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Research paper

Emotional and social loneliness and their unique links with social isolation, depression and anxiety

Nine E. Wolters [a,c], Lynn Mobach [a], Viviana M. Wuthrich [b], Peter Vonk [c], Claudia M. Van der Heijde [c], Reinout W. Wiers [a], Ronald M. Rapee [b], Anke M. Klein [a,d,*]

[a] University of Amsterdam, Developmental Psychology, Amsterdam, the Netherlands
[b] Macquarie University, Centre for Emotional Health, Sydney, Australia
[c] University of Amsterdam, Student Health Service, UvA, Amsterdam, the Netherlands
[d] Leiden University, Developmental and Educational Psychology, Leiden, the Netherlands

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ABSTRACT

Background: Loneliness and social isolation are known to be associated with depression, general anxiety, and social anxiety. However, knowledge on the overlapping and unique features of these relationships, while differentiating between social loneliness (perceived absence of an acceptable social network) and emotional loneliness (perceived absence of close connections), is lacking.

Methods: We constructed a network analysis to examine the relationships between self-reported social loneliness, emotional loneliness, social isolation, depression, general anxiety and social anxiety in a large sample of university students (N = 7314, 67.4 % female, range 16.3–75.8 years, M_{age} = 23.9, SD_{age} = 5.7). Hierarchical regression analyses were used to examine whether depression, general anxiety and social anxiety moderated the relationship between social isolation and loneliness types. As comorbidity between anxiety and depression is high, the role of anxiety as a moderator in the relationship between depression and loneliness types was also examined.

Results: The network analysis showed that social loneliness was most strongly explained by social isolation, whereas emotional loneliness was most strongly explained by social anxiety and depression. General anxiety was solely related to loneliness through depression. The regression analyses showed that general and social anxiety and depression did not moderate the relationship between social isolation and loneliness types.

Limitations: Differences found between loneliness types may be influenced by a methodological artifact of the DJGLS.

Conclusions: These findings highlight the importance of social anxiety over general anxiety in relation to loneliness. Also, it showed unique relationships for social- and emotional loneliness with psycho-social variables, which has important implications for research- and clinical settings.

1. Introduction

Loneliness is an important and growing public health concern impacting approximately 6 to 8 % of the general population (Cacioppo and Cacioppo, 2018a; Cacioppo et al., 2015; Goosby et al., 2013; Victor and Yang, 2012), with 3 to 8 % being severely impacted by loneliness in emerging adulthood (Diehl et al., 2018). Loneliness is a negative affective state described as dissatisfaction with the discrepancy between someone's actual and expected quality or quantity of social connections (Perlman and Peplau, 1981). Importantly, it is not necessarily the size of someone's social network or social isolation that causes loneliness. Although loneliness and social isolation often co-occur, someone can have limited contacts and not feel lonely, or conversely, can have frequent social contacts and feel lonely (de Jong Gierveld, 1998). Initial studies on loneliness and social isolation used these terms interchangeably, but it is well-known that these terms refer to distinct constructs (Coyle and Dugan, 2012; Rico-Uribe et al., 2016). Therefore, understanding the factors that moderate the relationship between the

* Corresponding author at: Developmental and Educational Psychology, Leiden University, Pieter de La Court, Wassenaarseweg 52, 2333 AK Leiden, the Netherlands.
E-mail address: a.m.klein@fsw.leidenuniv.nl (A.M. Klein).

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size and quality of social networks and feelings of loneliness is needed.

Weiss (1973) was the first author to distinguish between social- and emotional loneliness. Emotional loneliness refers to the perceived absence of close relationships, whereas social loneliness refers to the perceived absence of an available (quantity) and acceptable (quality) social network. Social loneliness is often related to social variables such as the presence of close ties with friends, companionship, and size of the network, whereas emotional loneliness is often associated with the absence of emotional support (Lui and Rook, 2013; Green et al., 2001). A number of studies have shown that social- and emotional loneliness share limited variance (Dahlberg and McKee, 2014; De Jong Gierveld and van Tilburg, 2006; Green et al., 2001; Russell et al., 1984). For example, Dahlberg and McKee (2014) demonstrated a correlation of $r = 0.44$ between the two constructs. Similarly, Russell et al. (1984) showed a correlation of only $r = 0.17$, and Green et al. (2001) found a correlation of $r = 0.41$, indicating the importance of differentiating between the two types of loneliness as well as the factors that underlie these features.

Loneliness strongly correlates with symptoms of depression and anxiety. In general, loneliness consistently showed to be associated with increased negativity (Cacioppo and Hawkley, 2009), lower mood (Cacioppo et al., 2006a), hopelessness (Chang et al., 2019), depression and anxiety symptoms, and lower self-esteem (for a review see Heinrich and Gullone, 2006; Abdellaoui et al., 2018; Cacioppo et al., 2015). Depression and loneliness in particular, have been conceptualised as highly related, if not different aspects of the same problem (e.g., Anderson and Harvey, 1988). As such, common self-report measures of depression have typically included loneliness items (e.g., CES-D; Radloff, 1977). More recently, studies have started to differentiate the overlapping and unique aspects of the relationship between depression and loneliness (e.g., Ge et al., 2017; Matthews et al., 2016; Van den Brink et al., 2018). These studies provide evidence of a stable relationship between loneliness and depression across the lifespan (Victor and Yang, 2012; Cacioppo et al., 2006b), with longitudinal studies showing that loneliness is a unique predictor of depressive symptomatology (Cacioppo et al., 2010; Santini et al., 2020; Danneel et al., 2019) and depression predicting loneliness over time (Cacioppo et al., 2006b; Domènech-Abella et al., 2017).

Given that the symptoms of depression include social withdrawal (social isolation) and negative social cognition, depression might exacerbate dissatisfaction with social network size and perceived quality of those relationships (loneliness), therefore moderating the relationship between social isolation and loneliness. Consistent with this suggestion, depression moderated the relationship between social isolation and loneliness in old age (Domènech-Abella et al., 2017). Only recently has there been interest in teasing apart how depression relates to the different components of loneliness. Depression has been shown to be most strongly associated with emotional loneliness, compared to social loneliness, in young adults (Diehl et al., 2018; Hyland et al., 2019).

