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A behavior genetic analysis of personality and loneliness

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ABSTRACT

The phenotypic, genetic, and environmental correlations between the Big Five factors of personality and loneliness were examined. At the phenotypic level, loneliness had a strong significant positive correlation with neuroticism, significant moderate negative correlations with agreeableness, conscientiousness, and extraversion, and a small positive correlation with openness. Both loneliness and personality were found to be heritable. Bivariate genetic analyses resulted in significant positive genetic correlations between loneliness and neuroticism and openness, and significant negative genetic correlations with agreeableness, conscientiousness, and extraversion. Significant unique environment correlations were found between loneliness and four of the five personality factors (all negative except neuroticism) and a non-significant correlation with openness. The results suggest common genetic and unique environmental factors play a role in personality and loneliness.

1. Introduction

Loneliness has become more of a mainstream topic of concern following the media coverage of the appointment of a Minister for Loneliness in the United Kingdom in 2018. Investigating the correlates and effects of loneliness is important because loneliness has been found to increase the odds ratio for mortality (Holt-Lunstad, Smith, Baker, Harris, & Stephenson, 2015). Following, the present study expands on past research examining loneliness and personality by examining not only the phenotypic correlations between the two constructs, but also the genetic, common, and unique environmental correlations. By conducting bivariate genetic analyses, the present study adds to the understanding of loneliness and personality by demonstrating if the observed correlations may be due to common genetic and/or environmental factors.

1.1. Loneliness and personality correlates

Loneliness, like personality, is a relatively stable individual difference characteristic (Bartels, Cacioppo, Hudziak, & Boomsma, 2008; Boomsma, Cacioppo, Muthén, Asparouhov, & Clark, 2007). In a longitudinal study across 15 years, Mund and Neyer (2016) reported that loneliness influenced later neuroticism, extraversion, and conscientiousness scores. In addition, socially desirable personality characteristics predicted a decrease in loneliness. Across multiple cross-sectional studies, loneliness has been found to correlate positively with neuroticism and negatively with extraversion (Flett, Goldstein, Pechenkov, Nepon, & Wekerle, 2016; Levin & Stokes, 1986; Saklofske, Yackulic, & Kelly, 1986; Saklofske & Yackulic, 1989). Less consistent have been the correlations reported with the other Big Five personality factors.

1.2. Genetic studies of personality and loneliness

The Big Five personality factors typically demonstrate a heritable component. For example, Loehlin, McCrae, Costa, and John (1998) report that across three measures of the Big Five, heritability estimates for men and women ranged from 51% for agreeableness to 58% for neuroticism with the remaining variance due to unique environmental effects and not due to common environmental effects. In a large sample of twins from The Netherlands, Distel et al. (2010) examined the genetic and environmental properties of loneliness using the three-item scale from the revised UCLA Loneliness Scale (Russell, Peplau, & Cutrona, 1980). Approximately 37% of the variance in loneliness was due to genetic factors. In the present study, the same loneliness scale was tested with a sample of same-sex Australian adult twins from an archival data set (Lynskey et al., 2012). In summary, the present study adds to the literature by examining the genetic and environmental correlations between personality and loneliness.

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2. Method

2.1. Participants

Participants were from a cross-sectional twin study from Australia (see Lynskey et al., 2012) and included 764 pairs of same-sex adult twins (314 monozygtic (MZ) female pairs, 140 MZ male pairs, 223 dizygotic (DZ) female pairs, and 87 DZ male pairs) recruited through the National Health and Medical Research Council Australian Twin Registry. The mean age was 31.88 years (SD = 2.58, range = 26–43). Age was found to not differ across the zygosity and sex combinations based on a one-way ANOVA ($F = 1.42$, *ns*).

2.2. Measures and procedure

Individuals completed the three questions assessing loneliness from the revised UCLA Loneliness Scale (Russell et al., 1980). Items asked how often an individual felt that they lacked companionship, how often the individual felt that they were "left out", and how often the individual felt that they were "isolated from others". Responses to these items were on a *1 Hardly ever* to *3 Often* scale. The internal consistency (coefficient alpha) for these three items was 0.82 in the present data. A total loneliness score represents the aggregate of the three items (see Table 1 for descriptive statistics).

Individuals also completed a 74-item version of the NEO Five-Factor Inventory (McCrae & Costa, 2004), measuring the "Big Five" personality factors. The reliability estimates, based on Cronbach's alpha, were: 0.89 for neuroticism; 0.78 for openness to experience (one of the openness items, which asks about using religious authorities for moral decision making, was removed from the scale total as it significantly decreased the reliability of the scale); 0.80 for agreeableness; 0.85 for conscientiousness; and 0.83 for extraversion (see Table 1 for descriptive statistics).

