-0.10 , -0.01)	0.00 (-0.06, 0.05)	
Theory of mind	-0.08 (-0.13 , -0.04)	-0.08 (-0.13, -0.03)	-0.02 (-0.07, 0.02)
Openness to experience	0.02 (-0.03 , 0.07)		
Conscientiousness	-0.01 (-0.06, 0.04)		
Extraversion	-0.04 (-0.09, 0.01)		
Agreeableness	-0.03 (-0.09, 0.03)		
Neuroticism	0.13 (0.09, 0.18)	0.13 (0.08, 0.18)	0.07 (0.02, 0.12)
<i>Child mental health</i>			
Depression symptoms	0.24 (0.18, 0.29)	0.19 (0.13, 0.25)	0.16 (0.10, 0.22)
Anxiety symptoms	0.17 (0.13, 0.22)	0.12 (0.07, 0.16)	0.09 (0.04, 0.14)
Substance use	0.03 (-0.01, 0.08)		
ADHD diagnosis	0.06 (0.01, 0.11)	0.03 (-0.02, 0.08)	
Conduct disorder diagnosis	0.08 (0.03, 0.12)	0.03 (-0.02, 0.08)	
<i>Victimisation and social relationships</i>			
Maltreatment	0.05 (0.00, 0.10)	0.01 (-0.04, -.06)	
Bullying	0.15 (0.11, 0.20)	0.12 (0.07, 0.17)	0.08 (0.03, 0.12)
Social isolation	0.15 (0.11, 0.20)	0.12 (0.07, 0.17)	0.08 (0.03, 0.13)

β = Standardised regression coefficient (interpretable as equivalent to a correlation). CI = Confidence interval. For continuous predictors, a median split was taken to obtain mean differences in loneliness.

committed to job-seeking than non-lonely individuals, they were less optimistic about their career prospects. Even though they were no more likely to come from lower-SES families, they had lower qualifications at age 18 and were more likely to be NEET, suggesting that loneliness could be a force for downward social mobility. The informant ratings show that loneliness, although a private and intimate feeling, can be detected by others. However, they also indicate that lonely individuals can make a more negative impression on people: they are perceived as less good-humoured and likeable, and more suspicious, blaming, jealous and hostile. The longitudinal findings indicate that individuals who have experienced mental health difficulties, bullying or social isolation in childhood are at increased risk for experiencing loneliness in young adulthood.

Strengths and weaknesses

The E-Risk study has many strengths. As a large, nationally-representative cohort, the study sample captures the full range of young people's living circumstances in the UK. The longitudinal design and high retention permits the investigation of a wide range of early risk factors for loneliness in young adulthood. However, this study also has limitations. First, as loneliness was measured only at one time point, the directionality of the associations could not be tested. The associations with mental health were not explained by pre-existing symptoms in childhood, which helps to address the possibility of reverse causality; nonetheless, further longitudinal research is needed to advance causal hypotheses. Second, and for the same reason, it was not possible to investigate the stability of loneliness from childhood to adulthood. Different trajectories of loneliness during childhood and adolescence may predict different outcomes (Qualter, Brown, Rotenberg, Vanhalst, Harris, Goossens, Bangee & Munn, 2013). Third, because the sample consisted of twins, all participants had at least one sibling, which could mean that the effects of loneliness are underestimated. Nonetheless, the prevalence of loneliness in

this sample is similar to that found in other studies of young people in the UK (Mental Health Foundation, 2010; Victor & Yang, 2012).

Comparison to other studies

First, this study builds upon previous findings which show that loneliness is a risk factor for depression (Cacioppo et al, 2010; Cacioppo, Hughes et al, 2006; Vanhalst, Luyckx et al, 2012). With regards to physical health, the long-term outcomes of loneliness may not present until later in adulthood, and this could explain why no differences were found in BMI in this young sample, whereas such an association has been found in other samples of adults (Lauder, Mummary, Jones & Caperchione, 2006). The null association with CRP is consistent with other studies, and it possible that more objective social isolation, rather than feeling lonely, is more strongly associated with inflammation (Danese et al, 2009; Lacey, Kumari & Bartley, 2014; Shankar et al, 2011). However, the association between loneliness and poor sleep quality is well-replicated finding, and is hypothesised to be one of the pathways through which loneliness compromises physical health (Cacioppo, Hawkley, Crawford et al, 2002; Hawkley, Preacher & Cacioppo, 2010; Kurina et al, 2011). Third, the informant ratings of loneliness complement a recent study which showed that parent, friend and partner ratings correlate well with self-reports of loneliness (Luhmann et al, 2016). The present study extends these findings by showing that individuals' loneliness can be perceptible even to someone who has met them for the first time. Furthermore, informants' perceptions of lonelier individuals as less likeable is consistent with previous findings that lonely people are perceived more negatively by others (Rotenberg & Kmill, 1992). The finding that lonelier individuals were perceived to be more suspicious and hostile is also in line with the conceptualisation of loneliness as an unsafe feeling, which predisposes individuals to perceive others as potential threats and behave accordingly in their social interactions (Cacioppo & Hawkley, 2009).

Explanations and implications

Loneliness is an important determinant of long-term health and functioning, and is particularly common among young people in the UK. To reduce the public health burden of loneliness in later life, the experience of loneliness in this age group merits particular consideration. The findings of this study show that loneliness is not only aversive in its own right, but intrudes into many domains of functioning, with potentially broad implications for future health and well-being. For example, it appears to hold young people back in their educational and career attainment. Lonely individuals are characterised by shyness and lower self-esteem (Cacioppo, Hawkley et al, 2006), and these traits may undermine their confidence in their ability to compete in the labour market. Low income and unemployment may, in turn, be a contributing factor to feelings of loneliness (Lauder, Mummery & Sharkey, 2006). Use of technology such as email and social media among lonely individuals could provide opportunities to form and reinforce supportive social connections with others (Shaw & Gant, 2002; Valkenburg & Peter, 2007). However, excessive or compulsive use of electronic devices may constitute an additional risk for disrupted sleep patterns (Hysing, Pallesen, Stormark, Jakobsen, Lundervold & Sivertsen, 2015). The informant ratings indicate that lonely individuals' self-protective behaviours may have the unintended consequence of negatively biasing others' views towards them. This has important implications, as it has the potential to further alienate them from potential friends and thus the opportunity to escape loneliness. The longitudinal findings indicate that loneliness can affect individuals from a diverse range of backgrounds: it occurs across all socioeconomic strata, is evenly distributed across genders, and is unrelated to cognitive ability. However, the findings also indicate that young adults' propensity to feel lonely can be shaped by adversities earlier in life. Experiences in the family environment, though important for other emotional and behavioural outcomes (Caspi et al, 2004; Jaffee, Moffitt, Caspi, Taylor & Arseneault,

2002), do not appear to be associated specifically with loneliness. Instead, early risk factors for loneliness lie with children's own emotional health and peer experiences.

5.6 Conclusion

The long-term health outcomes of chronic loneliness attest to the importance of intervening early to prevent loneliness persisting across time. However, simply increasing individuals' amount of contact with others is unlikely to be sufficient, for two reasons. Firstly, loneliness is more related to the perceived quality rather than quantity of social contact (Pinquart & Sorensen, 2001), and therefore it can be experienced even in the company of others. Secondly, if loneliness shapes individuals' social interactions in ways that evoke negative perceptions from others, opportunities to form rewarding social connections may be thwarted. A meta-analysis of interventions to reduce loneliness indicates that the most successful strategies involve addressing destructive patterns of cognition and behaviour in a counselling or psychotherapeutic setting (Masi et al, 2011). Further research is warranted to determine the potential efficacy of such interventions in reducing loneliness. With regard to prevention, the findings of our study suggest that strategies to prevent the emergence of loneliness in young people should devote particular attention to children who experience problems of an internalising nature, or who are bullied or isolated by their peers.

