



Are biased interpretations of ambiguous social and non-social situations a precursor, consequence or maintenance factor of youth loneliness?

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ABSTRACT

Loneliness is common in youth, with suggestions that these negative emotions confer vulnerability for anxiety and depression. Here, we investigated for the first time whether, consistent with psychological models of loneliness, biased interpretations of social situations could prospectively predict loneliness in youth. 104 young people completed measures of loneliness and interpretations of ambiguous social and non-social (bodily or health-related) situations at three time-points with intervals of three months between each. As government-imposed social distancing measures (to control the COVID-19 outbreak) occurred between Times 2 and 3 (but not between Times 1 and 2), this enabled us to assess whether restricted social activity could provoke greater predictive power of biased interpretational styles on loneliness. Using cross-lagged panel models, we showed that after estimating paths representing within-time across-variable ("concurrent") paths and across-time within-variable ("stability") paths, there were no significant cross-lag "causal" paths between earlier interpretational style and later loneliness. Between Time 2 and 3, we demonstrated a significant cross-lag "consequential" path between earlier loneliness and later threatening interpretations of social situations, but this became non-significant after controlling for concurrent anxiety and depression. Biased interpretational style may reflect a concurrent maintenance factor of youth loneliness.

Loneliness is a major public health issue globally (Henriksen, Larsen, Mattisson, & Andersson, 2019). Defined as the distressing emotional state that arises when individuals are dissatisfied by the quality or quantity of their social relationships (Peplau & Perlman, 1982), loneliness has been labelled a "silent killer" given its association with poorer mental and physical health outcomes (Tiwari, 2013). For these reasons, efforts to mitigate loneliness are an urgent priority – made even more crucial by the recent COVID-19 pandemic, where government-imposed (physical) social isolation measures have disrupted regular interpersonal contact and typical social routines. There is now ample evidence from general population surveys (e.g. Mund et al., 2020 for a review) indicating that loneliness is commonly experienced by young people, yet research efforts to understand loneliness in younger populations lag behind those of older adults. For many young people, loneliness facilitates efforts to connect and re-connect with others at a time of social (and non-social) upheaval and transition (Larsen & Hartl, 2013; Qualter et al., 2015). But for some young people, loneliness can be persistent, and linked with other psychosocial difficulties emerging at this juncture (van Dulmen & Goossens, 2013). Implementing strategies

to manage loneliness in youth is crucial to reduce these negative feelings and psychosocial difficulties before they become habitual, but also to capitalise on enhanced learning and flexibility in youth (Lau, 2013). Most loneliness interventions in youth have been designed for youth with other primary health or social problems and while yielding moderate effects (Eccles & Qualter, 2020), may not meet the experiences and needs of youth in the general population. To target loneliness in the general youth population, a better understanding of the mechanisms contributing to youth loneliness is needed. Here, we investigate whether the tendency to draw threatening (over benign) interpretations of ambiguous social situations, maintains but also precedes loneliness in young people. We explore this hypothesis under typical levels of social interaction and during exposure to restricted social interactions imposed by COVID-19 related lockdown conditions.

Psychological models have proposed that loneliness is a biological alarm – warning individuals of potential social isolation and the need to reconnect with others to ensure continued social support. As part of this adaptive response, loneliness activates an initial period of social withdrawal and patterns of information-processing that favour social over

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non-social information (Cacioppo & Hawkley, 2009; Qualter et al., 2015). By enabling an individual to observe and evaluate immediate social situations, these changes are thought to promote re-engagement with others, limiting the length of time spent feeling lonely; loneliness is therefore usually transient. However, individuals with a preferential tendency to process threat at certain stages of social information-processing ('threat biases') are hypothesised to experience prolonged social withdrawal, increasing the propensity for high and persistent loneliness. In turn, loneliness experiences could further shape and reinforce these threatening cognitive biases, leading to a vicious cycle that results in chronic loneliness. Such threat biases have been proposed to emerge in attention patterns, but also during the interpretation of ambiguity in interpersonal cues during social interactions (Spithoven, Blijlevens, & Goossens, 2017). As threat interpretations of social situations may prolong social withdrawal, they could reflect risk markers for heightened loneliness, and thus, a potential target in loneliness interventions (Masi, Chen, Hawkley, & Cacioppo, 2011).

