Nonshared environmental influences on sleep quality: A study of monozygotic twin differences

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Abstract

Research has consistently demonstrated that environmental influences are important for explaining the variability in sleep quality observed in the general population. Although there is substantial evidence assessing associations between sleep quality and a host of environmental variables, it is possible that their effects are mediated by genetic influence. A monozygotic twin differences design was used to assess the specific contribution of nonshared environmental influences on sleep quality, whilst controlling for genetic and shared environmental effects in a sample of 380 monozygotic twins (mean age 19.8 years, SD=1.26, range=18-22 years). Participants completed the Pittsburgh Sleep Quality Index and questionnaires assessing several candidate "environmental" measures. When controlling for genetic and shared environmental effects, within monozygotic twin-pair differences in sleep quality were associated with within monozygotic twin-pair differences in general health for males (β=1.56, p<.001) and relationship satisfaction for females (β=1.01, p<.05). For the remaining environmental measures the results suggest that these seemingly "environmental" influences are actually in part dependent on genetics and/or the shared environment. These findings give insight into how specific environments affect sleep and the possible mechanisms behind these associations.

Keywords: Genetics, Gene-environment correlation, Monozygotic, Nonshared environment, Sleep, Twins

Introduction

Complaints about poor sleep quality are common, with at least some degree of sleep disturbance affecting around one third of the adult population at any one time (Ohayon 2002). Poor sleep is associated with a range of adverse health outcomes including depression, obesity, hypertension, metabolic syndrome, and all-cause mortality (Algul et al. 2009; Cappuccio et al. 2010; Ohayon 2009; Vgontzas et al. 1998). These associations are likely to be bi-directional such that poor sleep impacts on poor psychological functioning, particularly in mood disorders such as depression (Breslau et al. 1996; Ford and Kamerow 1989); yet sleep disturbances are also likely to be a consequence of an underlying condition, and so poses as a significant public health problem. Identifying contributory factors underlying sleep disturbances is important for identifying individuals at risk for problems.

There is now a growing body of evidence for genetic influence on sleep related phenotypes (for a review see Gregory and Franken 2009). From a quantitative genetic viewpoint, twin studies in adults have determined that objectively measured sleep characteristics such as the overall EEG spectral composition of non-REM sleep (Ambrosius et al. 2008; De Gennaro et al. 2008), the proportion of time spent in sleep stage 2 and slow-wave sleep (stages 3 and 4), and the density of REM (rapid eye movement) sleep (Linkowski et al. 1991; Linkowski et al. 1989) have a strong genetic component. In addition, studies using self-report data have estimated that around 30-50% of the variance in subjective sleep quality is accounted for by genetic influence (Barclay et al. 2010; Heath et al. 1990; Partinen et al. 1983). Of particular interest is that quantitative genetic designs such as the twin design tell us as much about the environment as they do about genetics. Indeed, the aforementioned adult twin studies highlighted that, in addition to genetics, experiences specific to each twin (known as nonshared environmental influences) appear to influence sleep quality; whereas shared environmental influences by contrast appear to contribute little. Partitioning 'shared' and 'nonshared' environmental components is a statistical concept which describes the effects of the environment on a trait. The nonshared environment can be described as environmental influences unique to each twin (or indeed sibling) which act to make family members different. An example of this could be a negative life event such as an accident experienced by one twin and not the other. Of course it is possible that some negative life events (e.g. parental divorce) could act so as to make individuals within a family more alike, in which case they would constitute part of the shared environment. However, it should be noted that some shared environmental influences, such as parental divorce, may act in a nonshared environmental manner, insofar as the *experience* of parental divorce may differ between family members, thus making them more *dissimilar.* Explicit investigation of the effects of these distinct types of environmental influence (shared vs. nonshared) is key to understanding the mechanisms through which the environment affects behaviour.

The shared environment is often important for sleep in childhood, for example Brescianini and colleagues recently reported that sleep duration is largely accounted for by shared environmental factors in a sample of 18-month old twins (Brescianini et al. 2011; see also Gregory et al. 2005). However, in adulthood shared environmental influences on many behavioural and emotional phenotypes (including sleep as outlined above) are typically negligible (Plomin et al. 2008). This is largely due to the increasing importance of environmental experiences that occur outside of the family environment as one gets older, and thus it is often the nonshared environment that is important for many traits (Plomin et al. 2008). This may also be true for sleep disturbance. As such, environmental influences not shared between twins may account for their differences in sleep.