Chapter 6: Sleeping with one eye open: loneliness and sleep quality in young adults

6.1 Abstract

Objective: Feelings of loneliness are common among young adults, and are hypothesised to impair the quality of sleep. In the present study, we tested associations between loneliness and sleep quality in a nationally-representative sample of young adults. Further, based on the hypothesis that sleep problems in lonely individuals are driven by increased vigilance for threat, we tested whether past exposure to violence exacerbated this association. **Method:** Data were drawn from the Environmental Risk (E-Risk) Longitudinal Twin Study, a birth cohort of 2,232 twins born in England and Wales in 1994 and 1995. We measured loneliness using items from the UCLA Loneliness Scale, and sleep quality using the Pittsburgh Sleep Quality Index. We controlled for covariates including social isolation, psychopathology, employment status and being a parent. We examined twin differences to control for unmeasured genetic and family environment factors. **Results:** Feelings of loneliness were associated with poorer sleep quality and daytime dysfunction. These associations were robust to controls for covariates. Among monozygotic twins, within-pair differences in loneliness were significantly associated with within-pair differences in sleep quality, indicating an association independent of unmeasured familial influences. The association between loneliness and sleep quality was exacerbated among individuals exposed to violence victimisation in adolescence or maltreatment in childhood. **Conclusion:** Loneliness is robustly associated with poorer sleep quality in young people, underscoring the importance of early interventions to mitigate the long-term outcomes of loneliness. Special care should be directed towards individuals who have experienced victimisation.

Chapter adapted from: Matthews, T., Danese, A., Gregory, A. M., Caspi, A., Moffitt, T. E., & Arseneault, L. (under review). Sleeping with one eye open: Loneliness and sleep quality in young adults. *Psychological Medicine*.

6.2 Introduction

Loneliness is defined as a distressing feeling that is experienced when social connections are perceived to be inadequate (Peplau & Perlman, 1982). An evolutionary account of loneliness proposes that for members of a social species, being embedded within a group provides safety, and the perception of being socially cut off gives rise to feelings of vulnerability (Cacioppo, Hawkley et al, 2006). This triggers changes in cognition and behaviour that serve to guard the individual against potential threats (Cacioppo & Hawkley, 2009). One hypothesis implied by this model is that feelings of loneliness are associated with impaired sleep quality: as sleep is a state in which it is impossible to remain vigilant, the unsafe feeling of loneliness is at odds with restful sleep. Research has shown that lonely individuals report poorer subjective sleep quality and experience more fragmented sleep, as measured via actigraphy, while their total duration of sleep is unaffected (Cacioppo, Hawkley, Berntson et al, 2002; Hawkley, Preacher & Cacioppo 2010; Kurina et al, 2011; Pressman et al, 2005). Thus, while lonely individuals do not appear to sleep more or less than non-lonely individuals, their sleep may be less restful, consistent with the hypothesis that raised vigilance for threat intrudes on the sleep state. In the present study, we investigated associations between loneliness and sleep quality in a nationally-representative cohort of young adults. This age group is of particular interest for two reasons. First, loneliness is especially prevalent at this stage of life, concomitant with shifts in young adults' social needs and environments (Office for National Statistics, 2014; Qualter et al, 2015). Second, a significant proportion of individuals experience loneliness persistently over time (Newall, Chipperfield & Bailis, 2013), and chronic social disconnection predicts poor health outcomes in a dose-response manner (Caspi et al, 2006; Danese et al, 2009). Therefore, individuals who become lonely early in life may be particularly at risk for ill health in the future. Prior studies which have found associations between loneliness and sleep in this age group have used opportunity

samples of university undergraduates (Cacioppo, Hawkley, Berntson et al, 2002; Pressman et al, 2005); however, it is important to ascertain whether the profile of sleep impairments generalises across the full range of socioeconomic and occupational circumstances in the young population.

Research has shown that the associations between loneliness and sleep problems are not accounted for by plausible confounders such as depression, body mass index or health-related behaviours (Cacioppo, Hawkley, Berntson et al, 2002; Hawkley, Preacher & Cacioppo, 2010; Kurina et al, 2011). However, sleep impairments are included among the diagnostic criteria for a number of mental health disorders, including generalised anxiety and post-traumatic stress disorder (American Psychiatric Association, 1994), underscoring the need to control comprehensively for symptoms of psychopathology in order to test the independence of the association between loneliness and sleep. Other sources of confounding are more difficult to control for, including genetic influences. There is evidence for substantial heritability of both loneliness (Goossens et al, 2015; Matthews et al, 2016) and sleep quality (Barclay et al, 2010), and their association may be partly explained by shared genetic aetiologies. Furthermore, unmeasured factors in the family environment, such as parental influences or life events, may also contribute jointly to the experiences of loneliness and sleep quality. One approach by which these confounds can be controlled is by comparing individuals from the same family, using a design such as monozygotic (MZ) twin differences (Vitaro et al, 2009). As members of an MZ twin pair share identical genomes and grow up in the same family home, any differences within pairs is attributable to experiences unique to individuals. Measuring MZ twin differences on two traits allows their association to be tested while holding family-wide influences constant.

Not all lonely individuals necessarily experience sleep problems, and it is possible that other factors play a role in exacerbating their susceptibility to sleep impairments. Given

that one of the posited reasons for the restless sleep of lonely individuals is a perception of threat in the environment, past exposure to actual threats may intensify this perception and further compromise the restfulness of sleep. Exposure to violence victimisation is one plausible candidate. Imaging studies have shown that childhood maltreatment is associated with increased amygdala activation in response to threatening social stimuli, suggesting heightened vigilance for threat (McCrory, De Brito, Sebastian, Mechelli, Bird, Kelly & Viding, 2011). This lends itself to the possibility that perceptions of threats triggered by loneliness may be particularly pronounced among individuals with a history of violence victimisation, magnifying the disruption of sleep. Using longitudinal data, we tested for an exacerbating influence of violence victimisation on the relationship between loneliness and sleep. Specifically, we examined recent victimisation experiences in adolescence, and tested whether the effect could be extended earlier in life with childhood maltreatment.

6.3 Method

Participants

Participants were members of the Environmental Risk (E-Risk) Longitudinal Twin study, described in Chapter 2.

Measures

Loneliness

We measured current feelings of loneliness at age 18 using four items from the UCLA Loneliness Scale, Version 3 (Russell, 1996). This measure is described in Chapter 2.

In addition to self-reported loneliness, we also assessed loneliness using interviewers' reports. After the home visit assessments, the study interviewers (N = 14) completed an inventory of questions about their overall impressions of the participants' personality and behaviour, based on their observations during the structured interview. Interviewers were trained to familiarise themselves with the questions in order to know what to observe, and

took comprehensive notes on which to base their responses. The questions were completed immediately after the home visit in order to maximise recall. The interviewers had not met the participants prior to the visit. We used three of the items to construct a measure of interviewer-rated loneliness: “seems lonely”, “feels that no one cares for them” and “has trouble making friends”. Items were coded “no” (0), “a little/somewhat” (1) and “yes” (2). As the self-report loneliness measure was administered via computer, interviewers were blind to participants’ responses. We summed the three items to create a scale (Cronbach $\alpha = 0.70$). The correlation between the self-report and interviewer ratings of loneliness was 0.46.

Sleep quality

We measured sleep quality at age 18 using the Pittsburgh Sleep Quality Index (PSQI; Buysse et al, 1989). The PSQI consists of 18 self-report items relating to individuals’ sleep patterns and different forms of sleep impairment in the past month. These questions can be used to derive scores for seven different *components* of sleep (subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication and daytime dysfunction), each scored 0-3, which were summed to produce a *global* score ranging from 0-21, with higher scores reflecting worse sleep quality. The mean global PSQI score in the present sample was 5.39 (SD = 3.18).

Covariates

To test the independence of the association between loneliness and sleep quality at age 18, we controlled for social isolation, based on the hypothesis that the subjective experience of loneliness would be associated with sleep quality over and above individuals’ actual degree of social connection. We further controlled for symptoms of depression, anxiety, alcohol abuse and dependence, attention-deficit/hyperactivity disorder (ADHD) and post-traumatic stress disorder (PTSD). We also controlled for individuals who were not in employment, education or training (NEET) or who were a

parent of an infant, two circumstances which could lead to changes in social activities and sleeping schedules. Full details of covariates are presented in Table 6.1.

