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Mindfulness and associations with symptoms of insomnia, anxiety and depression in early adulthood: A twin and sibling study

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ABSTRACT

This study investigated associations between mindfulness and symptoms of insomnia, depression and anxiety. Mindfulness was disaggregated into five subscales: 'nonreactivity to inner experience', 'observing', 'acting with awareness', 'describing' and 'nonjudging of inner experience'. Twin models were used to examine genetic and environmental influences on mindfulness, symptoms of insomnia, depression and anxiety and on their associations. Data came from a longitudinal twin/sibling study (G1219) comprising 862 individuals (age range 22–32 years, 66% females). Less mindfulness was associated with greater symptoms of insomnia, depression and anxiety (r = .22-.48). Of the mindfulness subscales, 'nonjudging of inner experience' was most strongly associated with the other traits. Overall mindfulness was largely influenced by non-shared environmental factors (E = .72) although familial influences played a role for overall mindfulness, as well as for the 'acting with awareness' and 'describing' subscales. The genetic correlations between overall mindfulness and symptoms of insomnia, depression and anxiety ranged from .32 to .75 (but were non-significant), while the shared environmental correlations ranged from −.78 to .79 (also non-significant). The non-shared environmental influences between these three variables were moderately, significantly correlated (rE = .21-.55).

1. Introduction

1.1. Conceptualisation of mindfulness

Mindfulness is generally defined as being present in the moment and being aware of inner as well as outer experiences while obtaining a non-judging perspective (Kabat-Zinn, 1994). Although there has been increasing research into the concept of mindfulness over the last two decades (Ie, Ngnoumen & Langer, 2014; Kabat-Zinn, 2003), it remains poorly understood as to why some people are so much more mindful than others. Mindfulness can be conceptualised in various ways, as a state, trait, or a skill that is learned (Sauer et al., 2013). In addition, mindfulness can be viewed as a unitary or a multi-dimensional concept (Sauer et al., 2013).

To allow a detailed understanding of the concept of mindfulness, the focus of the current study was not only on the overall mindfulness score, but also on five subscales or facets of trait mindfulness: 'nonreactivity to inner experience', 'observing', 'acting with awareness', 'describing' and 'nonjudging of inner experience'. 'Nonreactivity to inner experience' refers to the extent to which one is able to notice emotions and thoughts but let them go without having to react to them. For example, one may notice that (s)he is sad without having to cry. 'Observing' reflects the extent to which one is able to observe, notice or attend to the world around them as well as one's inner experience, including one's sensations, perceptions, thoughts and feelings. The subscale 'acting with awareness' examines the extent to which one is present in the moment, the here and now, and paying attention to what (s)he is doing or experiencing. The facet 'describing' refers to the ability to label or describe any experience of the inner world (e.g. feelings, thoughts, beliefs and expectations). Finally, 'nonjudging of inner experience' reflects the extent to which one is able to accept feelings and thoughts, avoiding judging one's inner experience (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006). This concept is in line with the Baer et al. (2006) view of mindfulness as having various facets which are useful to be explored. There is statistical evidence supporting the multi-dimensional model. When the FFMQ (Five Facet Mindfulness

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Questionnaire) was validated in the original publication (see Baer et al., 2006) the correlated five-factor model provided the best fit. This model assumes that the scale measures five distinct but related elements of mindfulness. Furthermore, a different research team evaluated the FFMQ and found that the unidimensional model showed a poor fit, while the correlated five-factor model had a good fit (Bohlmeijer, ten Klooster, Fledderus, Veehof, & Baer, 2011). The second-order hierarchical model (testing whether the five subscales are elements of an overall mindfulness factor) had a good fit as well (Bohlmeijer et al., 2011). Confirmatory factor analysis (CFA) run by another team has confirmed the five-facet structure for mindfulness as assessed by the FFMQ as well (see, for example, Veehof, Peter, Taal, Westerhof, & Bohlmeijer, 2011). The various subscales differ in their associations with other traits and research in this area is limited but may potentially help to improve the treatment and prevention of insomnia, depression and anxiety. Therefore, we consider the subscales worth further investigating.

1.2. Mindfulness sub-scales and other traits

Greater mindfulness has been associated with better sleep quality (Howell, Digdon, Buro, & Sheptycki, 2008), superior well-being (Brown & Ryan, 2003), as well as lower levels of depression and anxiety symptoms (Cash & Whittingham, 2010; Waszczuk et al., 2015). Furthermore, mindfulness-based approaches are used to treat insomnia, depression and anxiety (Hofmann, Sawyer, Witt, & Oh, 2010; Hubbling, Reilly-Spong, Kreitzer, & Gross, 2014; Ong, Ulmer, & Manber, 2012; Vøllestad, Sivertsen, & Nielsen, 2011). Mindfulness has also been considered to be crucial in the development and maintenance of insomnia and has taken a central role in cognitive theories of insomnia (for a detailed discussion see Ong et al., 2012).

It is important to consider mindfulness subscales when examining the correlation with other traits because certain mindfulness subscales may be particularly strongly associated with certain psychiatric difficulties. For example, self-reported ability to adopt a nonjudging attitude has been shown to predict lower levels of depression and anxiety symptoms (Cash & Whittingham, 2010). Furthermore, a greater ability to act with awareness was found to predict lower levels of depression symptoms, but not anxiety symptoms (Cash & Whittingham, 2010). In one study, four of the five subscales of mindfulness ('nonreactivity to inner experience', 'describing', 'acting with awareness' and 'nonjudging of inner experience', but not 'observing') were associated with sleep quality (Caldwell, Harrison, Adams, Quin, & Greeson, 2010) – with greater mindfulness related to better sleep quality. No study has yet examined the role that the subscales of mindfulness play in insomnia symptoms, further investigation of the subscales may eventually be useful in the development of better treatments for insomnia.

1.3. Aetiology of mindfulness

Little is known about the aetiology of mindfulness. To date, only one twin study has explored the genetic and environmental influences on 'trait' mindfulness in adolescents. This study focused exclusively on the attentional aspect of mindfulness finding that 'trait' mindfulness in adolescence was moderately heritable (additive genetic influence, A = .32) and was influenced by non-shared environmental factors (E = .66), with no significant influence of shared environmental factors (C = .02; Waszczuk et al., 2015). No previous study has investigated the genetic and environmental influences on different subscales of mindfulness.

Only one study has addressed the reason for overlap between mindfulness and other variables (namely depression symptoms and anxiety sensitivity) in adolescence (Waszczuk et al., 2015). The associations were largely explained by overlapping genetic influences. These associations are yet to be examined in an adult sample and here we attempt to replicate these results. Our interest is in the links with depression and anxiety symptoms along with the insomnia variable as previous research has highlighted strong associations between these symptoms both phenotypically and genetically (Gregory et al., 2005; Gregory et al., 2011; Gregory et al., 2016; Gregory, Van der Ende, Willis, & Verhulst, 2008).

1.4. Aims of the current study

Given the links between mindfulness and mental health, it is important to understand the aetiology of individual differences in mindfulness and its associations with other traits. The current study is novel in estimating genetic and environmental influences on mindfulness subscales and on symptoms of insomnia, depression and anxiety in early adulthood. The specific aims were to examine:

1) The magnitude of associations between mindfulness (as well as its subscales) and symptoms of insomnia, depression and anxiety.
2) Genetic and environmental influences on mindfulness (including the subscales) and on the association with symptoms of insomnia, depression and anxiety.

2. Method

2.1. Sample

Data from wave 5 of the Genesis 12-19 (G1219) longitudinal twin/sibling study (McAdams, Gregory, & Eley, 2013) was the focus of this study as this is the only wave at which mindfulness has been measured. Wave 5 included data from 223 monozygotic (MZ) twins, 404 dizygotic (DZ) twins and 218 non-twin siblings (see Denis et al., 2015). Participants were aged between 22 and 32 years (mean age 25 years) and 34.3% were male. There was a total of 862 individuals.