However, while studies have reported that youth loneliness is associated with greater expectations of rejection rather than benign outcomes (Spithoven et al., 2017), and endorsement of hostile intent as the explanation for ambiguous (but not unambiguous) exchanges (Qualter et al., 2013), it is less clear whether threat interpretations also increase loneliness, as hypothesised by key psychological models. Most studies assessing the association between threat interpretations and loneliness have used cross-sectional designs (Spithoven et al., 2017). One study demonstrated a longitudinal association between negative expectations of rejection (both angry/aggressive and anxious/withdrawal responses) and loneliness, but this was in early adolescence (London, Downey, Bonica, & Paltin, 2007), with no studies assessing this prospective association in late adolescence, during which loneliness peaks. This prior study also did not assess whether these negative expectations of threatening social situations were also affected by loneliness experiences. The primary goal of this research was to investigate whether threat interpretations in young people (i) correlated with loneliness within the same time-frame (concurrent association), (ii) predicted loneliness across time (longitudinal association) and (iii) were predicted by loneliness across time (consequential association). Here, we expected concurrent but also longitudinal and consequential associations. Because most previous studies of the cognitive substrates of loneliness have measured threat interpretations using self-reported questionnaires of rejection sensitivity, questions over the content-specificity of these biases have been difficult to address. As this has important implications for identifying risk markers or potential intervention targets, we also explored whether the threat interpretations that characterise lonely individuals only emerge in response to ambiguous social information, or if they emerge to non-social ambiguous situations, such as those that could signal bodily harm (physical danger, illness).

Finally, it is also possible that the effects of cognitive risk factors on youth loneliness are amplified under conditions of social challenges (e.g. isolation, rejection). That a social factor may precipitate latent cognitive vulnerability factors is consistent with stress-diathesis models of other internalizing disorders e.g. (Hankin & Abela, 2005; Monroe, Slavich, Torres, & Gotlib, 2007), yet this question has yet to be explored in relation to loneliness. To address this, we took advantage of the fact that one of our data collection phases occurred during an intensive period of lockdown and government-imposed social distancing measures, designed to mitigate the effects of the global coronavirus disease (COVID-19) pandemic. Widespread closure of most workplaces, educational institutions, and other non-essential organisations and facilities meant that regular social routines and interpersonal contacts were disrupted for most people. Under these social restriction conditions, we explored the extent to which individual differences in threat interpretations would predict loneliness, compared to an earlier phase of data collection with typical levels of social activity ('baseline'). Therefore, we estimated concurrent and temporal paths between interpretational style and loneliness. Given that loneliness co-occurs with

anxiety and depression in young people, and is considered as a gateway to these conditions, identifying what is and is not shared with these emotional symptoms may be insightful; therefore we presented findings with (but also without) controlling for anxiety and depression. Our questions will be addressed in a sample of mid-to-late youth (18-24-year olds), covering a developmental period when loneliness is commonly experienced and likely to be elevated. Compared to earlier in childhood, late adolescence to early adulthood is also a period when protracted neurocognitive maturation overlaps with, and may contribute to, the consistency with which interpretational styles of social situations associate with emotional symptoms (Stuijffzand, Creswell, Field, Pearcey, & Dodd, 2018). Simultaneously, maladaptive patterns of interpretation are less likely to have become entrenched and habitual than in adulthood, making them an appropriate target for early intervention.

1. Methods

Sample and procedures: Approval for the study was granted by the Psychiatry, Nursing and Midwifery Research Ethics Subcommittee (HR-19/20-14499). One hundred and four young people aged 18–24 years were recruited from Universities in London to take part in a study of youth loneliness. Recruitment strategies included advertisement on research pages of selected universities, university-wide recruitment emails and word of mouth. Students showing interest were emailed an information sheet about the study, alongside a consent form and an additional checklist of the eligibility criteria. Inclusion criteria for the study were: (1) aged 18–24 years; (2) informed consent given. Exclusion criteria were: (1) learning disability or significant head injury, neurological disorder or epilepsy (2) unable to fluently communicate in English. Participants were asked to confirm that they met each of these criteria before returning this with the consent form to the research team.