The relationship between anxiety and loneliness is less well understood. Initial studies established that general anxiety was related to loneliness (Van Halst et al., 2013). However, more recent studies showed that both general anxiety and social anxiety predict loneliness over time across all ages (Danneel et al., 2019; Lim et al., 2016; Santini et al., 2020). Furthermore, recent studies found that social anxiety is a unique predictor of loneliness over and above depression and general anxiety (Lasgaard et al., 2011; Meltzer et al., 2013; Saris et al., 2017). As with depression, the link between social anxiety and loneliness seems to be bidirectional (Beutel et al., 2017; Richardson et al., 2016). There is some evidence that socially anxious symptoms such as shyness, negative social cognitions, beliefs about other people and themselves, lower quality of social interactions, and interpersonal impairments overlap with features of social isolation and loneliness (Ruscio et al., 2008; Lim et al., 2016; Danneel et al., 2019). To date, only one study examined differences in the relationship between general anxiety and emotional- or social loneliness separately, and found general anxiety was associated with emotional-, but not social loneliness (Hyland et al., 2019). Studies have not yet investigated the relationship between social anxiety and loneliness types, and given the strong overlap between depression and loneliness, and depression and social anxiety in general (Anderson and Harvey, 1988), it is unclear how these three variables relate to one another.

In separate samples, social isolation has been associated with loneliness (Cacioppo and Cacioppo, 2018b), depression (Cacioppo et al., 2006b), general anxiety (Santini et al., 2020), and social anxiety (Lim et al., 2016), however, no studies have examined these factors comprehensively in the same sample to better understand the overlapping and unique features of these relationships, and in particular with regards to emotional- and social loneliness. This study aimed to 1) examine the unique and overlapping variance between emotional- and social loneliness, social isolation, depression, general anxiety and social anxiety by means of a network analysis as this method particularly gives insight in the uniqueness and overlapping associations, and 2) examine whether depression, general anxiety and social anxiety moderate the relationship between social isolation and emotional- and social loneliness. Based on previous research, we hypothesised that: 1) social- and emotional loneliness would be strongly associated with depression, general anxiety and social anxiety, but more so for emotional- than social loneliness, 2) social isolation would be strongly associated with social- and emotional loneliness, but more so for social- than emotional loneliness, 3) social anxiety will be more strongly related to emotional- and social loneliness compared to general anxiety, and 4) depression, general anxiety and social anxiety will moderate the relationship between social isolation and emotional- and social loneliness in unique ways.

2. Methods

2.1. Participants

All university students and PhD students at the University of Amsterdam (UvA), the Netherlands, were invited to take part in the survey (N = 35,535). In total, 9549 students (26.9 %) responded to the invitation, of which 7085 participants (74.2 %) completed all self-report measurements. Participants (67.5 % female; $M_{age} = 23.9$, $SD_{age} = 5.7$; range 16.3–75.8 years) completed electronic questionnaires in either Dutch or English, depending on their preference.[1]

2.2. Materials

Loneliness was assessed using the 11-item De Jong Gierveld Loneliness Scale (DJGLS; de Jong Gierveld and Kamphuis, 1985) which measured emotional- and social loneliness. Emotional loneliness (EL) was measured with six negatively phrased items, whereas social loneliness (SL) was assessed with five positively phrased items. Participants were asked to rate the extent to which statements applied to their situation. The following statements are examples for the social- and emotional loneliness subscales respectively: 'There are plenty of people I can lean on when I have problems' and 'I miss having a really close friend'. All items were scored on a 5-point Likert scale. The emotional loneliness score is calculated by summing the neutral and positive answers on items 2-3-5-6-9-10. The social loneliness score is calculated by summing the neutral and negative answers on items 1-4-7-8-11. The total scores of the subscales ranged from 0 to 5 and from 0 to 6, for social loneliness and emotional loneliness respectively. Higher scores indicated more severe social- or emotional loneliness, with scores of ≥ 3 identifying socially- and emotionally lonely adults (de Jong Gierveld

[1] The mean age of this sample is representative of the UvA population in terms of the usual age range of students and PhD students (18–30 years of age). Our sample includes 67.5 % females, while the percentage of females in Dutch university students in general is 55 % (Central Bureau for Statistics, 2020).

and van Tilburg, 1999). Validation research on the DJGLS and its subscales revealed good reliability coefficients (EL: α = 0.90; SL: α = 0.88) and good congruent validity in non-clinical young Dutch adults (de Jong Gierveld and van Tilburg, 2010). In the current study, internal consistency of the emotional and social loneliness subscales scores were good (EL: α = 0.81; SL: α = 0.82).

Social isolation was measured using the 6-item self-report Lubben Social Network Scale (LSNS-6; Lubben, 1998). The LSNS-6 consisted of two subscales; the first three items assessed the social support received from family members; the second three items focussed on social support from friends. For example, participants were asked to quantify 'How many relatives/friends do you see or hear from at least once a month?'. All items were scored on a 6-point Likert scale. We reverse scored all items for clarity reasons, so that higher scores on the LSNS-6 scale indicated more social isolation. The total score of the LSNS ranged from 0 to 30. This scale was initially developed for older adults, with scores showing good internal consistency (α = 0.83; Lubben et al., 2006) and excellent test-retest reliability (ICC = 0.91; Myagmarjav et al., 2019), but the short form (LSNS-6) has been more recently validated in younger samples (Nandi et al., 2012; Rice et al., 2020; Watabe et al., 2015). Internal consistency of the LSNS-6 score in the current study was good (α = 0.81).