2.2. Mindfulness

Mindfulness was assessed by the Five Factor Mindfulness Questionnaire (FFMQ, Baer et al., 2006). The FFMQ comprises five subscales ('nonreactivity to inner experience', 'observing', 'acting with awareness', 'describing' and 'nonjudging of inner experience'). The original version of the measure contains 39 items. For the current study the measure was shortened to 21 items. The four items with the highest factor loading for each subscale were selected (Baer et al., 2006). Including the items with the highest factor loading is a common approach taken by others (e.g. Tschannen-Moran & Hoy, 2001; Bohlmeijer et al., 2011). This approach has also been evaluated in previous research and found to be useful (see Juniper, Guyatt, Streiner, & King, 1997). The 'nonreactivity to inner experience' subscale had three items with the same factor loading, therefore five items were included for this scale. Each item of the FFMQ was coded 1 to 5, ranging from "never or very rarely true", to "always or almost always true" (Baer et al., 2006). Items were summed for the subscales and for overall mindfulness that had a theoretical range from 21 to 105. Usually, higher scores on the FFMQ indicate greater mindfulness. For ease of interpretation and to allow the decomposition of positive associations in the multivariate genetic models, all mindfulness scores were reverse coded so that higher scores indicate less mindfulness. The question "How much experience do you have with meditation?" allowed us to control for meditation experience in our analyses, which is known to influence the mindfulness score (e.g. Walach, Buchheld, Buttenmüller, Kleinknecht, & Schmidt, 2006; Baer et al., 2006). This way we could look at individual differences in this trait regardless of training. The FFMQ is one of the most frequently used measures to assess mindfulness (Park, Reilly-Spong, & Gross, 2013; Sauer et al., 2013). In the original publication evaluating the FFMQ (Baer et al., 2006), good support for construct validity for the overall score and the subscales was found and good reliability was indicated. In that paper the Cronbach's alpha coefficients for all facets in all samples

were adequate-to-good, ranging from .72 to .92 in various samples, except for non-reactivity, which was .67 in one of the subsamples, but .81 to .86 in the three other samples (Baer et al., 2006). Other previous studies have found good criterion validity and reliability. Cronbach's alpha was .81 for the FFMQ for various age groups and different languages (e.g. Barros, Kozasa, Souza, & Ronzani, 2014; Veehof et al., 2011). Cronbach's alphas for the current sample were: .87 for 'non-reactivity to inner experience'; .80 for 'observing'; .84 for 'acting with awareness'; .86 for 'describing'; .88 for 'nonjudging of inner experience'; and .81 for overall mindfulness.

2.3. Insomnia symptoms

Insomnia symptoms were measured by the Insomnia Symptoms Questionnaire (ISQ, Okun et al., 2009), using a 6-item version. Each item of the ISQ was coded 0 to 4 based on frequency response (never/don't know = 0; rarely = 1; sometimes = 2; frequently = 3; always = 4). The total scale score is the sum of these responses, ranging from 0 to 24, with higher scores meaning more severe insomnia symptoms. Previous studies have found good reliability for the ISQ (Cronbach's alpha = .86 - .89, depending on the study) and the measure can identify the cases which meet diagnostic criteria for insomnia (Okun et al., 2009; Okun, Buysse, & Hall, 2015). The ISQ has been reported in twin research before (see Gregory at al., 2016 – using the same G1219 sample as reported in this manuscript). Cronbach's alpha for the ISQ in the current sample was .87.

2.4. Depression symptoms

Depression symptoms were measured by the mood and feelings questionnaire (MFQ; Angold et al., 1995), which assesses depression symptoms experienced over the past two weeks via self-report. The measure includes 13 items which are coded 0 = not true, 1 = sometimes and 2 = true. Items were summed to produce a total score. Items include "I felt miserable or unhappy" or "I cried a lot". The MFQ (Angold et al., 1995) shows moderate to high criterion validity and acceptable reliability. Cronbach's alpha for the current sample was .90. This measure has been found to be a satisfactory tool for screening for major depressive disorder as diagnosed by clinical interviews (Angold et al., 1995; Burleson Daviss et al., 2006; Crowe, Ward, Dunnachie, & Roberts, 2006; Kent, Vostanis, & Feehan, 1997; Wood, Kroll, Moore, & Harrington, 1995). It is frequently used in twin studies (see, for example, Haworth, Carter, Eley, & Plomin, 2017; Wilkinson, Trzaskowski, Haworth, & Eley, 2013).

2.5. Anxiety symptoms

Symptoms of anxiety were measured by an age-adapted version of the revised children anxiety and depression scale (RCADS, Willis, 2007; Chorpita, Yim, Moffitt, Umemoto, & Francis, 2000), comprising 36 items for assessing symptoms of anxiety as described by the DSM-IV (APA, 2000). Examples of the items are "I would feel afraid of being on my own at home" and "I feel worried when I think someone is angry with me" (Chorpita et al., 2000; Willis, 2007). The total score was calculated by coding each item (never = 0, sometimes = 1, often = 2, always = 3) and then taking the sum (Gregory et al., 2011). The RCADS has shown favourable discriminant, factorial and convergent validity and good reliability (in some studies excellent reliability with a Cronbach's alpha of .96; Chorpita et al., 2000; Esbjørn, Sømhovd, Turnstedt, & Reinholdt-Dunne, 2012; Ebesutani et al., 2011; Morin, Belleville, Bélanger, & Ivers, 2011; Kösters, Chinapaw, Zwaanswijk, van der Wal, & Koot, 2015; Willis, 2007). Cronbach's alpha for the current sample was .94. This measure of anxiety symptoms is often used in twin research (see, for example, Brown et al., 2014; Hallett et al., 2013; Mikolajewski, Allan, Hart, Lonigan, & Taylor, 2013).

2.6. Data preparation

Skewness and kurtosis were within an accepted range for all variables, with the exception of depression symptoms. Skewness ranged from −.36 (SE = .08) for 'acting with awareness' to 1.16 for anxiety; kurtosis ranged from −.30 for 'nonreactivity to inner experience' to 1.34 for anxiety. For depression symptoms, skewness was 1.42 (SE = .08) and kurtosis was 1.67 (SE = .17). The depression symptoms variable was therefore log-transformed before analyses as in a previous paper using this data (Gregory et al., 2016), which successfully reduced the skew (skew = −.15, SE = .08; kurtosis = −.79, SE = .17). For all variables, outliers more than +/- 3 standard deviations away from the mean were excluded from the sample (in total 17 cases). For the twin analyses all variables were age and sex regressed which is standard in genetic model fitting (Bolhuis et al., 2014; Gregory et al., 2011). All phenotypic analyses were performed on data from one randomly selected twin/sibling from each pair, to control for non-independence of observations.

2.7. Analyses

Descriptive statistics were run on untransformed variables in SPSS (version 22; IBM, 2013). Phenotypic correlations examined associations among the variables. Partial correlations were also examined to assess associations between each mindfulness subscale and insomnia, depression and anxiety symptoms, free from any relationship with the other subscales. For example, when assessing the association between 'acting with awareness' and symptoms of insomnia, depression and anxiety, we controlled for the effects of all of the other mindfulness subscales. In this manner we could assess whether certain mindfulness subscales were more important than others in driving associations. The resulting partial correlations were compared in magnitude using Javascript (Lee & Preacher, 2013; Steiger, 1980).