Participants completed measures online using Qualtrics Survey at three time-points (T1, T2, T3), approximately three months apart (T1 to T2, Mean = 87 days, SD = 5.6 days; T2 to T3, Mean = 86 days, SD = 3.11 days). Given our interest in biased interpretations as a marker of more stable rather than transient feelings of loneliness, participants were asked to complete the UCLA Loneliness Scale (Russell, 1996) at each time-point, alongside a measure of interpretational style that assesses biases in the interpretation of social and non-social information. Brief measures of anxiety (GAD7) and depression (PHQ9) to control for affective symptoms given their links with loneliness and interpretation biases were also completed. At Time 1, participants provided the following demographic information: sex assigned at birth, month and year of birth, ethnicity, parents' highest educational level. At Time 2, participants also completed a measure about social media usage, and at Time 3, participants completed additional measures around (physical) pain, health anxiety and the impact of the coronavirus pandemic and associated lockdown measures on daily functioning. These data were used to address independent research questions within undergraduate and postgraduate research dissertations supervised by the first author. A £10 voucher for every assessment that they completed was given to participants to compensate them for their time.

1.1. Measures

UCLA Loneliness Scale (Version 3; Russell, 1996): This is a 20-item scale measuring subjective feelings of loneliness as well as feelings of social isolation. Each item is assessed on a 4-point scale (Never, Rarely, Sometimes, Often), and a total score created by adding up the 20 individual items (with some reverse scored). The measure is highly reliable, in terms of internal consistency (coefficient alpha ranging from 0.89 to 0.94) and test-retest reliability over a 1-year period ($r = 0.73$) (Russell, 1996). Validity has also been established through significant correlations with other measures of loneliness (convergent validity) and with measures of theoretically-related constructs such as health and well-being (construct validity) (Russell, 1996). Internal consistency of the UCLA Loneliness

Scale in our sample, indexed by Cronbach's alpha, was 0.923 at Time 1, 0.924 at Time 2 and 0.925 at Time 3.

Adolescent Interpretation Bias Task (expanded): This task assesses young people's tendencies to select threatening and benign explanations and outcomes of ambiguous bodily harm and social evaluation situations (Lau et al., 2020). Participants read written vignettes that are considered ambiguous because it is unclear until the ending whether a threatening or benign outcome (or explanation) will occur. The resolution of the ambiguity of the scenario occurs in the final word; for this, participants are presented with a threatening or benign ending across different trials and asked to rate the likelihood of each ending on a scale from 1 to 5 (extremely unlikely to extremely likely).

While 12 vignettes describe social evaluation situations, 8 items describe bodily harm situations. Based on an earlier factor analyses of responses to these items in a community sample of youth (Lau et al., 2020), the social evaluation situations comprised items about potential rejection ("Your best friend invites you to go out with their new friends to the cinema. You hesitate at first but then agree to come along. At the end of the evening you think that the other people thought that you were ... dull/lovely") and potential performance failure ("You raise your hand to give your views during a debate in the English lesson. When the teacher picks you, you think that the others will think your views are ... ridiculous/important"). Loading onto a bodily harm factor were situations about potential injury and pain ("You are helping your mum prepare dinner and are cutting some vegetables. The knife slips and accidentally cuts into your ... carrot/finger") and potential longer-term illness ("You have made an appointment to see your doctor to discuss your test results. You think the results will probably show you are ... fine/ill"). Mean ratings were calculated for threatening and benign interpretations of social evaluation and bodily harm situations, making 4 subscales. Cronbach's alphas for Time 1 variables were: 0.820 for threatening interpretations of social evaluation, 0.816 for benign interpretations of social evaluation, 0.573 for threatening interpretations of bodily harm, and 0.402 for benign interpretations of bodily harm. For Time 2, these values were: 0.856, 0.842, 0.614 and 0.417. For Time 3, these values were 0.860, 0.822, 0.630 and 0.627. Removal of (the same) one item from the threatening interpretations of bodily harm increased the Cronbach's alpha to 0.630 and 0.644 for Time 1 and 2 respectively but did not change for Time 3. Removal of items from the benign interpretations of bodily harm did not alter Cronbach's alpha, therefore due to unacceptable internal consistency, this sub-scale was excluded from subsequent analysis.

GAD7: This tool assesses the severity of 7 anxiety symptoms by rating each on a 4-point scale for frequency of occurrence, in the last 2 weeks (from not at all to nearly every day) (Spitzer, Kroenke, Williams, & Löwe, 2006). A total score is made by summing these items. Cronbach's alpha for this scale at Time 1 was 0.827, at Time 2 was 0.806 and at Time 3 was 0.810.

PHQ9: This assesses severity of 9 depression symptoms as described in the DSM-IV (Kroenke, Spitzer, & Williams, 2001). These are also rated on a 4-point scale for frequency of occurrence in the last 2 weeks from not at all from to nearly every day. Cronbach's alpha for this scale at Time 1 was 0.880, Time 2 was 0.857 and Time 3 was 0.867.