Depression was measured with the 20-item Center for Epidemiologic Studies-Depression Scale (CES-D; Radloff, 1977). Participants were asked to indicate the frequency they felt a certain way during the past week on items such as 'I was bothered by things that usually don't bother me' and 'I felt that everything I did was an effort'. Responses were given on a 4-point Likert scale. The item 'I felt lonely' was excluded to avoid confounding effects. The total score ranged from 0 to 57. A higher total score indicated more severe depressive symptoms with scores of ≥16 indicative of clinical levels of depression. This measure has demonstrated good sensitivity, specificity and test-retest reliability in a range of samples (ICC = 0.87; Miller et al., 2008; Radloff, 1977; Vilagut et al., 2016). Internal consistency of the CES-D score in the current study was excellent (α = 0.91).

Social anxiety was assessed using the 6-item Social Interaction anxiety scale (SIAS-6; Peters et al., 2012). Participants were asked to complete items such as 'I have difficulty making eye contact with others' and 'I feel tense if I am alone with just one person'. Answers were provided on a 5-point Likert scale. Total score ranged from 0 to 24, with higher scores indicating more social anxiety. Research on its psychometric properties in Dutch clinical and non-clinical samples reveals good reliability and sensitivity (de Beurs et al., 2014; Peters et al., 2012). Participants scoring above the cut-off score of six were identified as socially anxious. Internal consistency of the scale score in the current study was good (α = 0.83).

General anxiety was measured with the 7-item General Anxiety Disorders-7 (GAD-7; Spitzer et al., 2006). Participants rated the frequency of being bothered by excessive anxiety and worries during the past two weeks. Statements as 'Feeling nervous, anxious, or on edge' and 'Worrying too much about different things' were assessed on a 4-point Likert-type scale. Total scores ranged from 0 to 21. Higher scores indicated more severe symptoms of GAD, and scores of ≥10 indicated moderate to severe anxiety. Validation research on the GAD-7 revealed good test-retest reliability in clinical and non-clinical samples (ICC = 0.83 and ICC = 0.74 respectively; Spitzer et al., 2006; Lebeau et al., 2012). Additionally, Donker et al. (2011) reported good reliability of an online assessment of the GAD-7, in a Dutch sample. Internal consistency of the scale score in the current study was good (α = 0.88).

2.3. Procedure

All students were invited via a personalised email sent by the research team. The email included information about the study and a link to the survey. Participants first gave informed consent before completing the questionnaire measures. The survey was part of a larger study designed to raise awareness on general satisfaction, stress, lifestyle, and (mental) health domains. The questionnaire took approximately 15 min to administer. After completion, participants received automatically generated feedback based on their answers. The Ethics Review Board of the University of Amsterdam approved the study (2017-DP-8115). Data collection ran from January 2019 to January 2020.

2.4. Statistical analysis

The data collection resulted in missing data on the questionnaires for ≤3.1 % participants. To handle missing data, we used multiple imputation (Rubin, 1987). Sensitivity analyses were used to check whether the analyses without imputation and the analyses with multiple imputations differed in results. The results were similar, and given that only 3.1 % of data were missing, we report on the analyses performed on all completers (N = 7085).

Correlations were calculated to investigate the associations of emotional and social loneliness with social isolation, depression, social anxiety, and general anxiety. Spearman correlations were calculated due to borderline non-normality of the social anxiety variable (skewness = 1.45, kurtosis = 2.07; De Winter et al., 2016). Second, a network analysis was performed to further explore the strength of these relationships, when controlling for all other variables. Third, hierarchical regressions were used to examine moderation effects.

Network analyses are a powerful technique to examine interacting components in which networks can be displayed visually to aid interpretation (e.g., Borsboom, 2017; Borsboom and Cramer, 2013; Fried et al., 2017). Network models are based on partial correlations and hereby enable investigation of the unique impact of variables on each other, while controlling for all other variables in the model. In addition, network analysis consists of *nodes,* representing the variables, and *edges*, representing the significant partial correlations between variables. Visual inspection of the model provides information on the thickness of the edges and the distance between nodes. The thicker and brighter the edges, the stronger the relationship. Also, the proximity of the nodes in the network indicates the closeness of constructs with multiple reciprocal relationships (Epskamp et al., 2012; Borsboom, 2008). Furthermore, the network provides information on the following informative psychometrical properties: edge strength (how strongly a variable is directly connected), betweenness (the extent to which a variable connects other variables in the network), and closeness (how strongly a variable is indirectly connected). Finally, to investigate the accuracy and stability of the network, the correlation stability coefficients (CS-coefficients) provide insight about the proportion of data that can be dropped while holding a correlation of 0.7 or higher with the original centrality (the connectedness of a variable with other variables in the network) measures (Epskamp and Fried, 2018).

In the current study, a Gaussian Graphic model (GGM) was used to estimate the network, using the graphical LASSO with EBIC model selection (EBICglasso). Spearman correlations were calculated before estimating the network because of the stability gained when there is non-normality of the data. After estimation, the network was assessed on stability and accuracy by bootstrapping techniques using 1000 samples in a non-parametric and case-dropping bootstrap method, respectively. To quantify the case-dropping bootstrapping, correlation stability coefficients (CS-coefficients) were calculated. Network analysis was performed in R using the *bootnet* package (Epskamp et al., 2018).

Moderation effects of general anxiety, social anxiety, depression, and social isolation were tested as additional contributors to predict loneliness subtypes using hierarchical regression analyses. Residuals were approximately normally distributed and multicollinearity assumptions were met (1.006 < VIF < 3.262; 0.307 < Tolerance<0.994). Two four-step hierarchical multiple regression analyses were conducted to investigate which factors significantly contributed to the continuous measures of social loneliness, and emotional loneliness as dependent

variables. The independent variables were entered into the hierarchical model in the following order: (1) control variables (age, gender); (2) social isolation; (3) depression, social anxiety, and general anxiety; (4) interaction terms for social isolation and depression, social anxiety, and general anxiety. Standardized beta coefficients will be presented to be able to compare the strengths of the effects of each individual predictors on the dependent variable in the model; the higher the absolute value, the stronger the effect. Regression analyses were performed using IBM SPSS Statistics 25.