Twin analyses were used to investigate the aetiology of mindfulness and its relationship with anxiety, depression and insomnia. The twin methodology compares the degree of similarity between monozygotic (MZ) twins who are genetically identical, with dizygotic (DZ) twins who share on average 50% of their segregating genes. The method assumes that MZ and DZ twin pairs share similarly equal environments (equal environment assumption) so any increased similarity in MZ twins relative to DZ twins is attributed to genetic influences. Using this design, it is possible to estimate additive genetic (A), common or shared environmental (C), and non-shared environmental (E) influences on single traits and correlations between traits. Additive genetic influences are those whereby individual differences in a phenotype are influenced by the additive effect of independent alleles (i.e. versions of a particular gene at one locus in the genome). Shared environmental influences are defined as environmental factors making members of the same family similar to one another, while non-shared environmental influences are environmental influences that make members of the same family different. E also includes measurement error (Knopik, Neiderhiser, DeFries, & Plomin, 2016; Schneider, Denis, Buysse, Kovas, & Gregory, 2018). Analyses were performed, using R with a package for genetic model fitting called OpenMX, which uses maximum likelihood estimation to compare model fits (Boker et al., 2011).

For each variable a univariate analysis was run, applying maximum-likelihood model fitting analysis to estimate the relative contribution of genetic, shared and non-shared environmental influence (Neale & Cardon, 1992). 95% confidence intervals are reported for all estimates to help interpret the results. Those that span 0 (for example, 95% CI = -1 - 1) are non-significant (Rijsdijk & Sham, 2002). Multivariate analyses, including overall mindfulness, insomnia symptoms, depression symptoms and anxiety symptoms, were run to examine the contribution of A, C and E to the associations between traits. Three models were compared: the correlated factors solution, the independent pathway and the common pathway model (see Fig. 1).

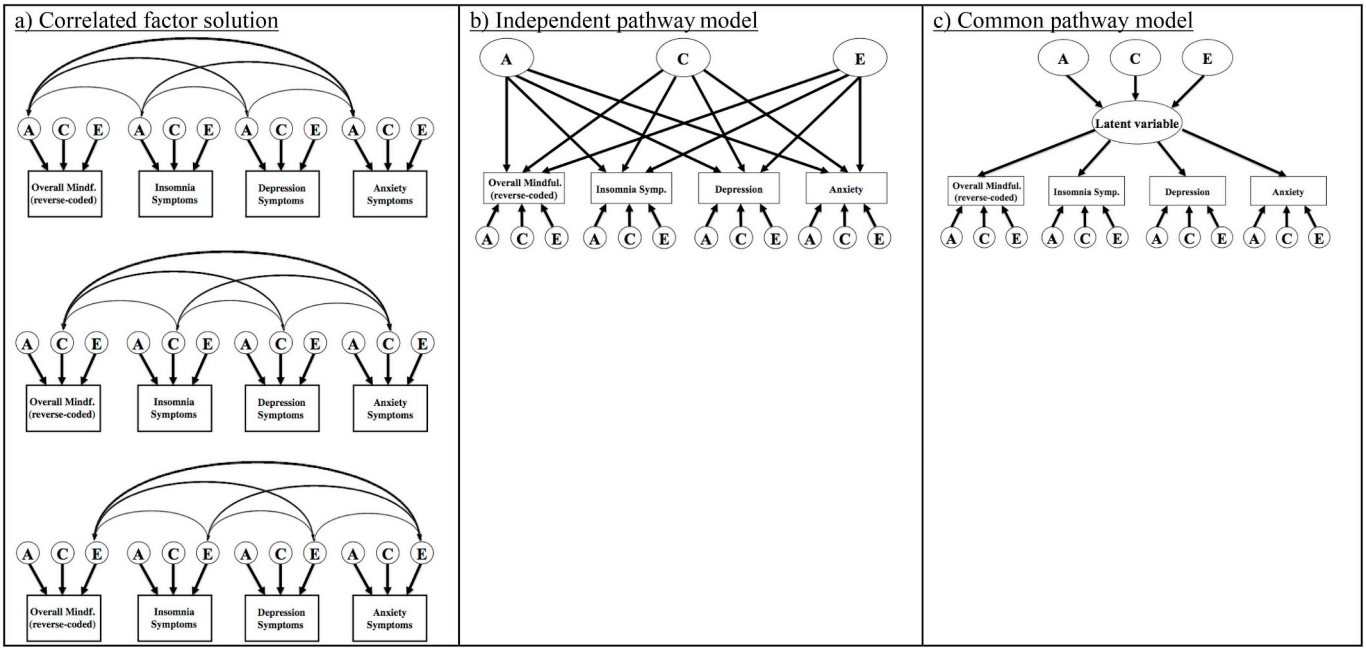

Fig. 1. Examples for path diagrams, explaining correlated factors solution, independent pathway model and common pathway model.
Note: A = additive genetic; C = shared environmental; E = non-shared environmental; Overall Mindful. = overall score of mindfulness (FFMQ), reverse coded, higher score indicating lower mindfulness; Insomnia Symptoms = insomnia symptoms (ISQ), higher scores indicating more insomnia symptoms; Depression Symptoms = symptoms of depression (MFQ), higher scores indicating more symptoms of depression; Anxiety Symptoms = symptoms of anxiety (RCADS), higher scores indicating more symptoms of anxiety.

In the correlated factor solution, it is assumed that each trait is influenced by genetic, shared environmental and non-shared environmental influences. These influences are allowed to correlate with those on the other traits in the model (see Fig. 1 a, Loehlin, 1996; Rijsdijk & Sham, 2002). The independent pathway model assumes that common genetic factors, common shared environmental factors and common non-shared environmental factors influence traits directly. Specific genetic, shared environmental and non-shared environmental factors are also allowed to contribute to the variance of each phenotype individually (see Fig. 1 b, Rijsdijk & Sham, 2002). The common pathway model assumes a genetic, shared environmental and a non-shared environmental influence, which influences the variables via a higher order latent factor. Specific genetic, shared environmental and non-shared environmental factors that contribute to the variance of each phenotype independently are also specified (see Fig. 1 c, Rijsdijk & Sham, 2002).

In addition to the analyses on the whole sample, a sensitivity analysis was performed by excluding all cases with meditation experience (N = 246) and re-running all twin analyses. The results were similar, therefore results from the full sample are presented.

After completing the analyses, power calculations were run in order to consider how to best interpret the estimates provided by the twin models. The results indicated that we had limited power (under 80% in all analyses) to detect significant heritability estimates of the magnitudes reported in the univariate analyses. However, by comparing the ACE to the E model it was possible to consider if the variables showed familial influence even when the individual genetic or shared environmental influences were not significant. Familial influence means that genes and/or shared environment (influences coming from sharing the same family) influenced the trait. This can be significant even when individual A and C estimates are not (because we are underpowered to disentangle the extent to which influence comes from one and/or the other factor). Because of the limitations of statistical power, we do not focus exclusively on significance but also consider the magnitudes of effects.

3. Results

3.1. Descriptive statistics

Descriptive statistics for each variable are summarised in Table 1. Males (mean = 34.23, SD = 10.90) were more mindful than females (mean = 36.46, SD = 10.01, $t(847) = 3.01$, $p < .01$, $d = .21$). Males (mean = 5.65, SD = 4.89) reported fewer insomnia symptoms than females (mean = 6.92, SD = 5.33, $t(625) = -3.28$, $p < .01$, $d = .25$). Males (mean = 4.68, SD = 4.73) reported fewer depression symptoms than females (mean = 5.64, SD = 5.55, $t(681) = -2.63$, $p < .01$, $d = .19$). Males (mean = 17.31, SD = 13.19) reported fewer symptoms of anxiety than females (mean = 24.65, SD = 14.99, $t(662) = -7.23$, $p < .01$, $d = .52$).