One way to specifically address the issue of the nonshared environment is to use monozygotic (MZ) twins. Because MZ twins share 100% of their genetic material and by definition their shared environment, any differences between them must be due to the nonshared environment (including measurement error). In standard twin analyses, identifying nonshared environmental factors that function independently of genetics and the shared environment is complicated due to the possibility that genetic factors may influence, or indeed interact with, the environment. Research has demonstrated that genetic factors often influence exposure to certain environmental conditions – a process termed gene-environment correlation (Plomin et al. 2008). Thus, many measures traditionally thought of as "environmental" are actually in part genetically driven. This would mean that we may select our environments based on our genetic predispositions. For example, a genetic predisposition to poor sleep quality may influence exposure to negative life events if an individual's behaviour is adversely affected by the consequences of a poor night's sleep. Furthermore, genes and environments may interact to influence behaviour. Gene-environment interaction may mean that an individual is genetically sensitive to a particular trait or disorder, but that symptoms are evident only in the presence of an identified environmental stressor. Thus, gene-environment correlation and interaction make it difficult to identify purely nonshared environmental components that are independent of genetics or the shared environment.

The MZ twin differences design, however, assesses the degree of dissimilarity between MZ twins which allows us to disentangle the interplay between genes and environments to determine purely nonshared environmental components. The MZ twin differences design has been used to determine specific nonshared environmental effects for a number of traits, for example behavioural development and adolescent depression (Asbury et al. 2003; Caspi et al. 2004; Liang and Eley 2005), and is a simple yet powerful method of determining twin discrepancy that is independent of genetics and the shared environment (Pike et al. 1996).

Candidate Nonshared Environmental Influences on Sleep

Prior research has implicated a number of "environmental" influences on sleep quality that may be worthy candidates for analysis. Several studies have highlighted the negative effects of negative life events on sleep quality (e.g. Lavie 2001; Mezick et al. 2009; Sadeh 1996; Vahtera et al. 2007). Within the life events literature, it is common to categorise life events as dependent or independent, according to the controllability of such events (Brown and Harris 1978). Dependent negative life events can be defined as those that an individual has some degree of control in bringing about, whereas independent negative life events are defined as those not influenced by an individual's behaviour. Dependent and independent negative life events are associated differentially with sleep disturbance, and the association between dependent negative life events and sleep quality is partially accounted for by gene-environment correlation (Barclay et al. 2011). However, negative life events may also contribute to sleep disturbance independent of a gene-environment correlation effect, and the MZ differences method allows us to determine this by focusing on the role of pure nonshared environmental influence.

Other candidates for study include demographic differences and relationships. Epidemiological data suggest that sleep difficulties are more prevalent among individuals with a low income, low educational attainment, and those unemployed (Ford and Kamerow 1989; Grandner et al. 2010; Ohayon 2002). They are also more prevalent in separated/divorced and widowed individuals as compared to married couples (Ford and Kamerow 1989; Grandner et al. 2010; Hale 2005), and in women experiencing less marital satisfaction (Troxel et al. 2009). As well as romantic relationships, peer relationships and friendships appear to have associations with sleep. In children bullying interferes with sleep (Williams et al. 1996), and low connectedness with peer groups is associated with subjective insomnia in adolescents (Yen et al. 2008). Similarly, in adults workplace bullying is associated with sleep disturbances (Neidhammer et al. 2009). Additionally, the depression literature shows that affiliation with deviant peers is associated with increased depressive symptoms (Fergusson et al. 2003). This relationship is in part mediated by the increase in deviant behaviours that occurs in individuals affiliating with deviant peers. Research from our team has demonstrated that sleep problems are associated not only with depression (Gregory et al. 2011), but also with deviant behaviours (Barclay et al. 2010). Because of these associations it is worth considering whether peer groups and affiliations with deviant peers also influence sleep quality.

A final candidate for study is general health. Poor sleep is associated with a number of health problems (see above, and also Briones et al. 1996; Buysse et al. 2010; Finn et al. 1998; Gangswisch et al. 2010), and so it is possible that differences in health are associated with differences in sleep between twins.

In addition, consideration of possible sex effects is also worthy of investigation. Sleep is known to differ between males and females (Ohayon 2002), and it is possible that the influences that affect sleep are also sex dependent.