Violence victimisation

We assessed violence victimisation between ages 12 and 18 using the Juvenile Victimization Questionnaire (JVQ; Finkelhor, Hamby, Turner & Ormrod, 2011). The JVQ contains questions covering seven forms of victimisation: crime, peer/sibling, internet, sexual, family, maltreatment and neglect. We asked participants to answer ‘yes’ or ‘no’ to each item, and when an instance of victimisation was reported, further notes were taken about the details of the incident. Information from the JVQ was used to compile victimisation ‘dossiers’ of each participant, which were coded for severity by 4 raters (Fisher, Caspi, Moffitt, Gray, Newbury, Ambler, Zavos, Danese, Mill, Odgers, Pariante, Wong & Arseneault, 2015). Overall severity of violence victimisation was grouped into three categories: no exposure (47.6%), some exposure (28.1%) and severe exposure (24.3%).

We assessed exposure to maltreatment in childhood when participants were aged 5, 7, 10 and 12, via interviews with participants’ mothers. At age 5, assessments were based on the standardised clinical protocol from the MultiSite Child Development Project (Dodge et al, 1990; Lansford et al, 2002). At ages 7, 10, and 12 this interview was modified to expand its coverage of contexts for child harm. Interviews were designed to enhance mothers’ comfort with reporting valid child maltreatment information, while also meeting researchers’ responsibilities for referral under the UK Children Act. We asked mothers whether either of their twins had been intentionally harmed (physically or sexually) by an adult or had contact with welfare agencies. Information on maltreatment collected over the years of data collection was compiled into a profile for each participant. These profiles were reviewed by two clinical psychologists and coded no harm (78.9%), probable harm (15.4%) and definite harm (5.7%).

Table 6.1: Descriptive statistics of covariates

	Measure	Range	Mean (SD) or %	Reference
Social isolation	Multidimensional Scale of Perceived Social Support. Items reverse-scored with higher scores reflecting greater isolation.	0-24	3.29 (4.35)	Zimet et al (1998)
Psychopathology	Diagnostic Interview Schedule for DSM-IV Depression, anxiety, alcohol use and ADHD are measured as symptom scales; PTSD is a diagnosis.	Depression: 0-9 Anxiety: 0-6 Alcohol use: 0-11 ADHD: 0-18 PTSD: 0-1	1.81 (2.97) 0.95 (1.82) 1.13 (1.67) 5.79 (4.29) 3.49%	Robins et al (1995); American Psychiatric Association (1994)
NEET	Participants were categorised as NEET if they reported that they were not studying, working or undertaking vocational training at the time of the interview.	-	11.57%	Goldman-Mellor et al (2016)
Being a parent	Based on participants reporting either having given birth to or fathered a child.	-	2.03%	-

Data Analysis

We used linear regressions to examine the associations between loneliness and overall sleep quality. To test for a specific profile of sleep complaints associated with loneliness, we conducted ordinal logistic regressions using each of the 7 components of the PSQI. We verified the robustness of these associations first by controlling individually for each covariate (social isolation, depression, anxiety, alcohol use, ADHD, PTSD, NEET and being a parent), and finally by entering all covariates simultaneously in the model. As both loneliness and sleep quality were measured via self-report, we conducted a sensitivity analysis by testing the association between interviewer ratings of participants' loneliness and self-reported sleep quality.

We controlled further for genetic and shared family factors using twin differences. MZ twin differences are attributable only to experiences unique to individuals, as the influence of genes and experiences within the family are held constant. Thus, if associations between loneliness and sleep quality are environmentally-mediated, MZ twins who are lonelier than their co-twins would also have more sleep difficulties. To test this, we regressed the within-twin pair differences for sleep quality on the within-twin pair differences for loneliness. We conducted this analysis first on the whole sample, which controlled completely for the shared environment. We then repeated the analysis using MZ twins (N = 560 pairs), to control for both genetic and family environmental confounds.

We tested for an exacerbating effect of violence victimisation on the association between loneliness and sleep quality using linear regression. In each analysis, we regressed sleep quality on loneliness, victimisation and an interaction term (loneliness $\times$ victimisation). We carried out this analysis firstly using adolescent victimisation (age 12-18) as the moderator, and secondly using childhood maltreatment (birth to age 12). As a further step, we repeated these analyses while controlling separately for covariates.

All analyses were conducted in Stata 14 (StataCorp, 2015). Participants in this study were pairs of same-sex twins, and therefore each family contained data for two individuals, resulting in nonindependent observations. To correct for this, we used tests based on the Huber-White or sandwich variance (Williams, 2000), which adjusts the estimated standard errors to account for the dependence in the data.

6.4 Results

Associations between loneliness and sleep quality

Individuals who were lonelier reported worse overall sleep quality ($\beta = 0.28$, 95% CI = 0.24 – 0.33; Table 6.2). Social isolation, depression, anxiety, alcohol use, ADHD, PTSD, NEET and being a parent were all associated with sleep quality over and above loneliness. However, none of these individual covariates explained the association between loneliness and sleep quality. When all covariates were entered simultaneously, this association reduced but remained significant ($\beta = 0.07$, 95% CI = 0.02 – 0.12).

Sensitivity analyses indicated that interviewer-rated loneliness was significantly associated with self-reported sleep quality, with a similar effect size to that of self-reported loneliness ($\beta = 0.23$, 95% CI = 0.17 – 0.28). This association remained significant when controlling for each covariate. Entering social isolation into the model led to greater attenuation of the regression coefficient for interviewer-rated loneliness (43%) compared to that of self-reported loneliness (21%). Nonetheless, social isolation failed to fully account for the association.

Loneliness was significantly associated with each of the 7 components of the PSQI (Table 6.3). However, after controlling for all covariates, loneliness remained independently associated specifically with poorer subjective sleep quality (OR = 1.10, 95% CI = 1.03 – 1.16) and greater daytime dysfunction (OR = 1.24, 95% CI = 1.17 – 1.31).

Table 6.2: Associations between loneliness and poor sleep quality in young adulthood, controlling for covariates.

	β (95% CI)								
	Baseline	Controlling for:							
		Social isolation	Depression	Anxiety	Alcohol use	ADHD	PTSD	NEET	Being a parent
Loneliness	0.28 (0.24, 0.33)	0.22 (0.17, 0.27)	0.16 (0.12, 0.21)	0.22 (0.17, 0.26)	0.26 (0.22, 0.31)	0.22 (0.17, 0.26)	0.25 (0.20, 0.29)	0.28 (0.23, 0.32)	0.28 (0.23, 0.33)
Covariate	-	0.15 (0.09, 0.20)	0.30 (0.25, 0.35)	0.19 (0.14, 0.24)	0.20 (0.15, 0.25)	0.23 (0.19, 0.28)	0.16 (0.11, 0.21)	0.07 (0.01, 0.12)	0.05 (0.00, 0.09)

β = Standardised regression coefficient, CI = confidence interval, ADHD = attention deficit/hyperactivity disorder, NEET = Not in employment, education or training

All analyses adjusted for gender and SES

Table 6.3: Associations between loneliness and components of sleep quality in young adulthood

Component	OR (95% CI)	
	Unadjusted ¹	Adjusted ²
Subjective sleep quality	1.26 (1.20, 1.32)	1.10 (1.03, 1.16)
Sleep latency	1.19 (1.14, 1.25)	1.04 (0.99, 1.10)
Sleep duration	1.15 (1.10, 1.21)	1.03 (0.97, 1.10)
Habitual sleep efficiency	1.06 (1.01, 1.11)	0.96 (0.90, 1.01)
Sleep disturbances	1.20 (1.14, 1.27)	1.03 (0.97, 1.10)
Use of sleep medication	1.28 (1.15, 1.42)	0.96 (0.84, 1.10)
Daytime dysfunction	1.43 (1.36, 1.51)	1.24 (1.17, 1.31)

¹ Adjusted for gender and SES

² Adjusted for social isolation, depression, anxiety, alcohol use, ADHD, NEET, being a parent, gender and SES

OR = odds ratio, CI = confidence interval

Significant associations in bold.