3. Results

3.1. Descriptive statistics

In total, 41.3 % of the participants reported feeling moderately-severely lonely and 14.2 % participants reported feeling severely-very severely lonely. Inspecting the emotional and social loneliness subscales separately showed that while 43.3 % of the participants reported feeling moderately-severely *emotionally* lonely, 29.3 % of the participants reported feeling moderately-severely *socially* lonely. An overview of the descriptive statistics and average scores on the mental health variables are presented in Table 1.

3.2. Correlations

Table 2 provides an overview of all correlations and associated *p*-values. Social- and emotional loneliness were significantly and positively correlated ($r = 0.65$). Social- and emotional loneliness showed a significant, positive correlation with social isolation (r's $= 0.59$ and 0.52, respectively), indicating that higher loneliness scores are associated with higher social isolation scores. Emotional loneliness was associated with higher levels of depression ($r = 0.56$), social anxiety ($r = 0.44$), and general anxiety ($r = 0.42$). The associations of social loneliness with depression ($r = 0.44$), social anxiety ($r = 0.38$), and general anxiety ($r = 0.30$) were also significant and in a positive direction, indicating that higher emotional and social loneliness scores are associated with higher depression, social anxiety, and general anxiety scores.

3.3. Network analysis

All edges in the estimated network were significant, except for the relationship between general anxiety and social isolation and for the relationship between general anxiety and emotional loneliness (see Fig. 1 and Appendix 3). The visual interpretation of the network indicated a strong relation between emotional- and social loneliness. Moreover, emotional loneliness showed strong associations with depression and social anxiety, whereas social loneliness was most strongly influenced by social isolation, when controlling for all other variables in the network. All relationships were positive (as shown by the solid lines). That means higher levels of emotional loneliness were related to higher levels of depression and social anxiety and higher levels of social loneliness was related to greater social isolation. Finally, general anxiety was almost completely explained by depression. Moreover, general anxiety was the least centrally located variable in the network, indicating it had weak relationships in the network compared to the other variables, except for its relationship with depression. The estimated network and centrality measures are presented in Figs. 1 and 2, respectively. The edge weights matrix can be found in Appendix 1.

The stability and accuracy analyses suggested excellent results. Bootstrapping of the edge weights resulted in a small variation (grey area in Appendix 2), indicating excellent stability of the edge weights. The correlation stability coefficients (CS-coefficients) for the network accuracy parameters, betweenness, closeness, and strength, were all excellent (*CS* (cor = 0.75). The stability and accuracy findings are presented in Appendix 2.

Table 1
Descriptive statistics (N = 7085).

	Mean/frequency	SD/%
Age in years[a]	23.9	5.7
Gender		
Female	4785	67.5 %
Male	2251	31.8 %
Other	49	0.7 %
Preferred language		
Dutch	4645	65.6 %
English	2440	34.4 %
Social loneliness	1.6	1.8
Emotional loneliness	2.4	2.1
Social isolation	11.9	5.1
Depression	17.0	10.7
Social anxiety	4.1	4.2
General anxiety	8.0	5.1

Note: SD = Standard Deviation.
[a] For 42 participants this data was missing (N = 7043).

Table 2
Spearman's correlations (N = 7085).

	1	2	3	4	5	6
1. Social loneliness	–	0.65*	0.59*	0.44*	0.38*	0.30*
2. Emotional loneliness		–	0.52*	0.56*	0.44*	0.42*
3. Social isolation			–	0.43*	0.37*	0.31*
4. Depression				–	0.45*	0.79*
5. Social anxiety					–	0.37*
6. General anxiety						–

* $p < .001$.

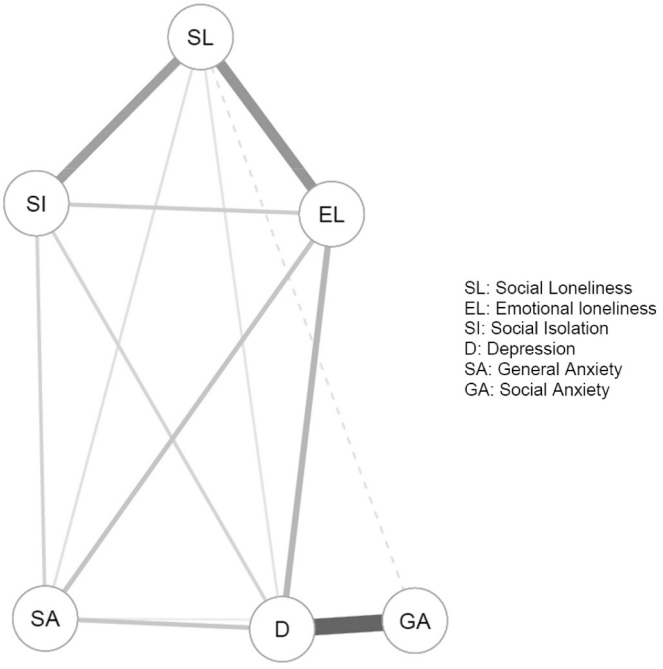


Fig. 1. Estimated network between social loneliness, emotional loneliness, social isolation, social anxiety, depression, and general anxiety. Solid lines indicate positive associations while dashed lines indicate negative ones. The thickness and brightness of the edges represent the strength of the relationships. As a reference, the weight of the edge between EL and SL is 0.43. The location of the nodes in the network represents its frequency of connecting and closeness to other variables in the network.