Although the extant literature demonstrates that these traditionally viewed "environmental" factors are associated with sleep, many have been shown to be under genetic influence (Kendler and Baker 2007). Thus, whether these associations are also influenced by a purely nonshared environmental component is in question. Investigating this issue will shed light on the mechanisms by which these factors are associated with poor sleep. Accordingly, we used the MZ twin differences design to investigate whether negative life events (dependent and independent), demographic characteristics, aspects of relationships (both romantic and with peers) and general health were significant nonshared environmental influences on subjective sleep quality, independent of genetic and shared environment effects, in a sample of young adult MZ twins. Furthermore, we assessed differences between males and females separately in order to determine whether the effects were sex-specific.

Methods

Sample

Data from all complete monozygotic (MZ) twin pairs (n=190 complete pairs) from Wave 4 of the G1219Twins study were used in analyses (Mean age=19.8 years [SD=1.26], range=18-22 years; 65.8% female). G1219 initially comprised adolescent offspring of adults from a large-scale population-based study (GENESiS: Sham et al. 2000). The G1219Twins are a random selection of live twin births born between 1985 and 1988 identified by the UK Office of National Statistics. At wave 1 of data collection (which took place between 1999 and 2002) 3640 respondents aged between 12 and 19 years participated in the study. Informed consent was obtained from parents/ guardians of all adolescents under 16 years, and from the adolescents themselves when 16 years and over. Ethical approval for different stages of this study has been provided by the Research Ethics Committees of the Institute of Psychiatry, South London and Maudsley NHS Trust, and Goldsmiths, University of London. At wave 4 (which took place in 2007 and is the focus of this current report as it is the first wave to include data on sleep) we traced participants who had taken part in wave 2/ wave 3 and sent them a questionnaire booklet. A total of 1556 individuals were included in the wave 4 dataset (61% of those targeted; 74% of those participating at wave 3). Zygosity was established through a questionnaire measure completed by mothers at waves 2 and 3, assessing physical similarity between twins (Cohen et al. 1975). Questionnaire methods have been shown to yield ~95% accuracy in correctly determining zygosity when validated against DNA markers (Price et al. 2000).

Measures

Sleep Quality

The Pittsburgh Sleep Quality Index (PSQI: Buysse et al. 1989) was used to assess sleep disturbance over the past month. The PSQI is a widely-used questionnaire containing 18 items, with global scores ranging from 0-21. Higher scores indicate poorer sleep quality. The PSQI has previously demonstrated good psychometric properties with both internal consistency and test-retest reliability in the .8 range (Backhaus et al. 2002), as well as excellent stability measured over a 1 year period (Knutson et al. 2006). The PSQI also has favourable convergent validity when compared to other self-report sleep measures (Backhaus et al. 2002; Carpenter and Andrykowski 1998). In the present sample the PSQI global score yielded satisfactory internal reliability (Cronbach's alpha (a) = .71).

Dependent and Independent Negative Life Events

Negative life events were assessed using items from the ‘List of Threatening Experiences’ (Brugha et al. 1985) and the ‘Coddington Stressful Life Events Scale’ (Coddington 1984). Participants are required to respond to these checklists by indicating whether or not they have experienced a particular negative life event in the last year. Twenty one items were summed to give a score of total life events, which were further subdivided into 13 items assessing dependent negative life events (e.g. separation due to marital difficulties) and 8 items assessing independent negative life events (e.g. death of a parent). Dependent and independent negative life events were classified according to whether it is likely that their occurrence is the consequence of an individual’s behaviour (Brown and Harris 1978). This distinction between life events has been used in previous studies (Silberg et al. 2001) as well as other papers from the G1219 study (Barclay et al. 2011; Liang and Eley 2005).

Education

Educational achievement was assessed by one question asking participants their highest UK qualification (ranging from high school to university level qualifications). Higher scores indicated a higher level of education attained.

Employment

Participants were initially asked to indicate their employment status according to one of the following categories: unemployed, full-time student, employed full-time, part-time student/work, on a study break, on government benefit, or full-time parent. However, a large proportion of our sample (93.9%) fell into either the ‘employed full-time’ (48.4%) or ‘full-time student’ (45.5%) category, with only a few participants unemployed (n=13) or full-time parents (n=7). No participants fell into the remaining categories. As such employment status was categorised as ‘employed full-time’ vs. ‘full-time student’ as the number of cases in the other categories were considered too small for analysis and so were not included in analyses.