3.2. Phenotypic correlations and MZ, DZ and sibling correlations

The phenotypic correlations are displayed in Table 2. Less mindfulness was associated with more insomnia symptoms, more depression symptoms and more symptoms of anxiety ($r = .22$ to .48; note again that mindfulness and its subscales were reverse coded). When considering mindfulness subscales, the 'nonjudging of inner experience' scale, was the subscale most highly correlated with insomnia symptoms ($r = .34$, $p < .01$), depression symptoms ($r = .54$, $p < .01$) and symptoms of anxiety ($r = .55$, $p < .01$). Partial correlations did not find any of the specific subscales to drive the association between overall mindfulness and symptoms of insomnia, depression and anxiety (see Table 3). After partialling out the other subscales, the 'nonjudging of inner experience' subscale still showed the highest correlation with insomnia symptoms, $r = .23$, $p < .01$ (although note that the correlation between 'acting with awareness' and insomnia symptoms, $r = .18$, $p < .01$ was not significantly lower, $p = .45$). The 'nonjudging of inner experience' subscale (as compared to the other mindfulness subscales) also correlated most strongly with depression symptoms ($r = .43$,

Table 1
Means (SD) of raw scores for overall mindfulness, mindfulness subscales and symptoms of insomnia, depression and anxiety.

	Means (SD)					
	Total	Males	Females	MZ	DZ	Siblings
Overall Mindf.	35.70 (10.37)	34.23 (10.90)*	36.46 (10.01)*	35.88 (10.47)	36.19 (10.74)	34.67 (9.68)
'Nonreactivity'	9.40 (4.54)	8.00 (4.39)	10.12 (4.45)	9.77 (4.72)	9.44 (4.57)	8.96 (4.35)
'Observing'	9.53 (3.59)	9.42 (3.54)	9.59 (3.61)	9.47 (3.75)	9.49 (3.67)	9.60 (3.29)
'Acting with Awareness'	5.27 (3.21)	5.37 (3.27)	5.21 (3.18)	5.07 (3.15)	5.30 (3.39)	5.42 (2.95)
'Describing'	6.69 (3.66)	6.70 (3.79)	6.69 (3.60)	6.85 (3.88)	6.93 (3.60)	6.16 (3.60)
'Nonjudging'	4.83 (3.73)	4.79 (3.68)	4.85 (3.76)	4.74 (3.77)	5.04 (3.91)	4.54 (3.30)
Insomnia Symptoms	6.48 (5.22)	5.65 (4.89)*	6.92 (5.33)*	6.09 (4.97)	6.68 (5.38)	6.61 (5.19)
Depression Symptoms	5.31 (5.30)	4.68 (4.73)*	5.64 (5.55)*	5.34 (5.44)	5.73 (5.73)	4.54 (4.21)
Anxiety Symptoms	22.13 (14.81)	17.31 (13.19)*	24.65 (14.99)*	23.93 (15.03)	22.32 (15.32)	20.11 (13.32)

Note: MZ = monozygotic twins; DZ = dizygotic twins; Siblings = non-twin sibling pairs; * sex differences were found; Means and SD were obtained from SPSS and are based on the raw data (untransformed, including outliers, etc., but reverse coded for overall mindfulness and mindfulness subscales). Overall Mindf. = overall score of mindfulness (FFMQ), reverse coded, but not transformed in any other way, higher scores indicating lower mindfulness; 'Nonreactivity' = subscale of mindfulness (FFMQ), reverse coded, higher scores indicating stronger reaction to inner experience; 'Observing' = subscale of mindfulness (FFMQ), reverse coded, higher scores indicating lower ability to observe, notice, attend to sensations, perceptions, thoughts and feelings; 'Acting with A.' = subscale of mindfulness (FFMQ), reverse coded, higher scores indicating acting less aware; 'Describing' = subscale of mindfulness (FFMQ), reverse coded, higher scores indicating lower ability to describe or label feelings, thoughts, beliefs, expectations, etc.; 'Nonjudging' = subscale of mindfulness (FFMQ), reverse coded, higher scores indicating more judging of inner experience; Insomnia Symptoms = insomnia symptoms (ISQ), higher scores indicating more insomnia symptoms; Depression = symptoms of depression (MFQ), higher scores indicating more symptoms of depression; Anxiety = symptoms of anxiety (RCADS), higher scores indicating more anxiety symptoms.

$p < .01$) and anxiety symptoms ($r = .44$, $p < .01$). The subscales 'describing' and 'observing' were not significantly correlated with insomnia and depression symptoms; and 'describing' was not significantly correlated with anxiety symptoms, after controlling for the other subscales.

The MZ, DZ and sibling within-trait correlations and the cross-trait correlations for all of the variables are presented in Table 4. The MZ correlations for overall mindfulness (and all subscales, except for 'nonreactivity'), symptoms of insomnia, depression and anxiety were stronger (although not significantly, as indicated by overlapping 95% confidence intervals) than the DZ correlations, indicating possible genetic influence. As the MZ correlations are substantially less than 1 for all of the traits, the importance of non-shared environmental influence (E; including error) is highlighted.

3.3. Univariate genetic model fitting

Univariate analyses were run on all variables for completeness; even for 'nonreactivity to inner experience' for which the DZ and the sibling correlations were marginally higher than the MZ correlations and so genetic influence would not be indicated. The fit statistics and the results of the full ACE models (estimates of A, C and E with 95% confidence intervals) are presented in Table 5. Full ACE models are presented for the univariate analyses throughout. Overall mindfulness was mainly influenced by E (E = .72; 95% CI = .06–.88). The estimate for genetic influence on overall mindfulness was small (A = .17) and did not reach significance. However, when A and C were both dropped from the model, it led to a significant decline in fit ($\chi^2 = 6181.56$, df = 831, $p < .01$, AIC = 4519.56), suggesting familial influences also play a role in the aetiology of mindfulness. For the subscales, non-shared environment appeared to be most important and familiality was indicated for the subscales 'acting with awareness' and 'describing' but not for 'nonreactivity', 'observing' and 'nonjudging of inner experience'. Similarly, non-shared environmental influence was key for symptoms of insomnia, depression and anxiety, which were all found to also show familiality. The estimates for genetic influence on insomnia symptoms (A = .36) and anxiety symptoms (A = .36) were medium but did not reach significance, while a significant medium estimate for genetic influence on depression symptoms was shown (A = .33; 95% CI = .01–.48).

Table 2
Phenotypic correlations for overall mindfulness, subscales of mindfulness, symptoms of insomnia, depression and anxiety.

	Overall Mindf.	'Nonreact.'	'Observing'	'Acting with A.'	'Describing'	'Nonjudging'	Insomnia Symptoms	Depression Symptoms	Anxiety Sympt.
Overall Mindfulness	1								
'Nonreactivity'	.62**	1							
'Observing'	.32**	.16**	1						
'Acting with Awareness'	.54**	.08	−10*	1					
'Describing'	.63**	.17**	.11*	.28**	1				
'Nonjudging'	.54**	.12*	-.17**	.40**	.24**	1			
Insomnia Symptoms	.22**	.01	-.13**	.31**	.17**	.34**	1		
Depression Sympt.	.48**	.25**	-.08	.42**	.26**	.54**	.49**	1	
Anxiety Symptoms	.46**	.29**	-.16**	.37**	.26**	.55**	.46**	.62**	1

Note: *$p < .05$; **$p < .01$. Correlations were calculated on transformed data, using twin 1 only to control for non-independence of observations. Overall Mindfulness = overall score of mindfulness (FFMQ), reverse coded, higher score indicating lower mindfulness; 'Nonreact.' = subscale of mindfulness (FFMQ), reverse coded, higher scores indicating stronger reaction to inner experience; 'Observing' = subscale of mindfulness (FFMQ), reverse coded, higher scores indicating lower ability to observe, notice, attend to sensations, perceptions, thoughts and feelings; 'Acting with A.' = subscale of mindfulness (FFMQ), reverse coded, higher scores indicating acting less aware; 'Describing' = subscale of mindfulness (FFMQ), reverse coded, higher scores indicating lower ability to describe or label feelings, thoughts, beliefs, expectations, etc.; 'Nonjudging' = subscale of mindfulness (FFMQ), reverse coded, higher scores indicating more judging of inner experience; Insomnia Symptoms = insomnia symptoms (ISQ), higher scores indicating more insomnia symptoms; Depression Symptoms = symptoms of depression (MFQ), higher scores indicating more symptoms of depression; Anxiety Sympt. = symptoms of anxiety (RCADS), higher scores indicating more symptoms of anxiety.