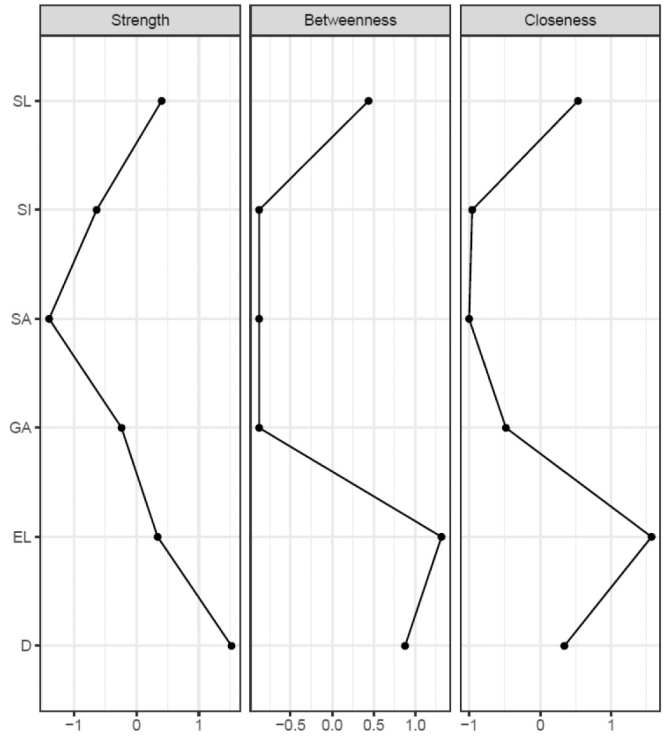


Fig. 2. Centrality indices of the network. X-axis represents the standardized z-scores of the edge strength, betweenness, and closeness. Y-axis represents the *nodes* (variables). SL = Social Loneliness, SI = Social Isolation, SA = Social Anxiety, GA = General Anxiety, EL = Emotional Loneliness, D = Depression.

3.4. Hierarchical regression analyses

3.4.1. Emotional loneliness

In the first step, we included age and gender in order to control for these variables. This first model was significant and explained 0.2 % variance of emotional loneliness, $F(2, 7040) = 7.51$, $p < .001$.[2] See Table 3 for all coefficients and related statistics. In the second step, we included social isolation which explained an additional 27.5 % variance, $F(3, 7039) = 901.63$, $p < .001$. In the third step, depression, social anxiety, and general anxiety were included. The model was again significant and explained 13.5 % additional variance, $F(6, 7036) = 822.48$, $p < .001$. In the fourth and final step, interaction terms were included to investigate moderation effects of depression, social anxiety, and general anxiety on the relationship between social isolation and emotional loneliness. This model significantly explained an additional 0.3 % of the variance, $F(9, 7033) = 544.07$, $p < .001$. The moderation effects of depression and social anxiety on the relationship between social isolation and emotional loneliness were significant, but small ($\beta = -0.04$, $p = .015$, $\beta = -0.03$, $p = .005$, respectively). General anxiety did not significantly moderate the relation between social isolation and emotional loneliness ($\beta = 0.01$, $p = .425$; see Table 3).[3]

3.4.2. Social loneliness

The first level of the hierarchical regression model, including control variables age and gender, explained 0.6 % variance of social loneliness, $F(2, 7040) = 21.80$, $p < .001$. The second level indicated social isolation as a significant predictor of social loneliness by explaining an additional 36.4 % variance, $F(3, 7039) = 1376.03$, $p < .001$. In the third level, social isolation, depression, social anxiety, and general anxiety explained social loneliness significantly with 5.3 % additional variance, $F(6, 7036) = 858.92$, $p < .001$. It should be noted that the coefficient for general anxiety showed a very small effect ($\beta = -0.07$, $p < .001$). In the final level, the model explained an additional 0.2 % of the variance ($F(9, 7033) = 578.22$, $p < .001$), indicating depression as a significant moderator of the relationship between social isolation and social loneliness ($\beta = 0.07$, $p < .001$). This effect was small. Finally, social anxiety and general anxiety were not found to moderate the relationship between social isolation and social loneliness ($\beta = -0.01$, $p = .632$; $\beta = -0.02$, $p = .103$, respectively; see Table 3).

4. Discussion

The aim of this study was to examine the unique and overlapping variance of social isolation, depression, social anxiety, general anxiety and emotional and social loneliness in a university student population. Additionally, we wanted to examine whether depression, general anxiety, and social anxiety explained unique variance in, and moderated the relationship between social isolation and loneliness. Using a very large university student sample, it was demonstrated that social isolation, depression, social anxiety, general anxiety social loneliness, and emotional loneliness, were all strongly related to each other, but the relationships between social isolation, depression, and social anxiety differed for emotional and social loneliness. Further, no evidence was found for our hypothesis of additional moderation effects by depression, general anxiety, or social anxiety when explaining the relationship of social isolation with emotional loneliness and social loneliness.

4.1. Social and emotional loneliness

Our results showed that loneliness is comprised of a social and emotional loneliness component which are differentially related to mental health. In contrast to the literature, a strong correlation was found between the two loneliness types. As previously described by Russell et al. (1984) and Weiss (1973), emotional and social loneliness have a large common core of a similar subjective, negative experience of loneliness. However, these experiences are characterized by different unmet social needs. Emotional loneliness is often related to a lack in attachment provision by social relationships and/or the absence of a romantic relationship. Previous research in older adults suggested that the lack of emotional attachment connections might be the cause but also a consequence of depression and anxiety, and therefore likely to co-occur with emotional loneliness. Our results support previous findings that depression and anxiety are associated with both social and emotional loneliness, but more strongly with emotional loneliness compared to social loneliness (Diehl et al., 2018; Hyland et al., 2019; Russell et al., 1984). As stated in the literature, social loneliness often occurs when there is a shift in someone's social environment, for example when going off to college or changing one's residence. Feelings of social loneliness are associated with a lack of social integration. In the current study, social loneliness in emerging adulthood was related to an unmet need in the quantity of social relationships, as measured by social isolation. Thus, we found that social loneliness was most strongly explained by social isolation, whereas emotional loneliness was most strongly explained by social anxiety and depression, which in turn was connected to general anxiety, although social isolation was still an important predictor.

4.2. Moderation effects of depression, social anxiety, and general anxiety

Against our expectations, higher levels of depression, social anxiety and general anxiety did not strengthen the relationship between social

[2] Statistics refer to each new model with the additional steps/predictors included (e.g., change from model 1 to model 2).

[3] To check whether the covariance between the dependent variables and coefficients had an influence on the results, a multivariate multiple regression model was conducted (Johnson and Wichern, 2007). The differences between the results for both dependent variables were negligible. For the interested reader, see Tables 1 and 2 in Appendix 4.