Relationship Status

Participants were initially asked to indicate their relationship status according to one of the following categories: married, living with partner, engaged, living with partner and engaged, going steady, casual or single. Although typically previous research has assessed relationship status with a wider scope (e.g. divorced, widowed: Ohayon 2002) our participants were relatively young (aged between 18 and 22 years), only one was married and none were divorced/widowed, so we were unable to distinguish between these categories. As a large proportion of our sample fell into either the 'going steady' (33.2%) or ' single' (48.2%) category, relationship status was finally categorised as those who were 'single' vs. 'those in a romantic relationship' (49.7%) at the time of assessment.

Relationship Satisfaction and Cohesion

Relationship satisfaction and cohesion were assessed by items included in the subscales of the Dyadic Adjustment Scale (Spanier 1976). The satisfaction subscale comprised 6 items tapping into aspects of the relationship such as happiness, and the cohesion subscale by 5 items assessing the extent to which the participant and their partner engage in activities together. For example, participants were asked to respond to statements such as "How often would you say that you think that, in general, things between you and your partner are going well?" on a 5 point scale, with responses ranging from 'all of the time, 'most of the time', 'more often than not', 'occasionally' and 'rarely/never'. Lower scores indicate better satisfaction and cohesion. These scales are widely used and have been found to have satisfactory validity and reliability (Spanier 1976). In the present sample a=.77 and .67 for relationship satisfaction and cohesion, respectively. Of note, approximately half of the sample stated that they were in a relationship at the time of study. Responses on the relationship satisfaction and cohesion scales were coded as missing for participants who indicated that they were 'single' (51.3%). Hence the sample size for the analyses including this measure was smaller than for other analyses.

Closest Friendship

The quality of closest same-sex friendship was assessed by 21 items from the Network of Social Relationships Inventory (Furman 1985). This measure comprised 7 three-item subscales tapping into a range of qualities of best friendships (e.g. affection, companionship, instrumental aid, intimacy/disclosure, nurturance, reliable alliance and support). For example, participants were asked to respond to questions such as, "How much do you talk about everything with this person?", with responses ranging from 'little/none', 'somewhat', 'very much', 'extremely', and 'the most'. Responses to all questions were combined to generate an overall mean measure of closest friendship quality. Higher scores indicate better quality of friendship. The individual scales have demonstrated good psychometric properties (Furman 1985), and the global score in the present sample demonstrated excellent internal reliability (a=.93).

Friendship Quality

General friendship quality was measured by 5 items included in the Edinburgh Study of Youth Transitions and Crime (ESYTC: Smith and McVie 2003) and assessed "How often do your friends, (i) support you when you need them; (ii) fall out with you; (iii) put you down in front of others; (iv) make you feel confident; and (v) put pressure on you to do things you don't want to." Responses ranged from 'most days', 'at least once a week', 'less than once a week', and 'hardly ever/never'. Scores from these items were combined (and where necessary responses were reversed) to provide a total score on friendship quality. Higher overall scores indicated poorer friendships. In the present sample a=.44 (it should be noted that the small alpha is due to the small number of items included in this scale and so results should be interpreted with caution).

Deviant Peers/Affiliation with Deviant Peers

The presence of deviant peers was assessed by asking participants how many of their friends engaged in a number of deviant behaviours, including alcohol, tobacco or cannabis use, and whether they truanted or broke the law, as outlined by Fergusson and colleagues (2003). Responses were categorised as ‘none’, ‘one or two’, ‘some’, ‘most/all’. Deviant peer affiliation was assessed by 3 items asking “How likely is it that you would still stay with your friends if they were getting you in trouble (i) with your family; (ii) at work/college; (iii) with the police?”, with responses ranging from ‘not at all likely’, ‘not very likely’, ‘fairly likely’, and ‘very likely’ as outlined in the ESYTC (Smith and McVie 2003). Higher scores on both measures indicate greater problems.

General Health

General health was assessed by one item assessing subjective general health using the question, “In general, how good would you say your health is now?” with responses on a 5-point scale ranging from 1 = Excellent to 5 = Poor, as outlined by Ware and Sherbourne (1992). General health has reliably been measured in this way in numerous studies (for example, see Troxel et al. 2009).