Table 3
Phenotypic correlations for each subscale of mindfulness with symptoms of insomnia, depression and anxiety after partialling out all other subscales.

	'Nonreactivity'	'Observing'	'Acting with Awareness'	'Describing'	'Nonjudging'
Insomnia Symptoms	-.04	-.07	**.18****	.06	**.23****
Depression Symptoms	.21**	-.03	.23**	.07	**.43****
Anxiety Symptoms	.29**	-.15**	.19**	.07	**.44****

Note: *p < .05; **p < .01; Insomnia Symptoms = insomnia symptoms (ISQ), higher scores indicating more insomnia symptoms; Depression = symptoms of depression (MFQ), 'Nonreactivity' = subscale of mindfulness (FFMQ), reverse coded, higher scores indicating stronger reaction to inner experience; 'Observing' = subscale of mindfulness (FFMQ), reverse coded, higher scores indicating lower ability to observe, notice, attend to sensations, perceptions, thoughts and feelings; 'Acting with Awareness' = subscale of mindfulness (FFMQ), reverse coded, higher scores indicating acting less aware; 'Describing' = subscale of mindfulness (FFMQ), reverse coded, higher scores indicating lower ability to describe or label feelings, thoughts, beliefs, expectations, etc.; 'Nonjudging' = subscale of mindfulness (FFMQ), reverse coded, higher scores indicating more judging of inner experience; the subscale most strongly correlating with insomnia symptoms, depression and anxiety is highlighted in bold, if no significant difference in correlation was found between the first and second most strongly correlating subscale then more than one value is highlighted in bold.

Table 4
Twin/sibling correlations (within-trait and across-traits) for overall mindfulness and symptoms of insomnia, depression and anxiety.

		Twin 1			
Twin 2		Overall Mindf.	Insomnia Symptoms	Depression Symptoms	Anxiety Symptoms
Overall Mindf.	MZ	.27 (.07 - .44)	-	-	-
	DZ	.20 (.05 - .34)	-	-	-
	Sib	.14 (-.14 - .38)	-	-	-
Insomnia Symptoms	MZ	.09 (-.05 - .22)	.37 (.19 - .53)	-	-
	DZ	.07 (-.04 - .18)	.21 (.05 - .35)	-	-
	Sib	.18 (-.01 - .34)	.12 (-.13 - .34)	-	-
Depression Symptoms	MZ	.23 (.08 - .35)	.32 (.18 - .45)	.36 (.17 - .52)	-
	DZ	.08 (-.04 - .19)	.10 (-.02 - .21)	.20 (.05 - .33)	-
	Sib	.09 (-.11 - .28)	.05 (-.14 - .24)	-.03 (-.27 - .21)	-
Anxiety Symptoms	MZ	.16 (.01 - .28)	.32 (.18 - .44)	.31 (.16 - .43)	.41 (.24 - .54)
	DZ	.09 (-.02 - .20)	.09 (-.02 - .20)	.11 (-.01 - .22)	.21 (.07 - .34)
	Sib	.24 (-.01 - .42)	.17 (-.05 - .35)	.18 (-.08 - .37)	.35 (-.01 - .56)

Note: The 95% confidence intervals are presented in brackets. MZ = monozygotic twins; DZ = dizygotic twins; Sib = sibling pairs; Overall Mindf. = overall score of mindfulness (FFMQ), reverse coded, higher scores indicating lower mindfulness; Insomnia Symptoms = insomnia symptoms (ISQ), higher scores indicating more insomnia symptoms; Depression = symptoms of depression (MFQ), higher scores indicating more symptoms of depression; Anxiety Symptoms = symptoms of anxiety (RCADS), higher scores indicating more symptoms of anxiety. Within-trait correlations are highlighted in grey.

3.4. Multivariate model fitting

Fit statistics for multivariate analyses are presented in Table 6. The fit of the correlated factors solution ($\chi^2 = 17616.00$, df = 3312, $p = .07$, AIC = 10992.00) and the independent pathway model ($\chi^2 = 17623.34$, df = 3318, $p = .06$, AIC = 10987.34) were similar, while the common pathway model had a significantly worse fit ($\chi^2 = 17650.15$, df = 3324, $p < .01$, AIC = 11002.15). As the fit of the correlated factors model and the independent pathway model were so similar it was equally valid to present either model. We decided to present the correlated factors model, which is typically considered most straight forward to interpret.

From Fig. 2a, we can see that the genetic correlations between overall mindfulness and the other variables ranged from .32 to .75 (although these were not significant, 95% confidence intervals all −1 to 1). The genetic correlations between insomnia, depression and anxiety symptoms were high, ranging from 0.87 to 1 (and were all significant). The shared environmental influences between the four traits ranged from −.78 to .79 (all non-significant, 95% confidence intervals all −1 to 1) – see Fig. 2 b. As Fig. 2 c shows, the non-shared environmental influences between overall mindfulness, insomnia symptoms, depression symptoms and anxiety symptoms were moderately correlated, ranging from .21 to .55 (all significant). The relative contribution of A, C and E to the overall phenotypic correlations is shown in Fig. 3.

Table 5
Fit statistics of all univariate genetic model fitting analyses.

Variable/Model	ep	-2LL	df	AIC	Δ -2LL	Δ df	*p*	*Parameter Estimates*		
								A (CI)	*C (CI)*	*E (CI)*
Overall Mindfulness										
Saturated	15	6165.79	818	4519.77	–	–	–			
ACE	4	6166.07	829	4508.07	10.29	11	.50	.17 (0–.45)	.11 (0–.32)	.72 (.06–.88)
E	2	6181.56	831	4519.56	15.48	2	< .01			
'Nonreactivity'										
Saturated	15	4835.75	821	3193.75	–	–	–			
ACE	4	4845.43	832	3181.43	9.68	11	.56	0 (0–.28)	.13 (0–.24)	.87 (.72–.98)
E	2	4850.46	834	3182.46	14.71	2	.08			
'Observing'										
Saturated	15	4505.53	823	2859.54	–	–	–			
ACE	4	4516.76	834	2848.76	11.22	11	.32	.16 (0–.31)	0 (0–.16)	.84 (.69–1)
E	2	4520.42	836	2848.42	3.66	2	.16			
'Acting with Awareness'										
Saturated	15	4244.63	819	2609.63	–	–	–			
ACE	4	4260.19	830	2600.19	15.56	11	.16	.09 (0–.40)	.12 (0–.28)	.79 (.60–.93)
E	2	4269.73	832	2605.73	9.54	2	.01			
'Describing'										
Saturated	15	4524.38	824	2876.38	–	–	–			
ACE	4	4533.24	835	2863.24	8.86	11	.63	.28 (.06–.42)	0 (0–.13)	.72 (.58–.88)
E	2	4544.54	837	2870.54	11.30	2	< .01			
'Nonjudging of inner experience'										
Saturated	15	4503.57	820	2869.86	–	–	–			
ACE	4	4522.29	831	2860.29	18.72	11	.07	.18 (0–.33)	0 (0–.21)	.82 (.67–.99)
E	2	4526.87	833	2860.87	4.58	2	.10			
Insomnia Symptoms										
Saturated	15	5033.03	819	3395.03	–	–	–			
ACE	4	5041.81	830	3381.81	8.78	11	.64	.36 (0–.50)	0 (0–.30)	.64 (.50–.84)
E	2	5059.69	832	3395.69	17.88	2	< .01			
Depression Symptoms										
Saturated	15	724.47	829	−933.53	–	–	–			
ACE	4	736.00	840	−944.00	11.53	11	.40	.33 (.01–.48)	0 (0–.20)	.67 (.52–.83)
E	2	752.27	842	−931.73	16.27	2	< .01			
Anxiety Symptoms										
Saturated	15	6632.89	820	4992.89	–	–	–			
ACE	4	6653.79	831	4991.79	20.89	11	.03	.36 (0–.53)	.04 (0–.33)	.60 (.47–.77)
E	2	6682.30	833	5016.30	28.51	2	< .01			