3. Results

The demographic variables of age and sex were examined for possible effects on personality and loneliness. Age had a small but significant positive correlation with conscientiousness ($r = 0.07$, $p < .01$, two-tailed) and a small significant negative correlation with neuroticism ($r = -0.06$, $p < .01$, two-tailed). All other correlations with age were non-significant. *F*-tests of the scale variance differences between men and women were all non-significant. Three significant *t*-tests of mean differences were found. Women ($M = 57.41$, $SD = 6.84$) had higher agreeableness scores compared to men ($M = 53.61$, $SD = 7.19$, $t = 11.16$, $p < .001$). Women ($M = 55.23$, $SD = 7.12$) scored higher than men ($M = 53.12$, $SD = 7.17$, $t = 6.02$, $p < .001$) on conscientiousness. Women ($M = 42.30$, $SD = 10.82$) also scored higher than men ($M = 39.26$, $SD = 10.44$, $t = 5.80$, $p < .001$) on neuroticism. No significant mean differences by sex were found for the other variables.

Table 1 reports the univariate genetic analyses for the personality and loneliness scales. For each of the scales, the MZ intraclass correlations (between twin 1 and twin 2) were higher than the DZ intraclass correlations suggesting additive genetic influences. First the full ACE (A = additive genetic, C = common environment, E = unique environment plus measurement error) univariate genetic model was tested using the program Mx (Neale, Boker, Xie, & Maes, 2006). Fixing the weight of the paths between genetic factors (A) to 1.00 for MZ twins (who share approximately 100% of their genes) and 0.50 for DZ twins (who share approximately 50% of their genes), and fixing the common environmental (C) influence to 1.00 (as the twins were reared together), the variance-covariance matrix of the MZ twins is compared to the variance-covariance matrix of the DZ twins. Using this model, the additive genetic (a^2), common environment (c^2), and unique environment (e^2) estimates are generated. Following, reduced models testing AE, CE, and E-only are assessed. A best fitting model is one which has the lowest chi-square and most negative AIC value. Dominant, or non-additive, genetic models were not tested as only conscientiousness had a MZ correlation which was twice the magnitude of the DZ correlation.

As reported in Table 1, the reduced AE model had a better fit to the variables, because of the non-significant common environment estimates and lower (more negative) AIC fit values, except for openness, which was best fit by the full ACE model and had a significant common environment (c^2) estimate of 22% (as the 95% confidence interval did not include zero). Heritability (a^2) estimates ranged from 32% for the openness scale to 47% for extraversion. All of the unique environmental effects (e^2) estimates were significant. These estimates are based on the raw scores and were not found to differ significantly from the estimates generated from age and sex regressed residuals.

Table 2 reports the phenotypic correlations between the personality factors and the loneliness scale. Neuroticism had a strong significant positive correlation with loneliness. Loneliness had significant moderate negative correlations with agreeableness, conscientiousness, and extraversion. Openness has a small significant positive correlation with loneliness. Following, bivariate genetic analyses were computed to examine the covariance between personality and loneliness. Cholesky models (see Neale & Cardon, 1992) were applied to the MZ and DZ between- and within-pair covariance matrices to calculate genetic and environ-

Table 1
Scale descriptive statistics, twin correlations, and univariate genetic analyses of the personality factors and loneliness scales.

Scale	Mean	SD	MZ*r*	DZ*r*	a^2	c^2	e^2	AIC
Neuroticism	56.13	10.78	0.45	0.24	0.42 (0.18 to 0.52)	0.03 (0.00 to 0.24)	0.55 (0.48 to 0.62)	−1.69
					0.45 (0.38 to 0.52)	–	0.55 (0.48 to 0.62)	−3.63
Openness	43.46	7.02	0.54	0.38	0.32 (0.11 to 0.55)	0.22 (0.01 to 0.40)	0.46 (0.40 to 0.52)	−5.18
					0.55 (0.49 to 0.61)	–	0.45 (0.39 to 0.51)	−2.79
Agreeableness	56.13	7.18	0.42	0.28	0.31 (0.07 to 0.49)	0.11 (0.00 to 0.31)	0.58 (0.51 to 0.66)	−4.69
					0.43 (0.36 to 0.50)	–	0.57 (0.50 to 0.64)	−5.72
Conscientiousness	54.53	7.20	0.44	0.22	0.41 (0.15 to 0.50)	0.02 (0.00 to 0.24)	0.57 (0.50 to 0.65)	−3.07
					0.43 (0.36 to 0.50)	–	0.57 (0.50 to 0.64)	−5.04
Extraversion	53.46	7.76	0.46	0.27	0.39 (0.14 to 0.53)	0.07 (0.00 to 0.28)	0.54 (0.47 to 0.61)	−5.12
					0.47 (0.40 to 0.53)	–	0.53 (0.47 to 0.60)	−6.68
Loneliness	4.44	1.63	0.34	0.22	0.23 (0.01 to 0.41)	0.11 (0.00 to 0.32)	0.66 (0.58 to 0.74)	−3.17
					0.35 (0.27 to 0.42)	–	0.65 (0.58 to 0.73)	−4.30

a^2 = additive genetic; c^2 = common environment; e^2 = unique environment; values in brackets represent the 95% confidence intervals and those not containing zero are deemed to be significant. Full ACE model results are presented first, followed by the better-fitting model results if applicable.