1.2. Statistical analysis

At each of the three time-points, whole-sample and sex-specific descriptive data (including means and standard deviations) were derived for loneliness scores, interpretational style subscales, and anxiety and depression. Although we had a relatively limited age range (18–24 years), this is still a period when there are different life transitions across age groups (e.g. some starting, others finishing University, some finding a job etc) that we thought it would be important to quantify these by computing correlations between each variable and chronological age. Mean levels of each variable were compared from Time 1 to Time 2 and Time 2 to Time 3. Finally, we reported within-time

and across-time correlations between loneliness, interpretational style subscales, anxiety and depression scores.

To examine concurrent and reciprocal paths between interpretation bias and loneliness, cross-lagged panel models (Figs. 1–3) were estimated using MPlus v8 (Muthén, L.K. and Muthén, 2017). These models estimated path coefficients for (i) within-time associations between different constructs (concurrent), (ii) cross-time associations within the same construct (stability), and (iii) cross-time associations between different constructs (cross-lags consistent with 'causal' and 'consequential' associations). Using separate cross-lagged analyses, we estimated these three sets of pathways between loneliness and: threat interpretations of social evaluation situations (Fig. 1); benign interpretations of social evaluation situations (Fig. 2); and threat interpretations of bodily harm situations (Fig. 3). Models were first run without statistically controlling for concurrent anxiety and depression, and then repeated with these variables included as covariates. We did not statistically control for sex and age in these models as these did not significantly associate with loneliness at any time-point. Model parameters were estimated using maximum likelihood with robust standard errors, with full information maximum likelihood (FIML) used to account for missing data. Model performance was evaluated using several goodness-of-fit statistics (chi-square test, comparative fit index [CFI], Tucker-Lewis index [TLI] and root mean-squared error of approximation [RMSEA]). Good model fit was determined by non-significant chi-squares, CFI values ≥ 0.95 , TLI values ≥ 0.95 , and RMSEA values < 0.08 (Browne & Cudeck, 1993, pp. 136–162; Hu & Bentler, 1999).

2. Results

Of the 104 participants, 35.6% ($n = 37$) were male. Participants sampled predominantly identified as Asian ($n = 49$; 47%), White ($n = 20$; 19%), or Other ($n = 23$; 22%). 44.4% of the sample reported that they had a parent who had obtained a degree or equivalent. Table 1 contains descriptive data, both across the whole sample and separately by sex, for loneliness scores, interpretational style subscales, anxiety and depression scores for each time-point, as well as their correlations with age. Sex differences were only found for threatening interpretations of social evaluation at Time 1, with females endorsing these more than men ($t(102) = -2.6$, $p = 0.007$, $d = 0.551$). From Time 1 to Time 2, no significant changes were observed in loneliness, anxiety, depression and threatening and benign interpretations of social evaluation ($-1.17 < t < 2.34$). Significantly lower scores were found for threatening interpretations of bodily harm between Time 1 ($M = 3.12$, $SD = 0.585$) and Time 2 ($M = 2.99$, $SD = 0.603$) ($t(95) = 2.34$, $p = 0.021$, $d = 0.219$). Between Time 2 and Time 3, no significant changes were present in loneliness, anxiety, depression and threatening and benign interpretations of social evaluation ($-6.00 < t < 2.52$). Lower scores were only significant for threatening interpretations of bodily harm between Time 2 ($M = 2.99$, $SD = 0.607$) and Time 3 ($M = 2.68$, $SD = 0.530$) ($t(92) = -6.00$, $p = 0.00$, $d = 0.544$).

2.1. Correlational data

Within each time-point, loneliness correlated significantly with social threat interpretations ($r_{T1} = 0.61$, $r_{T2} = 0.45$, $r_{T3} = 0.48$, all p 's < 0.01), and with social benign interpretations but in the opposite direction ($r_{T1} = -0.48$, $r_{T2} = -0.36$, $r_{T3} = -0.41$, all p 's < 0.01). Loneliness also correlated with bodily threat interpretations within each time-point ($r_{T1} = 0.46$, $r_{T2} = 0.30$, $r_{T3} = 0.39$, all p 's < 0.01). All other correlations between variables within each time-point are presented in Table 2. Briefly, within each time-point, loneliness correlated with anxiety ($r_{T1} = 0.51$, $r_{T2} = 0.47$, $r_{T3} = 0.46$, all p 's < 0.01) and depression ($r_{T1} = 0.60$, $r_{T2} = 0.52$, $r_{T3} = 0.50$, all p 's < 0.01), and correlations between anxiety and interpretation bias variables ranged in size between 0.33 and 0.55 while correlations between depression and interpretation bias variables ranged in size between 0.28 and 0.52.