Environmental association between loneliness and sleep quality

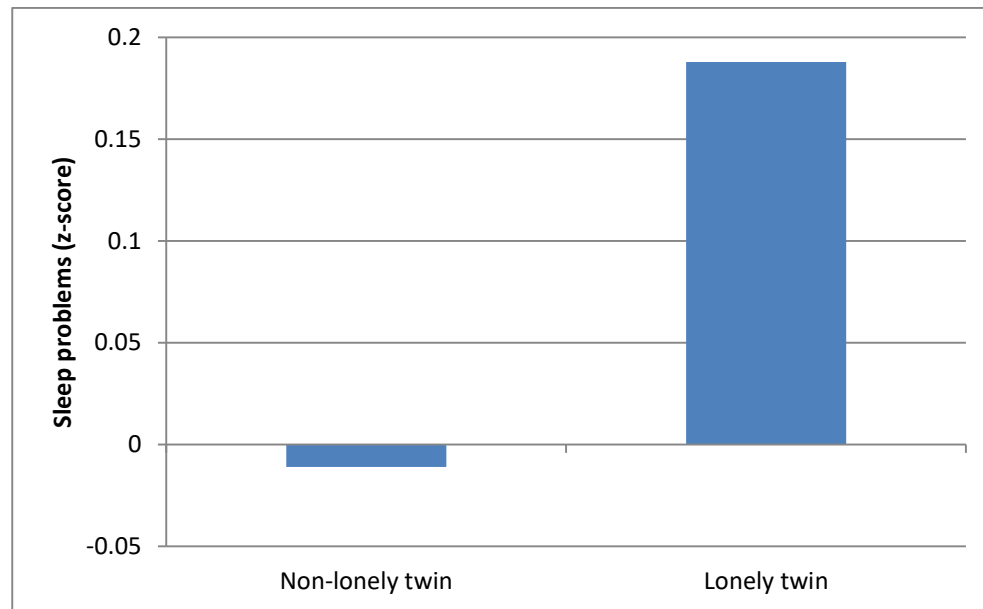
In the full sample (MZ and DZ twins), within-twin pair differences in loneliness were associated with within-pair differences in sleep quality ($\beta = 0.20$, 95% CI = 0.14 – 0.27), indicating that the association between these experiences is independent of unmeasured influences from the family environment. Among MZ twins, within-pair differences in loneliness remained significantly associated with within-pair differences in sleep quality ($\beta = 0.15$, 95% CI = 0.06 – 0.24). As shown in Figure 6.1, among a subset of MZ pairs who were discordant for loneliness, the lonelier twins experienced poorer sleep quality than their non-lonely co-twins (Cohen's $d = 0.20$). This indicates an environmentally-mediated association between loneliness and sleep which is independent of unmeasured genetic and family factors.

Exacerbating effects of violence victimisation on the association between loneliness and sleep quality

Individuals exposed to victimisation during adolescence experienced both greater loneliness ($\beta = 0.18$, 95% CI = 0.13 – 0.23) and worse sleep quality ($\beta = 0.24$, 95% CI = 0.19 – 0.28) in early adulthood. Violence victimisation moderated the association between loneliness and sleep quality, such that this association was stronger among those exposed to more severe victimisation (interaction term: $\beta = 0.06$, 95% CI = 0.02 – 0.10; Figure 6.2). When controlling separately for depression and PTSD, the interaction term became non-significant, suggesting that symptoms of psychopathology may be a pathway through which adolescent victimisation moderates the association between loneliness and sleep quality.

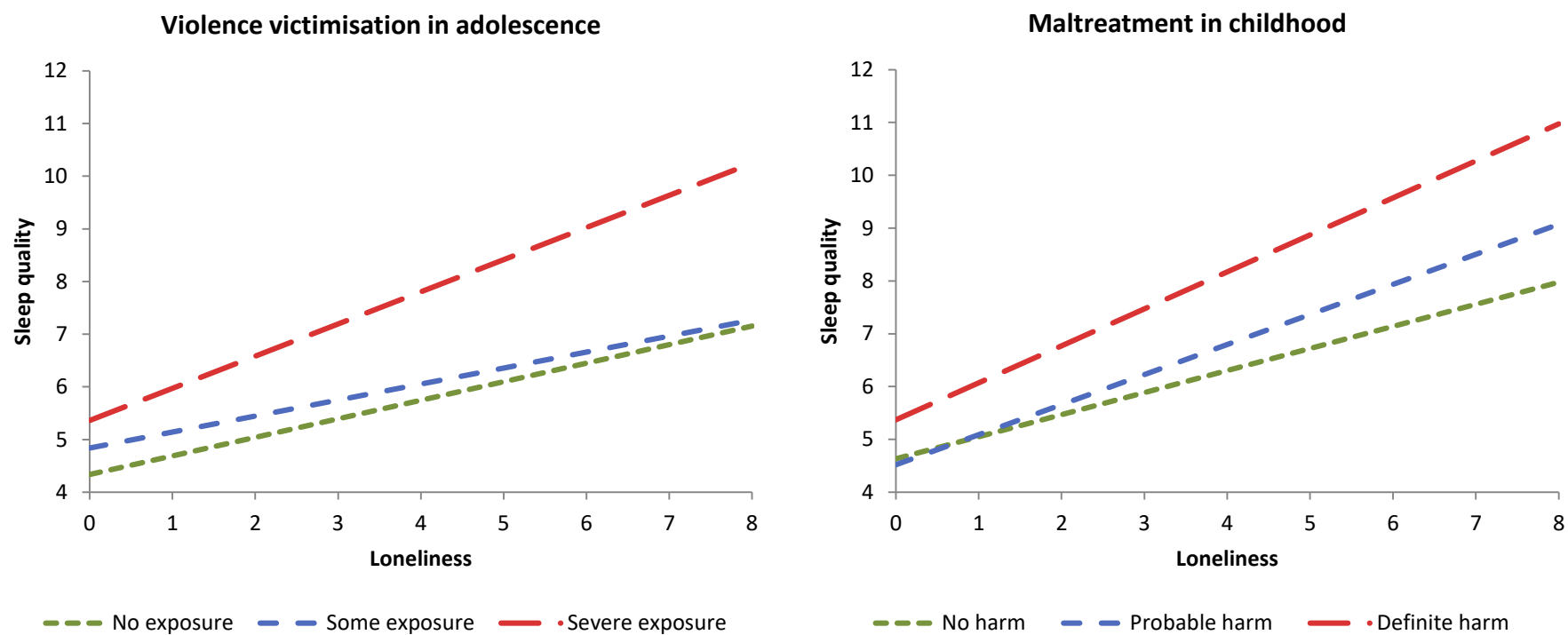
When looking at the effect of victimisation in childhood, individuals who experienced definite harm were lonelier ($\beta = 0.07$, 95% CI = 0.02 – 0.12) and had poorer sleep quality ($\beta = 0.10$, 95% CI = 0.05 – 0.16) in early adulthood. Childhood maltreatment showed a similar moderating effect to that of adolescent victimisation; the association between

Figure 6.1: Mean (z-scored) sleep quality among 193 monozygotic twin pairs discordant for loneliness.



Lonely and non-lonely groups were defined by taking a median split of the total loneliness score. Higher sleep quality scores reflect poorer quality sleep.

Figure 6.2: Exacerbating effect of violence victimisation on the association between loneliness and sleep quality in young adulthood.



Higher scores on the Y axis reflect poorer sleep quality.

loneliness and sleep was exacerbated among those exposed to maltreatment (interaction term: $\beta = 0.05$, 95% CI = 0.01 – 0.09; Figure 6.2). This effect was not explained by controls for covariates.

Sex differences

Loneliness did not differ by sex. Females had on average poorer sleep quality than males ($M = 5.69$ versus 5.07 respectively; $p < 0.001$). No sex differences were detected in the associations between loneliness and sleep quality.

6.5 Discussion

In line with previous studies (Cacioppo, Hawkley, Berntson et al, 2002; Hawkley, Preacher & Cacioppo 2010; Kurina et al, 2011), we showed a modest but robust association between loneliness and poorer sleep quality in a nationally-representative cohort of young adults. We furthered this evidence by showing that the association was attributable to individuals' unique experience of loneliness; it was not explained by loneliness and sleep quality having common genetic origins or by confounding influences from the environments shared by twins. Further, the strength of this association in young adulthood was moderated by exposure to violence during childhood and adolescence. In the case of more recent exposure in adolescence, symptoms of depression or PTSD may be pathways through which victimisation exerts this exacerbating effect.