Table 2
Phenotypic, genetic, environmental, and residual correlations between loneliness and personality.

Personality scale	Phenotypic	Genetic	Unique environment	Residual (personality covariation removed)
Neuroticism	0.62*	0.81 (0.72 to 0.90)	0.48 (0.41 to 0.54)	0.44*
Openness	0.10*	0.16 (0.02 to 0.29)	0.06 (−0.02 to 0.15)	0.09*
Agreeableness	−0.20*	−0.25 (−0.10 to −0.40)	−0.14 (−0.06 to −0.23)	0.02
Conscientiousness	−0.29*	−0.44 (−0.29 to −0.58)	−0.15 (−0.07 to −0.24)	−0.02
Extraversion	−0.39*	−0.62 (−0.49 to −0.74)	−0.23 (−0.15 to −0.31)	−0.11*

95% confidence intervals are in the brackets; those which do not contain zero are deemed to be significant and are in bold text.
* $p < .01$, two-tailed. The AE model best fit all combinations.

mental correlations using the program Mx (Neale et al., 2006). Specifically, one twin's loneliness score is correlated with their co-twin's personality score and that twin's loneliness score is correlated with the first twin's personality score. If these cross-correlations are higher in MZ twins compared to DZ twins, then this pattern of results suggests that the observed phenotypic correlation is due to some common genetic factor. Models tested included: the full ACE (A = additive genetic; C = common environment; E = unique environment and measurement error), AE, CE, and E only for each pair of variables. As with the univariate models, the model with the lowest chi-square per-degree of freedom and lowest (most negative) AIC was deemed to be the best fitting model. For all of the five personality scores, the AE model was found to have the best fit, indicating that the phenotypic correlations were best explained by common genetic and unique environmental factors.

The results of the bivariate genetic analyses are reported in Table 2. Correlations with a 95% confidence interval (values within the brackets) that do not include zero are considered to be statistically significant. Because the results were found to be very similar (or the same) when the uncorrected and the corrected (age and sex regressed) data were analyzed, the uncorrected results are presented. As reported in Table 2, all of the genetic correlations were significant, with the largest value with neuroticism. For four of the five unique environment correlations with loneliness, neuroticism was positive and significant, agreeableness, conscientiousness, and extraversion were negative and significant, and openness was nonsignificant.

To further investigate the phenotypic correlations between personality and loneliness, the unique variance for each personality factor was assessed. Specifically, for each personality factor, the other four personality factors were regressed onto the factor of interest and the residual values saved. These residual values represent the unique variance for each personality factor. The correlations between the residual values and loneliness are in the last column of Table 2. When compared to the phenotypic correlations, the residual correlations are lower in magnitude. The correlations between loneliness and agreeableness and conscientiousness residuals became nonsignificant, the negative correlation with extraversion is almost a quarter in size (although still significant), and the significant positive correlation with neuroticism is approximately two-thirds the magnitude of the original phenotypic correlation. Of interest is that the small positive significant phenotypic correlation with openness only decreased slightly suggesting that the covariance influence of the other personality variables has less of an impact on the correlation.

4. Discussion

Although loneliness had a slightly lower heritability value than in previous studies, such as Distel et al. (2010), using the same loneliness questionnaire, the heritability estimates for loneliness and the five personality factors were significant. Following, the correlations between personality and loneliness at the phenotypic, genetic, and environmental levels were examined. Neuroticism had the strongest phenotypic, genetic and environmental correlations with loneliness. This ranking remained even when the variance due to the other four personality factors was removed from the neuroticism scores. The phenotypic correlation replicates previous studies (Flett et al., 2016; Levin & Stokes, 1986; Saklofske et al., 1986; Saklofske & Yackulic, 1989). In addition to the replication, the robust genetic and strong unique environmental correlations found suggest that the observed relations reflect common genetic factors and common unique experiences for individuals which adds to the understanding of the relationship between loneliness and personality.