Table 3
Hierarchical regression analyses predicting emotional and social loneliness.

Step	Variables	Emotional loneliness					Social loneliness				
		β	*B*	*SE*	*t*	*p*	*β*	*B*	*SE*	*t*	*p*
1	Age	−0.046	−0.017	0.004	3.82	0.000	0.056	0.017	0.004	4.73	0.000
	Gender	0.011	0.048	0.051	3.93	0.351	0.050	0.181	0.043	4.22	0.000
2	Age	−0.112	−0.041	0.004	10.89	0.000	−0.019	−0.006	0.003	2.03	0.043
	Gender	0.000	−0.002	0.043	0.046	0.964	0.037	0.133	0.034	3.89	0.000
	Social isolation	0.529	0.214	0.004	51.81	0.000	0.608	0.207	0.003	63.71	0.000
3	Age	−0.050	−0.018	0.003	5.33	0.000	0.018	0.005	0.003	1.90	0.058
	Gender	0.035	0.148	0.040	3.72	0.000	0.054	0.196	0.033	5.89	0.000
	Social isolation	0.317	0.128	0.004	29.76	0.000	0.474	0.161	0.004	44.99	0.000
	Depression	0.360	0.070	0.003	22.60	0.000	0.235	0.039	0.003	14.88	0.000
	Social anxiety	0.160	0.079	0.005	15.03	0.000	0.123	0.051	0.004	11.68	0.000
	General anxiety	−0.044	−0.018	0.006	2.94	0.003	−0.066	−0.023	0.005	4.51	0.000
4	Age	−0.051	−0.019	−0.019	5.44	0.000	0.018	0.006	0.003	1.99	0.047
	Gender	0.036	0.155	0.155	3.91	0.000	0.053	0.193	0.033	5.81	0.000
	Social isolation	0.318	0.128	−0.156	29.90	0.000	0.472	0.161	0.004	44.74	0.000
	Depression	0.369	0.072	0.047	22.73	0.000	0.221	0.036	0.003	13.71	0.000
	Social anxiety	0.177	0.087	0.037	15.29	0.000	0.121	0.050	0.005	10.52	0.000
	General anxiety	−0.050	−0.020	−0.004	3.31	0.001	−0.059	−0.020	0.005	3.93	0.000
	Social isolation × Depression	−0.039	−0.076	0.001	2.43	0.015	0.071	0.115	0.026	4.42	0.000
	Social isolation × Social anxiety	−0.033	−0.060	0.003	2.82	0.005	−0.006	−0.008	0.018	0.48	0.632
	Social isolation × General anxiety	0.012	0.024	−0.001	0.80	0.425	−0.024	−0.041	0.025	1.63	0.103

Note: β = standardized beta coefficients, B = unstandardized coefficients, SE = standard error, *t* = *t*-value, *p* = *p*-value.

isolation and loneliness. On the contrary, the (albeit) significant moderation effects were negative for emotional loneliness. Considering our large sample and the very small effects of the moderations, these significant interactions should be interpreted with caution and as such most likely reflected a lack of meaningful moderation by depression and/or anxiety. These results indicated that even though depression and anxiety are associated with social withdrawal and negative social cognitions, and both uniquely predict emotional- and social loneliness, these mental health variables did not additionally impact the relationship between social isolation and loneliness. The lack of moderation could be explained by the large variety in definitions and measurements used to assess social isolation and loneliness. This makes it difficult to compare results. For example, Meltzer et al. (2013) found that social isolation, measured as social participation and support, did not significantly moderate the relationship between loneliness and depression. Conversely, Domènech-Abella et al. (2017) found that social isolation, objectively measured as marital status and size of network, significantly moderated the same relationship. In the current study we used the LSNS-6 scale to measure social isolation, which includes relatively objective items on the structural characteristics of social relationships (i.e., the number, frequency, and closeness of people with whom one interacts). Thus, the construct of social network comprises a broader range of indicators, that may have different implications for mental health (Valtorta et al., 2016). Further, the outcomes are in line with findings of moderate success of loneliness interventions aimed at increasing social network size or social participation solely without addressing depression or anxiety symptoms (Masi et al., 2011). However, as this study found significant and large unique effects of depression and anxiety (social anxiety in particular) over and above social isolation, increasing the number and type of social relationships available to a lonely individual as measured in the current study, may not buffer the risk of feeling lonely when being depressed or anxious.

4.3. Social anxiety and loneliness types

Particularly interesting were our findings that social anxiety explained unique variance in loneliness, over and above social isolation and depression. Whilst general anxiety has been related to loneliness previously, our results suggest that its influence is via depression. As visualized in the network analysis, general anxiety only functioned as a meaningful connection to depression when controlling for the rest of the variance in the network. These findings were confirmed in the regression model, showing a very small effect of general anxiety on social- and emotional loneliness. Based on these results, one might speculate that the correlation between loneliness and general anxiety is mainly based on the large shared variance between depression and general anxiety (Auerbach et al., 2018; Sunderland et al., 2010). Interestingly, this study underlined the importance of the relationship between social anxiety and loneliness, indicating that socially anxious individuals might be at increased risk for loneliness. The finding that social anxiety is a key predictor supports emerging research (Lim et al., 2016; Danneel et al., 2019). The link between social anxiety and loneliness is theoretically described in cognitive models (Cacioppo and Hawkley, 2009). Specifically, socially anxious, and lonely individuals are suggested to be characterized by a state of hypervigilance toward the social environment, leading to a more negative interpretation of their social contacts, increasing social withdrawal (i.e., avoid potentially threatening social situations) and potentially even further increasing levels of loneliness, resulting in a vicious cycle (Cacioppo and Hawkley, 2009). It is therefore unfortunate that most of the current literature reports on the relationship with general anxiety, as the relationship between loneliness and social anxiety may be of more relevance (Van Halst et al., 2013; Lasgaard et al., 2011, Saris et al., 2017; Meltzer et al., 2013). Further research should therefore shift its focus to the role of social anxiety in loneliness and social isolation.