Note: All analyses focus on transformed variables, regressed out age and sex. ep = estimated parameters; -2LL = −2*(log likelihood); df = degrees of freedom; $\Delta\chi^2$ and Δdf = change in chi-square statistic and corresponding degrees of freedom (computed as the difference in likelihood and df between each model and the saturated model); AIC = Akaike's Information Criterion statistic (calculated as $\chi 2$ – 2df); Saturated = full model; A = additive genetic; C = shared environmental; E = non-shared environmental. The fit of the ACE model is relative to saturated model, the fit of the E model relative to ACE model. The 95% confidence intervals are presented in brackets.

4. Discussion

The aims of the present study were to analyse the association between mindfulness (and its subscales) and symptoms of insomnia, depression and anxiety. A further aim was to estimate the aetiology of mindfulness (and its subscales) as well as of its associations with symptoms of insomnia, depression and anxiety.

4.1. Associations between variables

Lower mindfulness was associated with more symptoms of insomnia, depression and anxiety. This is in line with research by Waszczuk et al. (2015) – although the magnitude of the associations we reported were slightly higher than those in the aforementioned study (which focused on slightly different phenotypes). In line with previous findings, males were more mindful than females (Waszczuk et al., 2015).

Table 6
Fit statistics for the multivariate genetic model fitting analyses.

	ep	-2LL	df	AIC	Δ -2LL	Δ df	*p*
Model: Overall mindfulness, symptoms of insomnia, depression and anxiety							
Saturated	132	17496.51	3214	11068.51	–	–	–
ACE Correlated Factors Solution	**34**	**17616.00**	**3312**	**10992.00**	**119.49**	**98**	**.07**
ACE Independent Pathway	28	17623.34	3318	10987.34	126.84	104	.06
ACE Common Pathway	23	17650.15	3324	11002.15	153.64	110	< .01

Note: All analyses focus on transformed variables, regressing out age and sex. ep = estimated parameters; -2LL = −2*(log likelihood); df = degrees of freedom; $\Delta\chi^2$ and Δdf = change in chi-square statistic and corresponding degrees of freedom (computed as the difference in likelihood and df between each model and the saturated model); AIC = Akaike's Information Criterion statistic (calculated as χ^2 – 2df); Saturated = full model; A = additive genetic; C = shared environmental; E = non-shared environmental. The fit statistics of the ACE correlated factors model, the ACE independent pathway model and the ACE common pathway model are relative to the saturated model. *Model:* Phenotypes overall mindfulness (reverse coded, FFMQ), insomnia symptoms (ISQ), symptoms of depression (MFQ), anxiety (RCADS). The presented model is highlighted in bold.

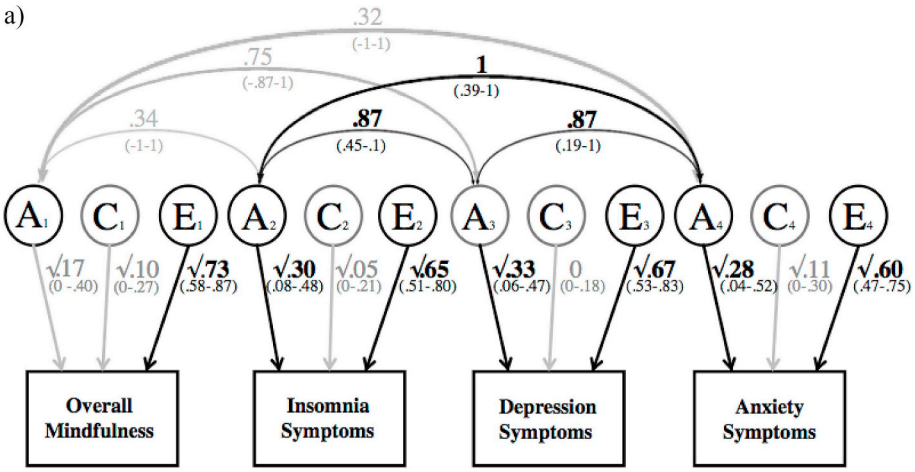

Fig. 2a. Path diagram of the genetic correlations in the correlated factors solution, including overall mindfulness, insomnia symptoms, depression and correlations.
Note: A = additive genetic, C = shared environmental; E = non-shared environmental. Significant paths are shown in black. Paths with confidence intervals spanning 0 are depicted in grey. Overall mindfulness = overall score of mindfulness (FFMQ), reverse coded, higher score indicating lower mindfulness; Insomnia Symptoms = insomnia symptoms (ISQ), higher scores indicating more insomnia symptoms; Depression Symptoms = symptoms of depression (MFQ), higher scores indicating more symptoms of depression; Anxiety Symptoms = symptoms of anxiety (RCADS), higher scores indicating more symptoms of anxiety.

Of the mindfulness subscales, 'nonjudging of inner experience' had the strongest association with symptoms of insomnia, depression and anxiety (although the associations with 'acting with awareness' were of a similar magnitude for the association with insomnia symptoms). These findings are in line with previous research, focusing on the subscales of mindfulness and sleep quality (Caldwell et al., 2010), depression and anxiety symptoms, which found that four of the five subscales of mindfulness ('nonreactivity to inner experience', 'describing', 'acting with awareness' and 'nonjudging of inner experience', but not 'observing') were associated with sleep quality – with greater mindfulness related to better sleep quality (Cash & Whittingham, 2010). Baer et al. (2006) also found that of the five subscales, 'nonjudging of inner experience' had the highest (negative) correlation and 'act with awareness' the second highest (negative) correlation with psychological symptoms. The current phenotypic analysis also showed that 'observing' was not associated with insomnia symptoms, which is in line with a study focusing on mindfulness and sleep quality (Caldwell et al., 2010). 'Observing' was further found to have a small non-significant negative association with depression and a small significant association with anxiety. Interestingly, Baer et al. (2006) have previously pointed out that when considering the association between the mindfulness subscales and other constructs, 'observing' was the only subscale that showed correlations in an unexpected direction. A possible explanation given was that the items of the 'observing' subscale may not adequately capture this aspect of mindfulness (Baer et al., 2006). Furthermore, Cash and Whittingham (2010) found that the 'observing' subscale did not predict depression, anxiety and stress symptoms, while 'nonjudging of inner experience' did.

While none of the subscales appeared to drive the association between overall mindfulness and symptoms of insomnia, depression and anxiety, it may be worth further investigating the trends reported here. Indeed, finding that certain subscales are more strongly associated with symptoms of insomnia, depression and anxiety than others could potentially be useful for generating ideas for improving mindfulness-based-treatment. For example, treatment could focus specifically on the importance of certain skills (such as the ability to avoid judgement about inner experiences such as thoughts and feelings).