Although the associations between loneliness and sleep quality were small, they emerged from a thorough and stringent test for an independent association, controlling for many other factors which may explain their co-occurrence. In particular, the MZ twin differences method is a robust test which controls comprehensively for unobserved sources of variation within families and other environments shared by siblings. Furthermore, loneliness is often accompanied by depressive symptoms (Cacioppo, Hughes et al, 2006; Matthews et al, 2016), which in turn has its own negative effects on sleep. Of all the covariates investigated, depression was the most strongly associated with

sleep problems; a finding that is not unexpected given that changes in sleep are included among the diagnostic criteria for major depression (American Psychiatric Association, 1994). However, the association between loneliness and sleep problems was independent of the contribution of depression.

Impoverished social connections increase the risk of numerous negative health outcomes, including elevated blood pressure (Hawkey, Thisted et al, 2010), impaired immune functioning (Pressman et al, 2005), obesity (Lauder, Mummery, Jones & Caperchione, 2006) and mortality (Holt-Lunstad et al, 2015). Deficiencies in the quantity and quality of sleep are predictive of similar health problems (Capuccio et al, 2010; Gangwisch et al, 2006; Irwin, 2002; Patel & Hu, 2008). Markers of long-term health outcomes are unlikely to be detectable at the young age of the present cohort. Nonetheless, our findings indicate that a relationship between loneliness and reduced sleep quality is already present in young adulthood. Longitudinal research is necessary to test whether the foreshortened lifespan observed in chronically lonely individuals is explained, in part, by the effects of diminished sleep quality. Furthermore, while young adulthood is an important period for the formation of social relationships, loneliness could also have roots in early attachment difficulties; therefore, a further goal for future research should be to investigate the potential role of attachment styles in explaining or modifying the relationship between loneliness and sleep.

We identified a subgroup of lonely individuals exposed to violence victimisation who were particularly vulnerable to experiencing poorer sleep quality. Loneliness is associated with changes in cognition that include raised vigilance for threats in the environment (Cacioppo & Hawkey, 2009). Past exposure to actual threats such as victimisation may establish a pre-existing vulnerability for loneliness to act upon, by reinforcing perceptions of others' intent to harm. To the extent that vigilance for threats undermines the restfulness of sleep, this may account for the exacerbating effect of violence victimisation

that we detected. It should be noted, however, that there could be other psychological processes that mediate the relationship between loneliness and sleep problems, such as rumination. Further investigation is warranted to investigate the range of pathways through which loneliness may intrude on sleep.

Some physiological processes may also explain the association between loneliness and sleep quality. A first possible candidate is the stress response. Loneliness is associated with changes in circulating cortisol, indicating elevated hypothalamic-pituitary-adrenal axis activation (Doane & Adam, 2010; Pressman et al, 2005). Physiological arousal resulting from this process may play a role in the disrupted sleep of lonely individuals. Second, when looking at individual items, lonely individuals reported 2 out of 10 specific sources of sleep disturbance: feeling too cold, and having bad dreams. Whilst this finding should be interpreted with caution, it suggests potential avenues of further investigation. For instance, experimental research has found an association between social exclusion and reductions in perceived ambient temperature (Zhong & Leonardelli, 2008). Further, dream disturbances are associated with greater stress and anxiety (Levin & Nielsen, 2007), and may represent a further manifestation of emotional distress in lonely individuals.

Our study has some limitations. Loneliness and sleep quality were measured cross-sectionally, and no conclusions can be drawn about the directionality of the associations. Daytime dysfunction may, for example, contribute to stability or increases in loneliness by hindering social interactions. However, prior longitudinal findings indicate that loneliness more strongly predicts subsequent sleep quality, rather than vice-versa (Hawkey, Preacher & Cacioppo, 2010). Secondly, by virtue of the twin design, all participants had at least one sibling, which should reduce loneliness on average. Twins are same-age siblings who may feel closer than typical siblings. If this is true, then rates of loneliness and effects of loneliness may be underestimated in our sample.

A third limitation is that both loneliness and sleep quality were measured via self-report. However, further analyses showed that the associations between loneliness and sleep quality were replicated when interviewers' ratings were substituted for self-reported loneliness. Interestingly, controlling for social isolation led to greater attenuation of the association between loneliness and sleep quality when loneliness was measured via interviewer report. A potential explanation for this is that independent observers are more likely to conflate social isolation and loneliness in others, in which case using self-reports is a strength, rather than a weakness, when assessing loneliness. It remains possible, however, that self-reports of sleep quality may be vulnerable to reporting bias. Polysomnography and actigraphy measure aspects of sleep more objectively but are less practical to implement in large cohort studies involving comprehensive interview assessments. Nonetheless, the PSQI is a well-validated and widely-used instrument, and is correlated with other measurement approaches such as sleep diaries (Backhaus et al, 2002; Buysse et al, 1989). Different methods each provide unique information about sleep, and there is value in using a variety of approaches to build a thorough profile of sleep impairments (Gregory & Sadeh, 2016). Our findings complement those of studies using objective measures (Cacioppo, Hawkley, Berntson et al, 2002; Kurina et al, 2011), showing that lonely individuals experience more fragmented sleep.

6.6 Conclusion

Diminished sleep quality is one of the many ways in which loneliness gets 'under the skin', and our findings underscore the importance of early intervention to reduce loneliness in young people, which may be the starting point for a cascade of physical health problems in later life. Studies of interventions to reduce loneliness suggest that resolving negative social cognitions that can damage social interactions is an expedient strategy (Masi et al, 2011). Further, our findings suggest that interventions should consider not only individuals' current social circumstances, but also influences of past

experiences including violence victimisation, which may constitute a pre-existing vulnerability that exacerbates the effects of loneliness. Future research should explore in more detail loneliness' relationship with victimisation and other forms of trauma.

Chapter 7: Discussion

Poverty of social connection is contrary to the fundamentally social nature of human beings, and can have significant implications for psychological and physical health (Baumeister & Leary, 1995). The research presented in this thesis focused on the experiences of social isolation and loneliness, two related but distinct conditions characterised by shortcomings in social relationships. Though often assumed to be afflictions of old age, problems associated with social relationships are particularly common among younger people (Mental Health Foundation, 2010; Victor & Yang, 2012). Therefore, the overarching aim of this thesis was to investigate the significance of social isolation and loneliness among young people, how they emerge and how they relate to health and functioning. The following chapter discusses the overall findings, the strengths and limitations of the methods, and implications for future research and clinical practice.

7.1 Loneliness versus social isolation as risk factors for mental health

The modest correlation between these two constructs confirms that not all isolated people are lonely, nor are all lonely people necessarily isolated (Chapter 4). Furthermore, the findings suggest that social isolation itself does not confer much risk for the development of mental health problems, whereas loneliness is more robustly associated with mental health. This is demonstrated in two ways:

Firstly, we showed that the longitudinal association from social isolation at age 5 to depression at age 12 was accounted for by pre-existing mental health difficulties (Chapter 3). Notably, the association became non-significant only after controlling for behavioural problems as well as emotional problems at baseline. Externalising problems in childhood are a risk factor for later internalising problems, an association partly mediated by overlapping genetic influences (Wertz et al, 2014). This is an example of heterotypic

continuity, whereby one psychological disorder predicts the development of a different disorder (Lahey, Zald, Hakes, Krueger & Rathouz, 2014).

Secondly, although social isolation and loneliness were associated with depression, the investigation of their independent effects in multivariate analyses showed that loneliness remained a strong correlate of depression, while the association between social isolation and depression was substantially diminished (Chapter 4). These findings are in line with prior research showing a strong association between loneliness and depression (Cacioppo, Hawkley et al, 2006; Cacioppo et al, 2010; Vanhalst, Klimstra et al, 2012; Vanhalst, Luyckx et al, 2012). Together, the findings are consistent with the hypothesis that isolated individuals are only at risk for mental health difficulties to the extent that they feel lonely. There is evidence, for example, that children who are isolated overall but have at least one friend are buffered against later internalising and externalising problems (Laursen et al, 2007). The companionship provided by a friend may have a protective effect on mental health by reducing feelings of loneliness.