4.4. Limitations

Besides the novel findings and strengths of this study (e.g., large sample), there are several limitations that should be addressed. Despite using a previously validated loneliness questionnaire (DJGLS), there is an ongoing debate about the potential bias caused by the negatively and positively worded items for the emotional loneliness and social loneliness subscales respectively: the method effect (de Jong Gierveld and Kamphuis, 1985; Penning et al., 2013; Tomás et al., 2017). We note that the differences found between the loneliness types may be influenced by a methodological artifact of the scale. Second, all variables were self-reported which means a possible social acceptability bias cannot be ruled out. Third, there may also be a selection bias – only 19.9 % of the full sample of students provided final data. Individuals suffering from loneliness and mental health issues may be more likely to participate than individuals who are not bothered by mental issues. In addition, the majority of the sample consisted of female participants (67.5 %), making generalisation of the results difficult. Furthermore, as this study utilised

a university sample, generalisation of the findings to other age groups and/or populations is not possible and should be further explored. Finally, the study describes cross-sectional data, which means no statements can be made about causal relationships. The longitudinal relationships between social isolation, depression, social anxiety, and loneliness need further investigation to gain a better understanding of the temporal effects of these variables on each other over time.

5. Conclusion

Emotional-, social loneliness, social isolation, depression, social anxiety, and general anxiety are interrelated. However, the network analysis showed that social loneliness is most strongly connected to social isolation, whereas emotional loneliness was connected to social isolation, depression and social anxiety with each explaining large amounts of unique variance. Our findings support Weiss' theory of a bi-dimensional nature of loneliness and showed that social isolation and mental health impacted emotional and social loneliness in unique ways. Based on our results, there might be different pathways leading to loneliness and it might be important to differentiate between social- and emotional loneliness in research- and clinical settings. Regarding the latter, increasing social network characteristics for socially lonely young adults might be an effective intervention approach, as well as addressing depression and social anxiety symptoms for emotionally lonely young adults.

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CRediT authorship contribution statement

RW, PV, AK, and CvdH were granted project funding for this study. All authors took part in the construction of the study design. RW, AK, VW, RR fulfilled an advisory and supervising role during the study. NW coordinated the data recruitment and management, and NW and LM wrote the manuscript, under supervision of AK. All authors provided feedback on and approved the final version of the manuscript.

Conflict of interest

The authors declare no conflict of interest.

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Appendix 1

Table 1
Partial correlation coefficient matrix corresponding with the weighted edges of the estimated network.

	Variable	1.	2.	3.	4.	5.	6.
1.	Emotional Loneliness	0.00	0.43*	0.13*	0.22*	0.15*	0.00
2.	Social Loneliness		0.00	0.36*	0.05*	0.06*	−0.04*
3.	Social isolation			0.00	0.09*	0.10*	0.00
4.	Depression				0.00	0.14*	0.70*
5.	Social anxiety					0.00	0.04*
6.	General anxiety						0.00

* $p < .05$.