4.2. Familial influences

In this study, we found that overall mindfulness as well as the subscales 'acting with awareness' and 'describing' were to some extent familial. This means that some influence was coming from factors common to family members (i.e., genetic and/or shared environmental influences). The magnitude of the findings reported here are largely consistent with the only previous twin study, which found genetic influence on attentional aspect of mindfulness (Waszczuk et al., 2015). The discrepancy in the magnitude of parameter estimates between studies (e.g. there was greater genetic influence and no shared environmental influence in the previous study) may arise from having used different measures and conceptualisations of mindfulness. Here we focused on mindfulness, including attentional as well as emotional/interpretational aspects, whereas the other report focused on the attentional aspects of mindfulness exclusively. Furthermore, heritability

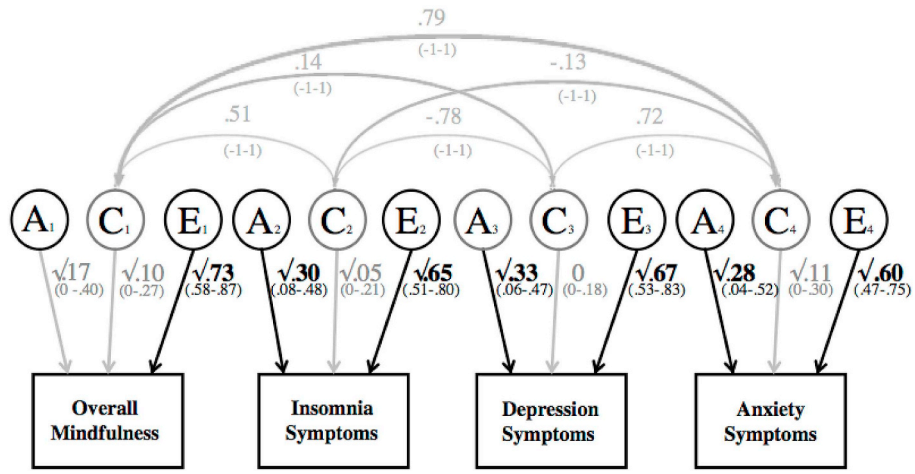

Fig. 2b. Path diagram of the shared environmental correlations in the correlated factors solution, including overall mindfulness, insomnia symptoms, depression and correlations.
Note: A = additive genetic, C = shared environmental; E = non-shared environmental. Significant paths are shown in black. Paths with confidence intervals spanning 0 are depicted in grey. Overall mindfulness = overall score of mindfulness (FFMQ), reverse coded, higher score indicating lower mindfulness; Insomnia Symptoms = insomnia symptoms (ISQ), higher scores indicating more insomnia symptoms; Depression Symptoms = symptoms of depression (MFQ), higher scores indicating more symptoms of depression; Anxiety Symptoms = symptoms of anxiety (RCADS), higher scores indicating more symptoms of anxiety.

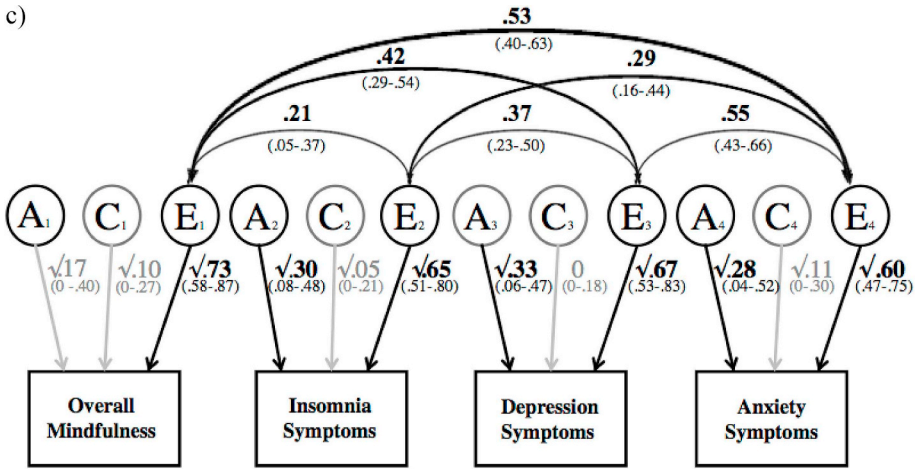

Fig. 2c. Path diagram of the non-shared environmental correlations in the correlated factors solution, including overall mindfulness and insomnia, depression and anxiety symptoms correlations.
Note: A = additive genetic, C = shared environmental; E = non-shared environmental. Significant paths are shown in black. Paths with confidence intervals spanning 0 are depicted in grey. Overall mindfulness = overall score of mindfulness (FFMQ), reverse coded, higher score indicating lower mindfulness; Insomnia Symptoms = insomnia symptoms (ISQ), higher scores indicating more insomnia symptoms; Depression Symptoms = symptoms of depression (MFQ), higher scores indicating more symptoms of depression; Anxiety Symptoms = symptoms of anxiety (RCADS), higher scores indicating more symptoms of anxiety.

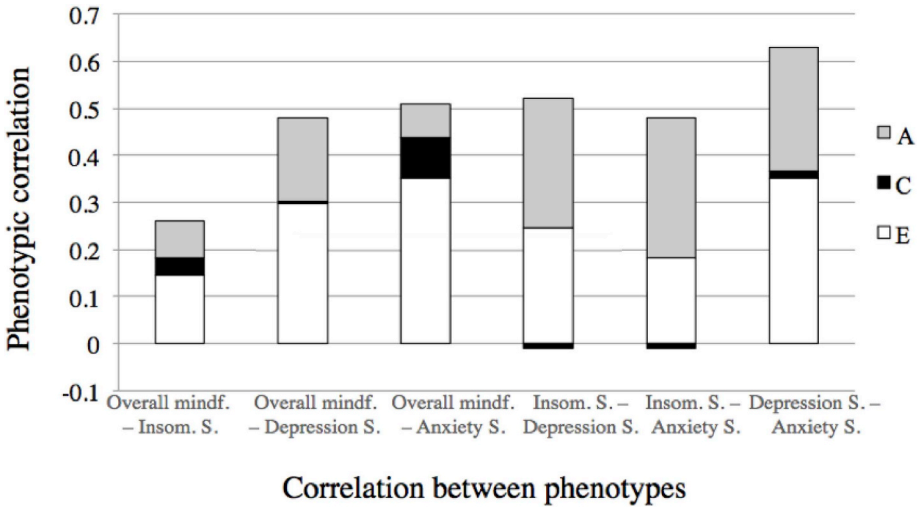

Fig. 3. Relative contributions of A, C and E to the overall phenotypic correlations.
Note: A = additive genetic, C = shared environmental, E = non-shared environmental. Overall mindf. = overall score of mindfulness (FFMQ), reverse coded, higher score indicating lower mindfulness; Insom. S. = insomnia symptoms (ISQ), higher scores indicating more insomnia symptoms; Depress. S. = symptoms of depression (MFQ), higher scores indicating more symptoms of depression; Anxiety S. = symptoms of anxiety (RCADS), higher scores indicating more symptoms of anxiety. This statistic shows how much A, C and E contributed proportionally (highlighted in grey, black and white) to the phenotypic correlations of two traits (shown on the x-axis). A black bar underneath the column indicates a negative correlation for C.

is a population statistic, which means that estimates may vary in different samples and while the current study focused on adults, the previous study analysed data from adolescents. The genetic influence for overall mindfulness was significant in the study by Waszczuk et al. (2015) and not here, and this difference is likely to reflect our small sample size.