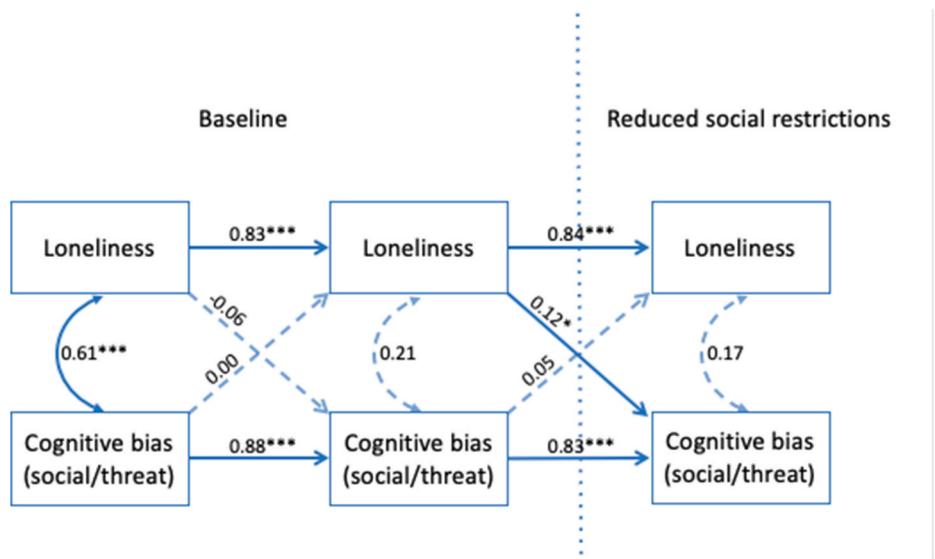


Fig. 1. Model containing within-time (concurrent) associations between variables, cross-time (stability) associations within variables, and cross-time, cross-variable (causal, consequential) associations between loneliness and threatening interpretations of social situations.

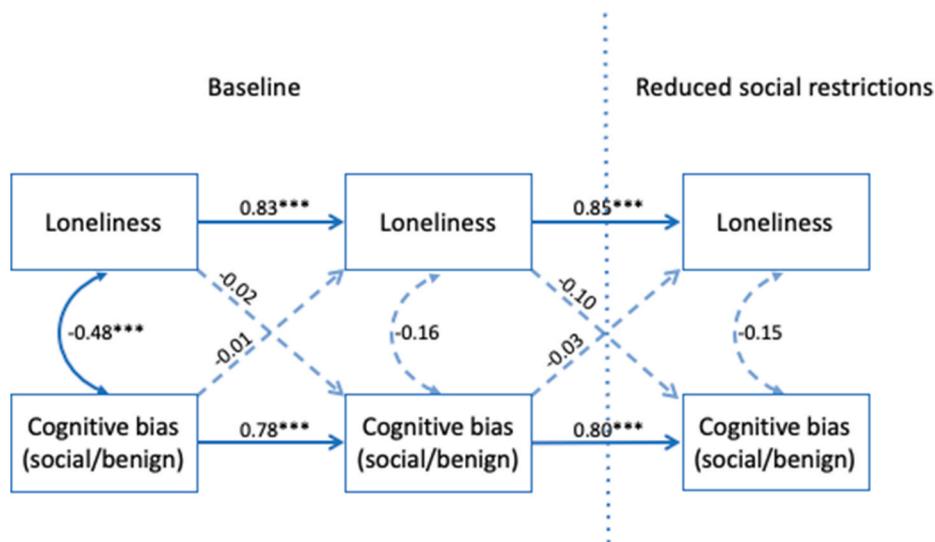


Fig. 2. Model containing within-time (concurrent) associations between variables, cross-time (stability) associations within variables, and cross-time, cross-variable (causal, consequential) associations between loneliness and benign interpretations of social situations.