Analyses

Prior to analysis, in each pair of MZ twins, one twin was randomly assigned as ‘Twin 1’ and the co-twin as ‘Twin 2’. A relative difference score was then calculated for sleep quality as well as each of the environmental measures by subtracting Twin 1’s score on each measure from that of Twin 2’s score on each corresponding measure. Because monozygotic twins share 100% of their genetic material, and that by design, MZ twins share 100% of their shared environment, any differences between them must be accounted for by the nonshared environment (including measurement error). Thus, the MZ twin difference measure provides an unbiased estimate of twin discrepancy due to the nonshared environment (including measurement error).

In the statistical analyses, a series of univariate linear regression analyses were first run in STATA (Stata 2002) to assess the contribution of each of the absolute environmental measures on absolute sleep quality scores. Second, a series of univariate linear regression analyses were run using MZ twin difference scores for each of the environmental measures to predict MZ differences in sleep quality. The MZ differences analysis, using a measure of twin discrepancy, thus controls for the effects of genetics and the shared environment. All regression analyses were run separately for males and females in order to determine whether the effects were sex specific. The regression analyses also considered effects of age as well as clustering within the sample due to the inclusion of MZ twins, and thus non-independence of observations, by using the Robust(cluster) command in STATA.

Results

The mean sleep quality score was 5.48 (*SD* = 2.86; range = 0-17; median = 5.00; mode = 3.00). There were no significant sex differences in sleep quality ($t(366) = 1.15$, $p=.25$). The frequency distribution of the MZ twin difference scores for sleep quality is shown in **Figure 1**. The mean of the MZ difference scores generally approximates zero since the random assignment of twins ensures that cases where 'twin 1' scores higher than 'twin 2' are cancelled out by cases in which 'twin 2' scores higher than 'twin 1'. What is important is the distribution of these scores. Clustering around zero demonstrates similarity between twins whereas deviations from zero demonstrate the presence of differential sleep quality due to the nonshared environment (Liang and Eley 2005).

[Insert Figure 1 here]

The results of the multiple univariate linear regression analyses are shown in **Table 1** for males and females separately. Column 'a' shows the results on absolute sleep quality scores. For males, the beta weights (β) were generally smaller for many of the environmental measures, and there were fewer significant associations between the environmental measures and absolute sleep quality score, than for females. This suggests that a greater range of environmental factors are associated with sleep disturbance in females. Dependent negative life events, deviant peers and general health were correlates of sleep quality for both sexes. In addition, however, relationship satisfaction as well as friendship qualities were among the strongest correlates of sleep quality in females.

Column ‘b’ shows the results of the MZ differences analyses, which control for the influence of both genetic and shared environmental effects, using twin difference scores on the environmental measures to correlate with twin differences in sleep quality. In these analyses only general health remained significantly associated with sleep in males, and only relationship satisfaction in females. Thus, greater disparity in general health and relationship satisfaction for males and females respectively, is associated with increased differences in sleep quality between twins within a pair. These associations are entirely due to the nonshared environment and not due to genetic/ shared environmental factors. This is also indicated by the smaller β values for these variables in the analysis without controlling for genetic and shared environmental factors, compared with when these factors are controlled.

[Insert Table 1 here]

Discussion

The present study used the MZ twin differences design to investigate nonshared environmental influences on sleep quality. When genetic and shared environmental factors were controlled, general health was significantly associated with sleep quality in males, whilst in females relationship satisfaction was significant. These findings suggest that it is the nonshared aspects of these environmental influences that are associated with sleep quality. All other environmental measures investigated did not remain significantly associated with sleep quality when genetic and shared environmental factors were controlled, suggesting that their associations with sleep quality are in part dependent on genetics and/or the shared environment. This study is to the authors’ knowledge the first investigation of purely nonshared environmental components to the associations between the environment and sleep quality. Although a number of twin studies have highlighted the importance of the nonshared environment on sleep quality the present analyses allow us to examine specific nonshared environmental influences. By selecting candidate environmental influences known to be associated with sleep quality, we have been able to further understand the possible mechanisms by which these associations occur.