The magnitude of our estimate of A for insomnia symptoms was .36 (95% confidence interval = 0 - .50) which is in the middle of the range which we expected. Indeed, the exact heritability estimates for insomnia vary across previous studies (for example, Drake, Friedman, & Wright Jr, 2011, A = .43 for males and A = .55 for females; Gehrman, Byrne, Gillespie, & Martin, 2011, A = .30; Wing et al., 2012, A = .48). For adults, the heritability of insomnia-related measures typically falls into a range between .25 and .45 (Gehrman et al., 2011; although there are some exceptions, e.g. Wing et al., 2012). While this estimate was not significant (reflecting our relatively small sample size), familiality was evident (influence was shown to come from A and/or C).

Our estimate for the genetic influence on depression of A = .33 (95% confidence interval = .01 - .48) does not deviate much from the genetic estimate of .37 reported in a meta-analysis of the genetic epidemiology of major depression (Sullivan, Neale, & Kendler, 2000).

Furthermore, our estimate for genetic influence on anxiety symptoms (A = .36; 95% confidence interval = 0 - .53; familiality was shown) is similar to a genetic estimate from a meta-analysis for genetic epidemiology of generalized anxiety disorder (A = .32) or panic disorder (A = .43) (Hettema, Neale, & Kendler, 2001). The lack of significance is again likely to reflect our sample size.

The genetic correlation between mindfulness and symptoms of insomnia, depression and anxiety ranged from .32 to .75 (all non-significant). The magnitude of these associations were in line with Waszczuk et al. (2015), which highlighted a moderate genetic overlap for mindfulness with anxiety sensitivity and depression. According to the "generalist genes hypothesis", we would expect that overall mindfulness, symptoms of insomnia, depression and anxiety to share common genetic influences, as co-variation between traits is often explained by additive genetic influences – with environmental influences explaining differences (Eley, 1997). The results should be interpreted carefully as the non-significant genetic correlation between overall mindfulness and the other three variables may reflect the small sample size. Therefore, further work including a larger sample size would be of value. However, the genetic correlation between anxiety symptoms and depression symptoms was significant (rA = .87), which is largely in line with expectations based on previous findings (see, for example, Mosing et al., 2009; Zavos, Rijsdijk, & Eley, 2012).

The shared environmental correlation between mindfulness and symptoms of insomnia, depression and anxiety ranged from −.78 to .79, but these estimates were not significant. This may again reflect the small sample size, meaning that it is possible that we did not have enough power to detect a significant shared environmental correlation and therefore this result should be interpreted with caution. Nonetheless, as the contribution of shared environmental influences to the individual variables was small, this influence is unlikely to explain much of the association between variables.

4.3. Non-shared environmental influences

Despite some evidence of familiality for overall mindfulness, the most important influence was that of the non-shared environment. Future research should attempt to specify non-shared environmental factors that play a role for mindfulness. While meditation experience is an obvious candidate, with more meditation experience associated with greater mindfulness (see, for example, Baer et al., 2006; Walach et al., 2006) – this was controlled for in the current study by running a sensitivity analysis, so this cannot explain the results reported here. Other candidates include certain life events, cultural influence and peer relationships (Waszczuk et al., 2015).

The moderate to strong genetic correlations between overall mindfulness and symptoms of insomnia, depression and anxiety were not significant, neither were the shared environmental correlations between all four variables. This may again reflect our limited statistical power. Non-shared environment was the only influence that was significantly correlated for all four variables (overall mindfulness and symptoms of insomnia, depression and anxiety; ranging from .21 to .55) suggesting overlap in those unique environmental experiences influencing the different phenotypes.

4.4. Limitations

The twin design has some limitations, discussed elsewhere (Knopik et al., 2016). Based on these, it is recommended that estimates should be considered as approximations rather than absolute values (Knopik et al., 2016). Furthermore, while results from twin studies are used to draw conclusions about individual differences in the general population, it is possible that twins may not be representative of the wider non-twin population (Knopik et al., 2016).

A further limitation relates to the sample size. This was relatively small for a twin study and meant that some of the 95% confidence intervals were wide (and some spanned −1 to 1). A larger sample size would have resulted in greater confidence in the results and hence narrower confidence intervals. Further work using large samples would be of value. Before collecting the data for wave 5, we calculated the expected number of participants based on participation rates at the previous wave of data collection. Specifically, we estimated 70% participation rate as estimated from the last wave of data collection. However, we obtained a lower participation rate, likely due to limitations in funding which meant that we were not able to provide each participant with a reward (as per the previous wave), but instead participants were offered a chance to win an iPad 2 (Schneider et al., in press). Although this twin sample is not as large as some others in the literature, we considered this work to be important as it benefits from a unique focus on emotional and behavioural problems and associated difficulties – including most recently a focus on sleep difficulties assessed over multiple waves and critical periods of development. Power analyses (see previously) showed that we had limited power to detect significant heritability estimates of the magnitudes estimated here. However, our heritability estimates align with those reported elsewhere in the literature. Furthermore, we found that for the key variables, our ACE models fitted the data better than our E models, indicating that familial influence is playing a role in explaining variance in our phenotype. Even though our sample is small, it is not unique in this respect and is larger than other valuable twin studies in the field (see, for example, Brescianini et al., 2011; Lau, Belli, Gregory, & Eley, 2014).

The small sample size may also explain why the estimates of genetic influence for anxiety symptoms and insomnia symptoms are non-significant which contrasts with previous findings (see, for example, Gehrman et al., 2011; Hettema et al., 2001). Overall, care should be taken before drawing strong conclusions about the significance levels of the findings per se.

Another limitation relates to the use of self-report measures, which may have artificially inflated associations. This was necessary given the scope of the study (i.e. assessing numerous variables in a sample of many hundreds of participants) and is also considered the optimal approach to assessing certain phenotypes (e.g. mindfulness and insomnia symptoms). Nonetheless, future work should incorporate additional information (e.g. symptoms rated by other reporters, objective measures of sleep).

Finally, it is important to note that short versions of the measures were used. This was the first twin study considering the FFMQ (and only the second twin study considering mindfulness, see Waszczuk et al., 2015), therefore limited information is available about the use of a shortened version of the FFMQ in twin studies. However, it is common for phenotypes to be assessed using just one or two items in twin studies (Koskenvuo, Hublin, Partinen, Heikkilä, & Kaprio, 2007; Paunio et al., 2008; Watson, Goldberg, Arguelles, & Buchwald, 2006; Watson, Buchwald, Vitiello, Noonan, & Goldberg, 2010) – reflecting the careful balance between assessing phenotypes thoroughly and avoiding overburdening participants.

5. Conclusion

The current findings give us novel insight into the concept of mindfulness and how it is associated with symptoms of insomnia, depression and anxiety. We found that 'nonjudging of inner experience' was the mindfulness subscale most strongly associated with symptoms of insomnia, depression and anxiety. Further research into the subscales of mindfulness would be useful in order to gain a deeper understanding of this concept and could potentially help to optimise mindfulness-based treatments in the future.

Conflicts of interest

MNS – None to declare.
HMSZ – None to declare.
TAM – None to declare.
YK – None to declare.
SS – None to declare.
AMG – Alice Gregory is an advisor for a project sponsored by Johnson's Baby. She has written a book (Nodding Off, Bloomsbury Sigma, 2018) and has a contract for a second book (The Sleepy Pebble, Nobrow). She is a regular contributor to BBC Focus magazine and has contributed to numerous other outlets (such as The Conversation and The Guardian). She has been interviewed by magazines and commercial websites. She has provided a talk for businesses and is occasionally sent trial products from commercial companies (e.g. blue light blocking glasses).

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