Informing the question of precursory effects across both “baseline” conditions and “social restriction” conditions, earlier social threat interpretations positively correlated with later loneliness ($r_{T1-T2} = 0.47$, $r_{T2-T3} = 0.39$, p 's < 0.01). Earlier social benign interpretations also negatively correlated with later loneliness across these “baseline” conditions and “social restriction” conditions: $r_{T1-T2} = -0.38$, $r_{T2-T3} = -0.31$; all p 's < 0.01. Informing the question of consequential associations across both “baseline” conditions and “social restriction” conditions, earlier loneliness positively correlated with later social threat interpretations ($r_{T1-T2} = 0.46$, $r_{T2-T3} = 0.35$; all p 's < 0.01) and negatively correlated with later social benign interpretations ($r_{T1-T2} = -0.38$, $r_{T2-T3} = -0.36$; all p 's < 0.01). Table 3 presents the remaining cross-time correlations between variables (including within-variable correlations). Of particular note, there were clear cross-time associations between earlier bodily threat interpretations and loneliness across both “baseline” conditions and “social restriction” conditions ($r_{T1-T2} = 0.28$, $r_{T2-T3} = 0.40$; all p 's < 0.01) and earlier loneliness and later bodily threat interpretations ($r_{T1-T2} = 0.38$, $r_{T2-T3} = 0.22$; all p 's < 0.01).

2.2. Cross-lagged models

Fig. 1 presents path coefficients for a cross lagged model between loneliness and threatening interpretations of social evaluation situations (without controlling for concurrent anxiety and depression symptoms at each time-point). Fit statistics suggested good overall fit ($\chi^2 = 7.28$, $p = 0.12$, CFI = 0.99, TLI = 0.97, RMSEA = 0.09). Significant path coefficients between repeated measures of each construct (loneliness_{T1-T2} = 0.83, loneliness_{T2-T3} = 0.84; social threat interpretations_{T1-T2} = 0.88, social threat interpretations_{T2-T3} = 0.83) suggested stability of each variable across time (i.e. temporal associations within each construct). Examining within-time associations between the two constructs (concurrent associations), a significant association between loneliness and threat interpretations was only observed at Time 1 (0.61). Finally, in relation to cross-time associations between constructs (cross-lags consistent with ‘causal’ and ‘consequential’ associations) despite previously finding associations between T1 threatening interpretations of social evaluation and T2 loneliness, and between T2 threatening

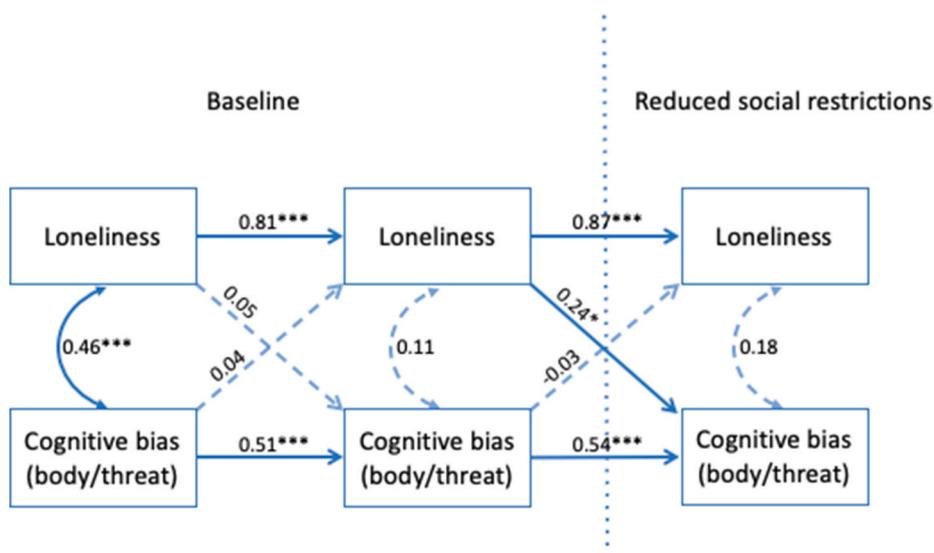


Fig. 3. Model containing within-time (concurrent) associations between variables, cross-time (stability) associations within variables, and cross-time, cross-variable (causal, consequential) associations between loneliness and threatening interpretations of bodily harm situations.

Table 1

Showing the mean, standard deviations and correlation with age for loneliness, depression, anxiety and interpretation styles across time points.