Before interpreting these findings, limitations of this study should be considered. First, our sample consisted of relatively young adults aged between 18 and 22 years, so the extent to which these results can be extrapolated to older adults is limited. This is particularly important as significant developmental changes in sleep occur during adolescence and young adulthood, and sleep continues to change throughout the lifespan (Ohayon et al. 2004). The age of the participants should also be considered when interpreting the results of this study. Specifically, although a purely nonshared environmental component of variance was found in association with sleep quality for general health and relationship satisfaction, it needs to be considered that young adults may have not (a); had many health problems; and (b) experienced many long-term stable relationships. Second, our sample largely consisted of females (65.8%). Therefore, where results are significant for females only may be a reflection of the smaller sample size and consequent reduction in power for males rather than being evidence of a true sex effect (indeed the power to calculate the observed effects drawn from the total sample for males ranged from 27%-59%, whereas for females ranged from 60%-85%) (all power calculations performed using G*Power 3.1). Replications of the current findings in larger samples are warranted before we can confidently draw conclusions as to the possibility of sex-dependent effects. Third, as data on sleep was only available from one time point we were unable to determine the direction of effects. Whilst it is likely that associations between sleep and the environment are bi-directional, longitudinal designs are necessary to specifically address this issue. Finally, even though the MZ twin difference measure allows us to determine the contribution of the nonshared environment independent of genetics and shared environmental influences, this component of variance inevitably includes measurement error, and so this should be taken into consideration when interpreting the current findings.

Associations between sleep and environment

The majority of the environmental measures included in the present study (with the exception of deviant peer affiliations and education) were significantly associated with sleep quality. However, when assessing these associations independently by sex, it appears that some of these associations are sex-specific. For females, there appears to be greater associations and a wider range of environmental factors associated with sleep quality than males. Previous studies have demonstrated that sleep problems are more prevalent in women (Ohayon 2002; Ohayon 1997; Ohayon 2005), and this could be in part due to the larger body of correlates of sleep disturbance in women as demonstrated here. However, in the present study we found no evidence of sex differences in sleep quality. Whilst this finding was unexpected, this result conforms with other reports which have found no evidence for statistically significant sex differences in global sleep quality score measured by the PSQI (for example, Buysse et al. 1991; Carpenter and Andrykowski 1998; Valentine et al. 2009; Valladares et al. 2008).

One of the strongest associations with sleep quality for both males and females in the present study was with dependent negative life events. This concurs with previous research which has demonstrated the negative effects of negative life events on sleep (for example, Vahtera et al. 2007). A previous paper from the G1219 study determined that the relationship between dependent negative life events and sleep may be accounted for by gene-environment correlation (Barclay et al. 2011). Specifically, it is possible that genetic factors on sleep quality influence exposure to negative life events either directly or via intermediate variables. For example, sleep disturbances are associated with internalizing disorders such as anxiety and depression (Ford and Kamerow 1989) - both of which are associated with the experience of negative life events (e.g. Silberg et al. 2001). Research from our own team suggests that there is substantial overlap in the genes influencing sleep, anxiety and depression (Gregory et al.

2011), and so it is possible that genes influencing sleep are shared with those influencing anxiety and depression which further influence exposure to negative life events. The present study confirms the presence of gene-environment correlation by showing that, when genetic and shared environmental factors are controlled, dependent negative life events no longer influence sleep quality. Since our previous research in the G1219 sample suggests no evidence for shared environmental influence on negative life events (Barclay et al. 2011), the relationship between negative life events and sleep appears to depend to some extent on genetic variability.

Gene-environment correlation is also a possibility for the remaining environmental measures assessed here (with the exception of general health and relationship satisfaction), where associations with sleep quality reduced to non-significance when genetic and shared environmental factors were controlled. This means that influences that we would traditionally consider “environmental” are in fact not working in a nonshared environmental way, but in part depend on genetics and/or the shared environment. This highlights the possible importance of our genetic and/or shared environment in selecting our environmental experiences.

Specific nonshared environmental influence: Health

Poorer general health was significantly associated with poorer sleep quality for both males and females. This is not surprising given that extensive research has linked sleep to a number of health problems (see above and Buysse et al. 2010), and given the comorbidity between sleep disturbance and psychiatric disorders (Ford and Kamerow 1989). What is interesting here, however, is that the mechanism underlying the association between sleep and health appears to differ between men and women. When controlling for genetic factors and the effects of the shared environment, general health only remained a significant correlate of sleep quality in males, acting as a purely nonshared environmental factor. Thus it appears for males that health outcomes that are independent of genetic and shared environmental effects are associated with sleep disturbance. This could shed light on the specific types of health problems associated with sleep in males, by identifying those that are not linked to underlying heredity or shared environment. Plausible candidates are health problems resulting from accidents. Accidents are a common cause of morbidity and mortality, especially in males within this age group, and are not directly genetically determined (Barker et al. 1996; Blum and Nelson-Mmari 2004) (although it is possible that some individuals may be genetically prone to experience more accidents than others, i.e. through greater risk taking behaviour). Although it is likely that in males, some genes influence both health problems and sleep disturbance, the effect size in the MZ differences analysis is somewhat higher than in the absolute measures analysis, which may indicate that genetic effects on the association between health and sleep in males are minimal. For females, however, it appears that the types of health problems associated with sleep may be those linked to genetic effects, and may work either directly or via genetically influenced mediators. That is, the association between sleep and health for females may be accounted for by gene-environment correlation.