Appendix 2

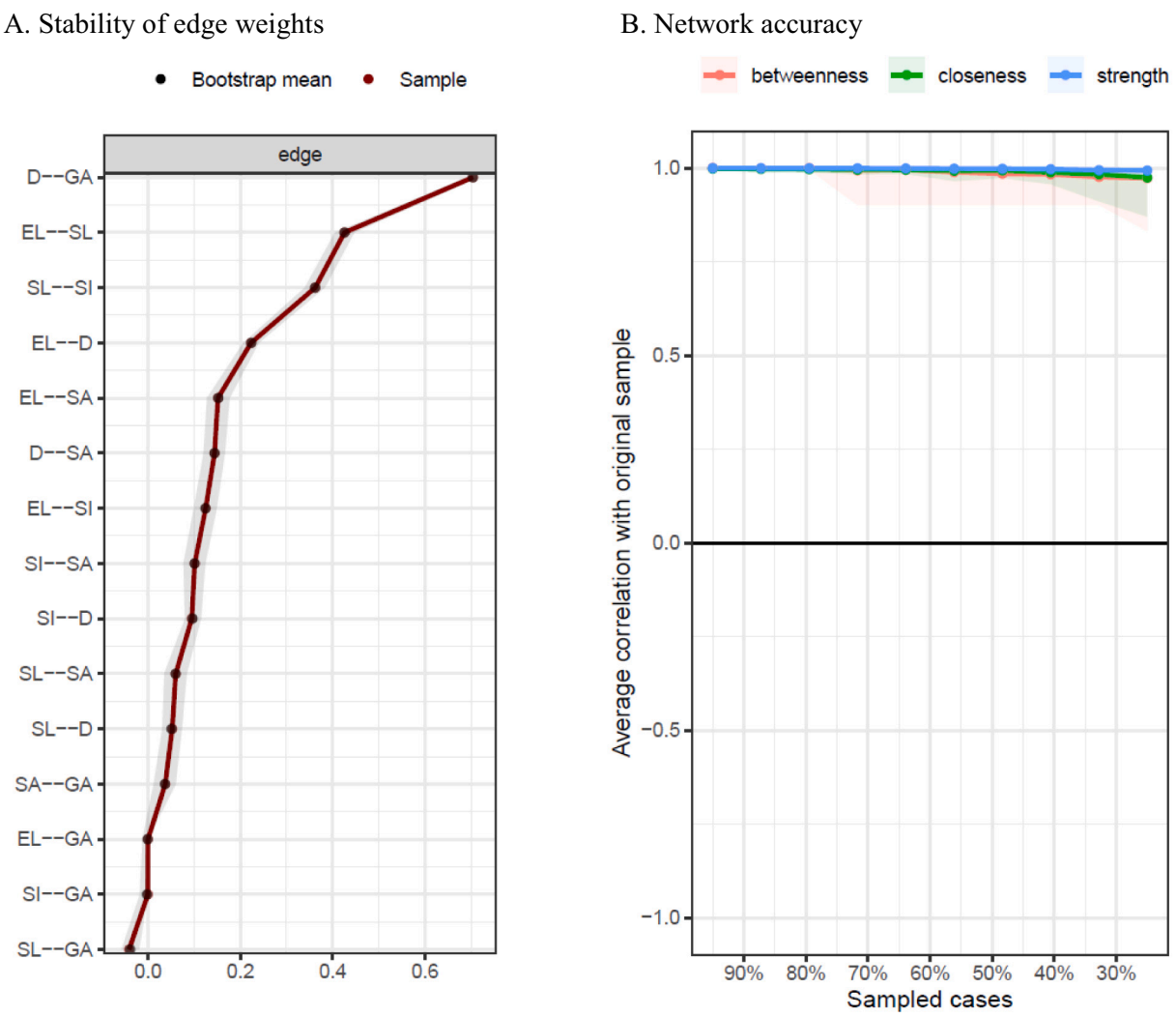


Fig. 1. A: Non-parametric bootstrapping results to assess edge weights stability of the network. X-axis shows the strength of the edges and the Y-axis represent the 95 % bootstrapped coefficient intervals (CIs) of pair-wise edges.
B: Case bootstrapping results to assess network accuracy. X-axis represents the percentage of sampled cases and the Y-axis shows the average correlation with the original sample.

Appendix 3

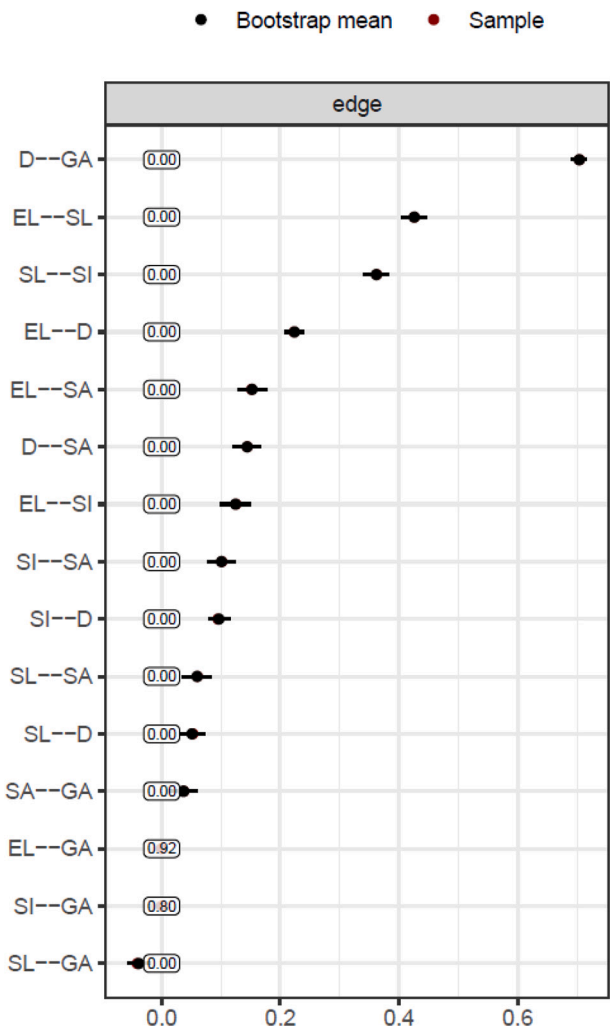


Fig. 2. Bootstrapped coefficient intervals (CIs) showing the proportion (%) of time an *edge* between two *nodes* was estimated as being 0.

Appendix 4

Data-analysis

A multivariate multiple regression model was conducted in R (R Core Team, 2021) following the guidelines from Johnson and Wichern (2007) to investigate any possible differences between our conclusions drawn from the univariate and multivariate multiple regression models. A multivariate multiple regression model takes into account that the coefficients and dependent variables covary. First, a multivariate multiple regression analysis was conducted. For all statistics, see Table 1 below. Next, multivariate test statistics were obtained by means of a multivariate analysis of variance (MANOVA) to determine whether predictors contribute to the model using modified hypothesis testing. The results are presented in Table 2. The results of the univariate and multivariate multiple regression models did not differ in terms of significance and differences in coefficients did not lead to different conclusions.

Table 1
Multivariate regression analyses predicting Emotional and Social Loneliness.

Variables	Emotional loneliness		Social loneliness	
	β	*95 %-CI*	*β*	*95 %-CI*
Age	−0.019	−0.025, −0.012	0.006	0.000, 0.011
Gender	0.155	0.077, 0.233	0.193	0.128, 0.257
Social isolation	−0.156	0.171, 0.141	−0.139	−0.151, −0.126
Depression	0.047	0.027, 0.067	0.074	0.058, 0.091
Social anxiety	0.037	0.005, 0.070	0.043	0.016, 0.070
General anxiety	−0.004	−0.044, 0.036	−0.048	−0.082, 0.014
Social isolation × Depression	0.001	0.000, 0.003	−0.002	−0.003, −0.001
Social isolation × Social anxiety	0.003	0.001, 0.005	0.000	−0.001, 0.002
Social isolation × General anxiety	−0.001	−0.003, 0.001	0.002	−0.000, 0.003

Note: β = standardized beta coefficients, *95 %-CI = 95 % Confidence Intervals.*

Table 2
Multivariate regression analysis MANOVA statistics.

Variables	Multivariate: emotional and social loneliness			
	Df	*Pillai* statistic	Approx. *F*	*p*
Age	1	0.008	26.63	<0.001
Gender	1	0.006	18.00	<0.001
Social isolation	1	0.235	1078.10	<0.001
Depression	1	0.072	272.51	<0.001
Social anxiety	1	0.036	131.06	<0.001
General anxiety	1	0.003	10.08	<0.001
Social isolation × Depression	1	0.006	21.59	<0.001
Social isolation × Social anxiety	1	0.001	2.75	0.064
Social isolation × General anxiety	1	0.001	4.33	0.013

Note: Df = degrees of freedom, *F* = *F*-value, *p* = *p*-value.

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