	Whole sample Mean (SD)	Female Mean (SD)	Male Mean (SD)	Correlation with age (r)
Time 1				
Loneliness	N=104 43.23 (10.57)	N = 67 44.50 (10.88)	N = 37 41.00 (9.71)	-.13
Depression	6.52 (5.77)	7.76 (5.86)	5.54 (5.53)	.10
Anxiety	7.49 (4.95)	8.22 (5.07)	6.16 (4.49)	.13
Social threat interpretations	3.02 (0.70)	3.15 (0.74)	2.79 (0.56)	.12
Social benign interpretations	3.24 (0.62)	3.16 (0.63)	3.39 (0.58)	-.01
Bodily threat interpretations	3.22 (0.64)	3.32 (0.67)	3.03 (0.52)	.05
Time 2				
Loneliness	N = 97 42.11 (10.06)	N = 63 42.35 (9.71)	N = 34 41.68 (10.81)	-.18
Depression	5.41 (4.95)	5.68 (4.82)	4.91 (5.21)	.02
Anxiety	6.92 (4.61)	6.97 (4.56)	6.82 (4.72)	.21*
Social threat interpretations	2.94 (0.73)	3.03 (0.75)	2.79 (0.68)	.02
Social benign interpretations	3.32 (0.62)	3.27 (0.62)	3.40 (0.62)	.09
Bodily threat interpretations	2.66 (0.55)	2.76 (0.54)	2.48 (0.54)	.24*
Time 3				
Loneliness	N = 99 42.98 (9.87)	N = 64 42.5 (10.4)	N = 35 43.8 (8.91)	-.21
Depression	6.20 (5.12)	6.30 (4.94)	6.02 (5.50)	-.10
Anxiety	7.31 (4.48)	7.15 (4.35)	7.60 (4.77)	.03
Social threat interpretations	2.95 (.70)	3.03 (.72)	2.80 (.65)	.04
Social benign interpretations	3.35 (.57)	3.32 (.57)	3.40 (.57)	.05
Bodily threat interpretations	2.67 (.52)	2.72 (.51)	2.57 (.54)	.11

* $p < 0.05$.

interpretations of social evaluation and T3 loneliness (Table 3), these cross-lagged 'causal' path coefficients were non-significant once within-construct stability and concurrent associations were included in the model. In terms of cross-lagged paths reflecting a 'consequential' effect, the association between T2 loneliness and T3 threatening interpretations of social evaluation was significant (albeit weakly; 0.12), but the association between T1 loneliness and T2 threatening interpretations of social evaluation was not. Of note, after controlling for concurrent anxiety and depression symptoms at each time-point, which still yielded a good fit ($\chi^2 = 19.81$, $p = 0.07$, CFI = 0.98, TLI = 0.96, RMSEA = 0.08), only the stability effects and the concurrent association between loneliness and threat interpretation at Time 1 remained significant (Supplementary Figure 1).

The same cross-lagged model configuration was estimated between loneliness and benign interpretations of social evaluation situations, again without controlling for concurrent anxiety and depression symptoms at first (Fig. 2). Again, model fit was good ($\chi^2 = 7.28$, $p = 0.12$; CFI = 0.99; TLI = 0.97; RMSEA = 0.09). Patterns of significance among path coefficients were similar to the model involving threatening interpretations; namely, there was again significant stability within measures across time (loneliness_{T1-T2} = 0.83, loneliness_{T2-T3} = 0.85; social benign interpretations_{T1-T2} = 0.78, social benign interpretations_{T2-T3} = 0.80), and a significant concurrent association between constructs at Time 1 (-0.48). Cross-lag path coefficients capturing causal and consequential pathways were not significant between any time-points. Model fit again remained good once concurrent anxiety and depression were controlled for ($\chi^2 = 24.34$, $p = 0.018$; CFI = 0.99; TLI = 0.97; RMSEA = 0.09) but with no change to the significance of parameter estimates (Supplementary Figure 2).

To inform the content-specificity of these associations, we repeated the cross-lagged model with threatening interpretations of bodily harm situations (Fig. 3). This showed good model fit ($\chi^2 = 4.99$, $p = 0.29$, CFI = 0.99, TLI = 0.99, RMSEA = 0.05). Findings were similar to the model involving threatening interpretations of social evaluation situations, although the size of path coefficients denoting the stability of threat interpretations of bodily harm across time-points was somewhat smaller (loneliness_{T1-T2} = 0.81, loneliness_{T2-T3} = 0.87; bodily threat interpretations_{T1-T2} = 0.51, bodily threat interpretations_{T2-T3} = 0.54). There was again a significant concurrent association between these variables at T1 (0.46) and a significant pathway between loneliness at T2 and threatening interpretations at T3 (0.24). Controlling for concurrent anxiety and depression symptoms revealed a model with similarly good

Table 2

Demonstrating the correlation between loneliness, anxiety and depression with interpretation styles across time points (** < 0.01).