This does not mean, however, that social isolation is inconsequential for children's development. Other research indicates that problems with peer relationships predict a number of outcomes other than mental health, such as academic difficulties, dropping out of school, engaging in criminal behaviour and unemployment (Parker & Asher, 1987; Woodward & Fergusson, 2000). Social isolation in childhood, particularly if experienced chronically, is a risk factor for later ill health (Caspi et al, 2006; Danese et al, 2009). Furthermore, children who are isolated during their early school years are at greater risk of being lonely as adults (Chapter 6). Nonetheless, loneliness appears to have greater implications from a mental health perspective than social isolation, and is therefore considered the primary construct of interest in the remainder of the thesis.

7.2 Genetic and environmental effects on isolation and loneliness

We found a moderate heritability estimate for loneliness (Chapter 4) that is consistent with previous behavioural genetic studies (Boomsma et al, 2005; Goossens et al, 2015; McGuire & Clifford, 2000). Previous findings were extended in the present work by using a multivariate approach to investigate genetic and environmental contributions to associations between loneliness and other traits. This was the first study to identify overlap in the genetic contributions to social isolation, loneliness and depression. The genetic correlations between these traits may reflect pleiotropy, whereby the same individual allele affects multiple traits (for example, by acting upon biological pathways that are common to these traits). However, the specific genes in question have yet to be identified. Complex psychological traits are influenced by many genetic variants, each having small individual effect sizes (Chabris, Lee, Cesarini, Benjamin & Laibson, 2015; Plomin et al, 2016). To date, only one genome-wide association study (GWAS) has been conducted on loneliness (Gao, Davis, Hart, Sanchez-Roige, Han, Cacioppo & Palmer, 2016). While showing further evidence for the heritability of loneliness, and a genetic correlation with depressive symptoms, no specific genetic variants associated with loneliness were identified. Further studies using genomic data from large samples are therefore needed before the genetic basis of loneliness can be better understood.

Heritability statistics explain variation in a trait across members of a population. In other words, a heritability of 38% does not mean that feelings of loneliness in a given individual are 38% genetically-determined. Instead, it means that the fact that some individuals in the population feel lonelier than others is 38% due to the genetic differences between them. The heritability of loneliness has therefore been interpreted as reflecting variation in people's tendency to find social disconnection aversive (Cacioppo et al, 2014). That is, it is not the feeling of loneliness itself that is transmitted genetically, but rather the susceptibility to experience it when estranged from others. From an evolutionary

perspective, it would make sense for there to be diversity in this trait, as both high and low degrees of susceptibility could confer different benefits and drawbacks under certain environmental pressures. For example, during times of scarce resources, an individual who was indifferent to the social group and acted purely in their own self-interest might increase their own chances of survival, but potentially jeopardise the survival of their offspring, while the opposite would be true for an individual who was more inclined to share resources with others (Boomsma et al, 2005).

If up to half of the variance in loneliness is explained by genes, the corollary of this is that a large amount of variance is also under environmental influence. No effect of the shared environment on loneliness was detected, and therefore only non-shared environmental effects were modelled. Shared environmental effects on loneliness have been found among children, and appear to increase from mid-childhood to preadolescence (e.g. Bartels et al, 2008). However, by adulthood, the environmental effects on loneliness are largely non-shared (e.g. Boomsma et al, 2005). This is the case for many other psychological traits, and can be attributed to twins becoming more independent with age and increasingly being exposed to environmental influences from outside the family home (Plomin et al, 2008). Consistent with this, none of the family environment factors investigated in childhood were associated with loneliness in young adulthood (Chapter 5). Instead, the risk factors for later loneliness were experiences that could be specific to individuals; namely, childhood mental health problems, bullying and social isolation. This study focused specifically on predictors early in life, and their effect sizes were small, possibly due to the time lag. Other, more proximal environmental risk factors for loneliness may include lack of contact with friends and family, poor relationship quality, bereavement and disability (Luo et al, 2012; Mullins & Dugan, 1990; Savikko et al, 2005).

Genetic and environmental influences do not exert their effects independently of one another. Environmental exposures can act upon a genetic vulnerability, such that carriers of different genotypes experience different outcomes in response to the same exposure. In the traditional ACE model, such gene-environment interactions cannot be disentangled. Interactions between genetic and shared environmental effects would be subsumed into the additive genetic (A) estimate, while interactions between genetic and non-shared environmental effects would increase the non-shared environment (E) estimate. Several studies have yielded evidence for gene-environment interactions in the context of loneliness. For instance, associations between social adversities (such as low family support) and loneliness are moderated by alleles for genes relevant to the stress response system (Chou et al, 2014; van Roekel et al, 2010; 2011). This further highlights that the aetiology of loneliness is a complex coalescence of genetic and environmental risk factors.

7.3 The pervasiveness of loneliness in young people

The descriptive analyses of loneliness indicate that this is a common experience among young people (Chapter 5). Loneliness was also evenly distributed between males and females. Findings on sex differences in loneliness have been inconsistent, and the detection of such differences appears to depend on the type of measure used. When loneliness is measured via the UCLA Loneliness Scale (which does not explicitly use the word ‘lonely’), gender differences are usually not found, with a small number of studies finding higher levels of loneliness in males. In contrast, higher levels of loneliness among females have been observed using measures in which participants are directly asked to self-identify as lonely (Borys & Perlman, 1985). This pattern may be due to an effect of gender roles, whereby males are less likely to label themselves as lonely due to perceived societal expectations. Despite having comparable levels of loneliness, males were on average more isolated, while social isolation and loneliness were more strongly correlated

in females, suggesting that there may be sex differences in susceptibility to feeling lonely in the absence of social connection.

Loneliness may have strong implications not only for mental health, but for other important domains of life as well, such as employment prospects. School leavers in the UK today enter an economy still recovering from the fallout of the 2008 financial crisis. Low wage growth, decreased job security and rising house prices mean that young people face considerable challenges and uncertainty in their pursuit of financial stability (Belfield, Cribb, Hood & Joyce, 2014). A significant proportion of young people are classed as not in employment, education or training (NEET), not for lack of motivation or commitment on their part, but rather due to low optimism and perceived lack of relevant skills (Goldman-Mellor et al, 2016). The burden of loneliness may contribute strongly to these perceptions: lonely individuals are more likely to be NEET than non-lonely individuals, despite being no less committed to job-seeking. Even if they are employed or studying, they are less optimistic about their ability to get ahead in life, and although they consider themselves to have the technical or manual skills required for gainful employment, they are less confident in their ‘soft skills’ such as leadership, teamwork, problem-solving and communication (Chapter 5).

Past studies have found that lonelier individuals are more fearful of negative evaluation (Cacioppo et al, 2000). This fear is not entirely without justification: when presented with vignettes depicting lonely and non-lonely people, raters tend to make more negative appraisals of the lonely person, particularly if that person is male (Borys & Perlman, 1985; Lau & Gruen, 1992). This stigma may influence not only how lonely people are treated by others in social interactions, but also how they themselves approach social interactions. For example, apprehensiveness about being judged harshly may be expressed via distrustful or aloof behaviour, unintentionally reinforcing the negative perceptions of others. This thesis presents evidence that independent raters are likely to

agree that lonely individuals are suspicious of others, think others are out to get them, get jealous and blame others for their own problems (Chapter 5). Moreover, raters were likely to disagree that lonely individuals have qualities such as leadership, common sense, initiative and a good sense of humour. Negative perceptions and expectations about social interactions, both on the part of lonely individuals and those they interact with, could therefore be a self-fulfilling prophecy which hinders lonely individuals' efforts to connect with others (Cacioppo & Hawkley, 2009).