Specific nonshared environmental influence: Relationship Satisfaction

Poor relationship satisfaction as measured by the Dyadic Adjustment Scale was significantly associated with poor sleep quality in females (although we acknowledge the possibility that this sex-dependent effect was due to in power issues and so these results should be interpreted with this in mind). This finding fits well with other studies which have shown that women reporting greater marital satisfaction experienced fewer sleep disturbances than those less maritally happy (Troxel et al. 2009). Of critical importance to the present study is specific consideration of the nonshared aspect of the environment. The differences in relationship satisfaction between twins within a pair were associated with twin discrepancy in sleep quality. If we interpret this finding as evidence of a purely nonshared environmental component to the association between relationship satisfaction and sleep quality, this could be explained by the fact that a large amount of satisfaction in romantic relationships is dependent on the behaviour of the partner as well as the individual, something which may be considered independent of one’s genetic or shared environmental background. One line of work investigating sleep and relationships suggests that we should consider the ‘social context’ of sleep (Troxel et al. 2007). That is, since the majority of adults typically share a bed with their partner, we should consider sleep as a dyadic process. It is possible that sleep disturbance in one increases the risk of sleep problems in their partner (Troxel et al. 2007). Indeed it has been found that women living with snorers report more insomnia symptoms than women living with non-snorers (Ulfberg et al. 2000), and that such disturbances from sleep are associated with greater marital dissatisfaction and divorce (Cartwright and Knight 1987).

Furthermore, it has been hypothesized that sleep is a vulnerable state and that optimal conditions for sleep occur when one can sufficiently down-regulate vigilance and alertness – a process that requires one to feel safe and secure both emotionally and physically (Troxel et al. 2007). It has been suggested that, from an evolutionary perspective women may rely on their larger, more dominant male partner to provide safety and protection. Thus, it is plausible that if a couple are experiencing relationship difficulties, the woman may not experience the safety and security necessary for optimal sleep (Troxel 2010). Evolutionarily this may seem plausible; however, males may also require feelings of safety and security emotionally for optimum sleep. Although these theories are compelling in the older samples typically studied in research on sleep and relationships, the fact that we found similar trends in our younger sample (only a few of whom were living with partners at the time of the study [n=24]) suggests that it is not only the immediate, proximal closeness of a relationship that affects sleep, but that other aspects of relationships outside of the bedroom are also important. Women are more sensitive to negative aspects of their relationships than men, spend more time thinking about events in their relationships, and become more upset from arguments (Kiecolt-Glaser and Newton 2001). Thus, it is possible that women consequently ruminate over their relationship issues, to the extent that this rumination disrupts their sleep. Indeed excessive cognitive activity and affective load are poor conditions for sleep (Harvey 2002), which may partially explain the gender differences so consistently evident in relation to sleep disturbance, and also the sex-dependent effect of relationships found here. Of course it is also possible that poor sleep adversely affects relationships. Indeed, evidence suggests that sleep deprivation has adverse effects on interpersonal and emotional responsiveness (Kahn-Greene et al. 2006), which may directly affect the way in which one interacts with their partner.

Regardless of the direction of the associations between sleep and the environment our results suggest that genetic influences (and possibly shared environmental influences) may be implicated in a wide range of seemingly “environmental” variables (with the exception of general health and relationship satisfaction). These findings may give insight into the mechanisms by which genes and environments affect sleep, and suggests that their influences may not be independent. It would be essential for future research to investigate the contribution of further candidate nonshared environmental influences on sleep quality. Furthermore, it would be beneficial for future research to incorporate a longitudinal element to the investigation of sleep and the environment in order to gain an understanding of the direction of effects, and to help us to further understand the variability in sleep observed in the population.

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Figure Caption:

Figure 1. Histogram of distribution of MZ difference scores for sleep quality (PSQI).