Openness had a small but significant positive correlation with loneliness at the phenotypic level, which remained small and significant when the covariance of the other four personality scores was removed. This finding suggests that the small positive correlation between openness and loneliness is unique to openness and not due to neuroticism. Openness also had a significant genetic correlation and a non-significant unique environmental correlation. Although the relationships between openness and loneliness have not been studied as extensively as the relationships with loneliness and neuroticism, Teppers et al. (2013) reported small positive correlations between openness and peer-related loneliness (but non-significant and negative correlations withe parent-related loneliness). One possible reason for the small positive correlation between loneliness and openness could be the degree of awareness characteristic of open individuals. For example, Spinhoven, Huijbers, Zheng, Ormel, and Speckens (2017) examined personality and mindfulness in adults who were in remission from their depression and found that openness to experience positively correlated with the mindfulness dimension of self-awareness. Possibly open individuals are more aware or are sensitive to feeling alone. Alternatively, lonely individuals may be slightly more interested in aesthetic domains. Future research may want to investigate the correlations between facets of openness and types of loneliness.

The negative phenotypic, genetic, and unique environmental correlations between loneliness and agreeableness were significant. These results may reflect the finding in the loneliness literature that suggests that others perceive lonely people negatively such as being less sociable (Rotengerg, Gruman, & Ariganello, 2002). If lonely people are perceived, and possibly treated, more negatively by others then this situational condition may increase the negative relationship between loneliness and agreeableness. Alternatively, disagreeable people may be avoided by others and hence experience more loneliness. Of interest though is that when the covariance due to the other four personality factors was removed, the correlation between the agreeableness residuals and loneliness became negligible. Possibly the correlation found between agreeableness and loneliness was being driven by covariance with dimensions such as neuroticism. Future research may

want to test this suggestion by assessing if levels of agreeableness and loneliness predict how people react to others by keeping neuroticism levels constant.

Conscientiousness had significant negative phenotypic, genetic, and unique environmental correlations with loneliness. Although researchers such as Flett et al. (2016) did not find a significant correlation, Jones, Carpenter, and Quintana (1985) reported significant negative correlations between loneliness and need for achievement, a personality trait which correlates strongly with the conscientiousness facet of self-discipline (Harris, 2004). Further information may be obtained in the future by examining multiple facets of conscientiousness with respect to loneliness. For example, conscientious people may be perceived positively by others as they are more likely to be on time for gatherings or meetings. This positive perception may result in more positive interactions with others thereby reducing loneliness. Alternatively, because the residual correlation between conscientiousness (controlling for the covariance of the other four factors) and loneliness was nonsignificant, the observed correlations may be due to common variance with neuroticism or extraversion.

Replicating previous studies, extraversion had significant negative correlations with loneliness at the phenotypic level (Flett et al., 2016; Levin & Stokes, 1986; Saklofske et al., 1986; Saklofske & Yackulic, 1989). Adding to this replication, significant genetic and unique environmental correlations were also found. Future research may want to investigate how extraversion and loneliness relate at the genetic and environmental levels when size of social networks is considered. For example, when Stokes (1985) partialled out the variance due to social networks, the correlation between extraversion and loneliness decreased. These results suggest that if an extravert is well connected socially, they tend to be less lonely. Of future interest would be if this social connection is the result of genetic and/or environmental factors. Interestingly, the phenotypic correlation, when examined at the residual level (with the covariance of the other four factors removed), decreased considerably but remained significant, suggesting that extraversion does have some specific variance in common with loneliness.

Limitations in the present study result from the cross-sectional nature of the data, the fact that the majority of the sample was female, and that personality and loneliness were assessed at the single dimension level (only one scale was used). The univariate heritability estimate for the three item loneliness scale in the present study was found to be slightly lower (35%) than the 37% reported by Distel et al. (2010) who used the same loneliness measure with a larger sample. Future research may want to further the investigation of the genetic and environmental relationships between loneliness and personality by examining multiple dimensions of both loneliness and personality. For example, Teppers et al. (2013) examined four aspects of loneliness, including parental-related, peer-related, affinity to be alone, and aversion to be alone with the big five personality dimensions and found different patterns of correlations. In particular, both parent and peer related loneliness correlated negatively with extraversion and agreeableness, but emotional stability had a significant negative correlation with peer-related loneliness only. Additionally, researchers such as Boomsma, Willemsen, Dolan, Hawkley, and Cacioppo (2005) and McGuire and Clifford (2000) reported higher heritability estimates for loneliness, 48% to 55%, using longer scales (six items and 16 items, respectively) further supporting the suggestion that future studies should investigate multiple dimensions of loneliness. Because the data used in the present study was from an archival sample, assessing the influence of factors such as relationship with partners was not possible, but may provide a rich source of information in future studies.

Furthering our understanding of the phenotypic, genetic, and environmental relationships between personality and loneliness is of importance due to the negative outcomes associated with loneliness. Loneliness has been described as serving an evolutionary function by increasing survival for the lonely individual by seeking out others (Cacioppo, Cacioppo, & Boomsma, 2014), described as a reaffiliation motive (Qualter et al., 2015). Future research may expand on the relationships found in the present study by examining types of loneliness as well as more narrow facets of personality.

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