7.4 Loneliness and health

The cross-sectional analyses at age 18 did not find evidence for elevated CRP or BMI among lonely young people (Chapter 5). Previous studies have also failed to find an association between loneliness and CRP, but associations have instead been reported for social isolation, and therefore inflammation may be an independent pathway via which isolation, rather than loneliness, impacts health (Danese et al, 2009; Lacey et al, 2014; Shankar et al, 2011). These studies measured markers of inflammation in adults aged 30 or older. Further analyses in the present sample of 18 year-olds did not find any associations between social isolation (either in childhood or young adulthood) and CRP in young adulthood. The effect of social isolation on inflammation may therefore act over the longer term. With respect to BMI, an association between loneliness and BMI has been found previously, and shown to be independent of age (Lauder, Mummery, Jones & Caperchione, 2006). BMI was on average lower and less variable in the E-Risk cohort compared to the sample in that study, which may account for the non-replication of this finding.

Nonetheless, we identified several other correlates of loneliness in young adulthood that suggest that it is still a cause for concern with regard to future health. Two examples are daily smoking and low daily physical activity. There are several possibilities as to why lonely individuals may partake in more health-damaging activities or, conversely, less

health-promoting activities. First, individuals who are more closely connected with others may receive more encouragement or pressure to maintain their health. Second, health-damaging behaviours such as smoking may be used as coping strategies among lonely individuals. Third, lonely individuals may have difficulties with self-regulation, with potential implications for health-related behaviours (Cacioppo et al, 2000; Hawkley & Cacioppo, 2010). Previous findings have been mixed as to whether loneliness is related to differences in health-related activities (Cacioppo, Hawkley, Crawford et al, 2002; Lauder, Mummery, Jones & Caperchione, 2006; Shankar et al, 2011), possibly because social relationships have the ability to promote both positive and negative health behaviours (Seemann, 2000). Whether health-related behaviours are a plausible pathway from loneliness to later health outcomes therefore requires further investigation.

Another correlate of loneliness was poor sleep quality. This is consistent with past studies showing that loneliness is associated with sleep impairments (Cacioppo, Hawkley, Berntson et al, 2002; Harris et al, 2013; Hawkley, Preacher & Cacioppo, 2010; Hawkley, Thisted et al, 2010; Kurina et al, 2011). The hypothesis that loneliness would intrude on sleep is in line with the evolutionary model of loneliness (Cacioppo, Hawkley et al, 2006). Ancestors of modern humans would have felt better protected when sleeping in the presence of people they trusted, whereas individuals deprived of this protection would be more acutely aware of potential threats, and would therefore be expected to sleep less restfully. In modern society, in which the threat of predation is less imminent, the objective presence of others in the sleep environment may not confer the same sense of protection. However, a vestigial instinct to associate social connection with safety would mean that the *perception* of being socially disconnected (i.e. loneliness) would feel similarly unsafe. Therefore, it would be expected that feelings of loneliness, rather than simply living or sleeping alone, would be associated with sleep problems (Hawkley, Preacher & Cacioppo, 2011).

Sleep, however is influenced by a wide variety of factors, including genetic influences (Barclay et al, 2010). In order to advance hypotheses about a causal effect of loneliness, it is necessary to address these sources of confounding. Therefore, the association between loneliness and sleep quality was subjected to stringent tests for robustness (Chapter 6). The association between loneliness and sleep quality was not explained by social isolation, mental health problems, or family-wide factors including genetic influences. A goal of future research should be to test for a mediating effect of sleep impairments on the association between loneliness and subsequent physical health measures.

7.5 Considerations for future research

The correlation between social isolation and loneliness was modest, indicating that some individuals find lack of social connection more aversive than others. However, it is not yet clear why this is the case. Given that loneliness is most commonly conceptualised as a discrepancy between desired and actual social relationships (Peplau & Perlman, 1982), this raises the question of how ‘desired’ social relationships are shaped. Are there protective factors that buffer people against feelings of loneliness even when they lack social contact? Conversely, are there risk factors that increase individuals’ susceptibility to feeling lonely even when surrounded by others? Personality traits and childhood experiences may be plausible candidates. Comparing the characteristics of individuals who are isolated but not lonely, versus those who are lonely but not isolated, could provide valuable information about how individuals’ social needs are shaped.

A further, related question, is the extent to which an individual’s preferred amount of social connection is stable, and whether it varies according to situational factors such as emotional states and life circumstances. It is conceivable, for example, that a university student in his or her first year of training might be eager to socialise and bond with peers, but at the dissertation-writing stage, the same individuals would perhaps be thankful for

a less busy social schedule in order to focus on the task at hand. The influence wielded by these situational factors may, in turn, vary depending on stable individual traits. For example, when faced with a stressful or burdensome item of business, some individuals may be inclined to seek support from friends and relatives, while others may prefer to withdraw from social contact in order to conserve time and resources. A lack of available social contact in the first scenario, or a surplus of it in the second, could both be a source of distress.

Given that social isolation and loneliness may both be independent risk factors for physical health (Cornwell & Waite, 2009; Holt-Lunstad et al, 2015; Shankar et al, 2011), it is also a possibility that those who experience both simultaneously have worse outcomes than those who experience only one or the other. For instance, one study, investigating associations between social networks and immune functioning in young adults, showed that the most strongly affected were those who were both high in loneliness and small social networks (Pressman et al, 2005). This highlights the importance of collecting data on both of these constructs simultaneously, in order to study their effects in parallel. A goal of future research should be not only to disentangle the differential effects of social isolation and loneliness, but also to investigate the possible interplay between them.

7.6 Limitations and methodological considerations

Low social support as a proxy for social isolation

Social isolation in young adulthood was assessed using a scale designed to measure social support. This measure was used because other common indicators of social isolation were either not available (e.g. number of social connections or frequency of contact) or not applicable to the 18 year-old participants (e.g. living alone or marital status). However, there are some limitations to this measurement approach. Support is not the only important characteristic of social relationships, and not all social relationships are

necessarily supportive. Nonetheless, the availability of different types of support depends upon having a well-established network of social connections, and conversely, to lack these sources of support would imply that the individual is to some extent disconnected from those around them. Therefore, in lieu of objective data on social contact, the rationale for this measurement approach was that a shortage of social connections would be reflected in having fewer sources of support.

Furthermore, although measuring individuals' number of friends or frequency of social contact may be a more objective measurement approach, it may still lead to ambiguities. For example, should telephone and electronic correspondence be considered a form of social contact? If so, an individual who lives far away from any friends or family and has no immediate contacts with whom to share social activities may still be considered non-isolated if they regularly use email or social media for long-distance communication. One way to address this would be to restrict the working definition of 'social contact' to include only face-to-face encounters. However, such an approach may in turn overlook the extent to which young people use the internet to maintain and augment their social relationships (Gross, 2004; Valkenburg & Peter, 2007). This highlights the fact that forms of social contact are more diverse in the digital age than they may have been in previous decades, and that there is still potential for bias when using certain objective indicators to quantify an individual's degree of social connection. For instance, the number of contacts an individual has on social media, or the number of text messages they send and receive, may or may not accurately reflect how many friends they have or how many meaningful interactions they have. A measure of social support has the advantage of excluding more trivial forms of social contact.

A final point is that in the context of a long interview assessment, asking participants to report how many friends they have and how frequently they interact with them would both be time-consuming and potentially introduce further sources of error. It would have

to be assumed, for example, that participants would be able to recall this information accurately when prompted, and that the degree of accuracy would be similar for all participants. As this could not be guaranteed, the use of a social support scale was considered a more feasible and reliable means of assessing the extent to which participants were socially connected.

Temporal priority of loneliness

Loneliness was only measured at the age-18 assessment. Consequently, its associations with other variables in adulthood could only be tested cross-sectionally, and no conclusions are drawn about the direction of these associations. In the case of depression, previous longitudinal studies indicate that loneliness is a stronger predictor of depressive symptoms than vice-versa (Cacioppo et al, 2010; Vanhalst, Klimstra et al, 2012; Vanhalst, Luyckx et al, 2012). However, with regards to the association between loneliness and ADHD, for example, there is less prior evidence on which to base hypotheses about directionality. There is evidence that loneliness may impair certain aspects of attentional control (Cacioppo et al, 2002); however, to suggest that loneliness is an antecedent of clinically-significant ADHD symptoms would be a much bolder proposition. Where possible, data on childhood mental health was included in analyses in order to partially address the question of reverse causality. However, repeated measures of loneliness are required to adequately test the directionality of the associations found.

The equal environments assumption

One of the assumptions of twin studies is that the environmental exposures which contribute to the similarity of twins do not differ by zygosity. That is, the only thing that makes MZ twins more alike than DZ twins is their difference in genetic similarity, rather than differences in shared environment effects. If this assumption were violated, and the effects of the environment on within-twin pair similarity were stronger for MZ than for DZ twins, estimates of heritability would be overestimated, and estimates of shared

environmental effects would be underestimated. Although both MZ and DZ twins are exposed to many of the same environmental influences, it is possible, for example, that parents or teachers would treat MZ twins more similarly than they would if the twins were DZ. One way this can be tested is by examining twins whose zygosity was misidentified at birth, and comparing the effects of ‘perceived’ versus ‘true’ zygosity on twin similarity. Evidence from such studies indicates the equal environments assumption is largely valid, and in those cases where MZ twins’ environments are more similar than DZ twins’, this does not substantively bias heritability estimates (Conley, Rauscher, Dawes, Magnusson & Siegal, 2013; Kendler, Neale, Kessler, Heath & Eaves, 1993).

Criticisms of evolutionary explanations for psychological traits

The evolutionary model of loneliness (Cacioppo, Hawkley et al, 2006) has been influential on the conceptualisation and study of loneliness, and is a reference point for the research presented in this thesis. However, a criticism of evolutionary accounts for psychological traits is that they are difficult to test empirically, and amount to ‘just-so’ stories; convenient but unfalsifiable explanations for observed phenomena made after the fact (Plotkin, 2004). One way in which the plausibility of evolutionary hypotheses can be advanced is by making predictions based on an *a priori* model, and testing whether these predictions are supported by subsequent observations. Three examples of such tests are presented in this thesis. The evolutionary model proposes that loneliness elevates feelings of vulnerability and vigilance for threat; a response which would have served a self-protective function for human ancestors cut off from their social group. Based on this premise, it would be expected that firstly, lonely individuals may approach others with distrust and suspicion. This prediction is supported by the finding that lonely individuals’ behaviour is perceived by others as more suspicious and hostile (Chapter 5). Secondly, it would be expected that lonely individuals would sleep less restfully, a hypothesis that is supported by the findings (Chapter 6). Thirdly, it would be expected that the experience

of being victimised in the past may reinforce vigilance for threat, exacerbating the effects of loneliness on sleep. The moderator analyses are consistent with this (Chapter 6).

Differentiating 'lonely' from 'non-lonely' individuals

From an epidemiological perspective, it is useful to quantify how prevalent loneliness is in the population. However, unlike clinical disorders such as depression, there is no symptom threshold at which loneliness is 'diagnosed'. When dichotomising scales, the choice of cut-off score is therefore a somewhat arbitrary decision. Some studies differentiate lonely from non-lonely individuals by taking a median split (e.g. Cacioppo, Hawkley, Crawford et al, 2002), but by definition this yields a 'prevalence' of 50%. Other studies group participants into those who report feeling lonely often, sometimes, or not at all (e.g. Mental Health Foundation, 2010). However, this approach typically relies on single questionnaire item, and therefore may not sufficiently capture the complexity of the construct. Estimating the true prevalence of loneliness is therefore not straightforward, and may result in inconsistent estimates across different studies. For this reason, loneliness was treated in this thesis as a linear variable reflecting variation across a continuum in the population.

Are twins less lonely than singletons?

Twins, by definition, have had at least one sibling from birth, which may reduce social isolation and loneliness on average. Previous studies have found that number of siblings is not related to loneliness (Mullins & Dugan, 1990; Uruk & Demir, 2003). However, twins are same age as one another, and may therefore feel closer than other pairs of siblings. The rates of loneliness in the E-Risk sample are similar to those observed among singletons (e.g. Mental Health Foundation, 2010; Victor & Yang, 2012). Nonetheless, the effects of social isolation and loneliness may be underestimated using twin data.

7.7 Implications

From a research perspective, it is important that loneliness and social isolation are studied together in order to disentangle their respective aetiologies and outcomes, and the potential interplay between them in predicting trajectories of mental and physical health. Loneliness in particular should be treated as an important risk factor for mental health problems, and studied alongside other well-studied risk factors such as neglect and victimisation. The high prevalence of loneliness among younger people as well as the elderly signifies the importance of studying this phenomenon across multiple stages of the lifespan. Furthermore, many questions remain to be answered as to the genetic underpinnings of loneliness, and further research in the fields of molecular genetics and epigenetics will be valuable in this regard.

For some individuals, loneliness is a transient state, arising from temporary changes in circumstances and resolving in due course. For others, however, loneliness can persist over time and become a self-reinforcing cycle. To what extent can interventions alleviate loneliness in these individuals, and what types of strategies are likely to be most effective? Increasing individuals' access to social contact would seem an intuitive target for intervention. However, while this may reduce social isolation, it neglects the fact that an individual can feel lonely even in the company of others. The experience of loneliness concerns not only an individual's objective circumstances, but the cognitions that shape how they appraise and respond to these circumstances. It is therefore likely that successful strategies to reduce loneliness would place an emphasis on addressing problematic cognitions within a psychotherapeutic framework. Evidence for this comes from a meta-analysis (Masi et al, 2010), which found that interventions to address maladaptive social cognitions were more effective at reducing loneliness in comparison to other strategies geared towards increasing social skills, social support or social contact. A follow-up review (Cacioppo, Grippo, London, Goossens & Cacioppo, 2015) proposes that there

may even be scope to combine such interventions with medical treatments such as selective serotonin reuptake inhibitors, allopregnanolone or oxytocin. Successfully reducing loneliness could, in turn, forestall its potential effects on mental and physical health outcomes. For instance, findings from one study suggest that interventions to reduce loneliness could lead to a substantive reduction in subsequent depressive symptoms (VanderWeele et al, 2011).

The research presented in this thesis has a number of implications for interventions. First, as well as contributing to an existing literature highlighting the need for such interventions, the findings offer evidence of the potential benefits of reducing loneliness. For example, by showing that the association between loneliness and poor sleep quality is environmentally-mediated (Chapter 6), an implication of this is that a reduction in loneliness would be accompanied by a reduction in sleep problems. Second, the informant ratings of participants' personality and behaviour (Chapter 5) indicate that lonelier individuals are more likely to be perceived as exhibiting hostile traits such as suspicion, anger, jealousy and blame. These behavioural styles – which the lonely individuals may or may not be aware of – are detrimental to the formation of close, satisfying social relationships, and could lead to them becoming trapped in loneliness. Targeting these behaviours could therefore be one of the key objectives in a goal-oriented intervention such as cognitive-behavioural therapy. Third, the findings in Chapter 5 also show that loneliness is often a marker of poor functioning across multiple domains. If an individual discloses to their doctor that they often feel lonely, this could be a signal of broader difficulties with mental health, lifestyle, coping and employment. Therefore, loneliness should not be viewed out of context, but rather on the understanding that it is often embedded within a constellation of interrelated problems.

Moving beyond interventions to help individuals who are lonely, greater understanding of the antecedents and trajectories of loneliness can inform primary prevention strategies

at the wider societal level. Such approaches would entail drawing on longitudinal findings to identify those most at risk, and orienting efforts towards prevention early in life (Valtorta & Hanratty, 2012). In pursuit of this aim, research should place emphasis on the emergence of loneliness in young people and its implications for public health. The longitudinal analyses presented in Chapter 5 identify a number of factors in childhood which are associated, albeit modestly, with greater levels loneliness in young adulthood, and could serve as useful indicators for identifying at-risk groups of young people.

7.8 Conclusion

The relevance of social relationships for health and development has been long-recognised in the fields of psychology, sociology and anthropology. However, loneliness as a psychological phenomenon in its own right, distinct from the objective concept of social isolation, has only become the subject of scientific investigation relatively recently. In the ensuing decades, innovative and informative studies of loneliness have proliferated at a growing pace. This thesis contributes to the existing literature by integrating longitudinal, genetically-sensitive and multi-informant methods to answer novel research questions about the nature of social isolation and loneliness. The findings demonstrate how multidisciplinary approaches can be used to further unravel the complexity of this phenotype in future research.

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