Time 1	Social threat interpretations	Social benign interpretations	Bodily threat interpretations	Anxiety	Depression
Loneliness	.610**	-.481**	.459**	.513**	.603**
Anxiety	.549**	-.395**	.470**		
Depression	.515**	-.412**	.386**		
Time 2	Social threat interpretations	Social benign interpretations	Bodily threat interpretations	Anxiety	Depression
Loneliness	.446**	-.364**	.295**	.478**	.524**
Anxiety	.549**	-.395**	.470**		
Depression	.455**	-.413**	.372**		
Time 3	Social threat interpretations	Social benign interpretations	Bodily threat interpretations	Anxiety	Depression
Loneliness	.484**	-.406**	.394**	.464**	.498**
Anxiety	.364**	-.356**	.333**		
Depression	.275**	-.313**	.350**		

Table 3

Demonstrating the correlations between loneliness and interpretational styles across time-points (correlations in bold reflect stability; ** < 0.01).

	Time 1				Time 2			
	Loneliness	Social threat interpretations	Social benign interpretations	Bodily threat interpretations	Loneliness	Social threat interpretations	Social benign interpretations	Bodily threat interpretations
Time 2								
Loneliness	0.819**	0.473**	-0.384**	0.384**				
Social threat interpretations	0.459**	0.830**	-0.765**	0.42**				
Social benign interpretations	-0.376**	-0.696**	0.795**	-0.346**				
Bodily threat interpretations	.0.277**	0.423**	-0.286**	0.542**				
Time 3								
Loneliness	0.774**	0.431**	-0.321**	.0.347**	0.852**	0.393**	-0.313**	0.217**
Social threat interpretations	0.467**	0.766**	-0.703**	0.473**	0.450**	0.875**	-0.745**	0.334**
Social benign interpretations	-0.428**	-0.603**	0.705**	-0.314**	-0.364**	-0.723**	0.831**	-0.131, n.s.
Bodily threat interpretations	0.357**	0.422**	-0.292**	0.455**	0.395**	0.468**	-0.369**	0.620**

fit ($\chi^2 = 21.33$, $p = 0.046$; CFI = 0.97; TLI = 0.93; RMSEA = 0.09), but the significant path between loneliness at T2 and threatening interpretations at T3 was no longer significant (Supplementary Figure 3).

3. Discussion

In the present study, we extended previous findings of a cross-sectional association between threat interpretations and loneliness by investigating whether threat interpretations also predicted later loneliness and/or whether loneliness predicted later threat interpretations. We examined whether biased interpretational styles in lonely individuals associated with a lack of benign interpretations, and also negative interpretations of other salient situations (e.g. bodily harm situations). We further examined whether these concurrent and reciprocal effects were amplified under “social restriction” conditions (relative to “baseline” with no such restrictions). Our data showed significant longitudinal associations between earlier threatening (and benign) interpretations of social evaluation situations and later loneliness (and between earlier loneliness and later threatening and benign interpretations of social evaluation situations). However, in a combined panel model, once longitudinal stability within each construct, and cross-sectional associations between loneliness and threat/benign interpretations at Time 1 were accounted for, any cross-lagged paths representing potential bidirectional effects were mostly non-significant. There was one exception: a significant temporal effect emerged between early loneliness and later threat interpretations during the period of social restrictions. However, this became non-significant once concurrent anxiety and depression were controlled for. Interestingly, similar findings were found when considering the relationship between loneliness and bodily threat interpretations, such that there were weak-to-

moderate sized correlations (within and across-time) between variables. However, the only significant paths to emerge (after controlling for anxiety and depression symptomatology) were those within variables across time (stability) and between variables at T1 only (concurrent path). Together these data suggest that, rather than directly conferring risk for later loneliness, a biased interpretational style for social evaluation situations maintains (early) concurrent loneliness, that this bias extends to bodily threat situations too, and restricted social activities do not seem to provoke or unleash a stronger relationship between loneliness and biased interpretations. Each of these findings is discussed.

Psychological models suggest that loneliness activates a pattern of information processing that focuses on social over non-social information in order to facilitate reconnection efforts with others (Cacioppo & Hawkley, 2010; Qualter et al., 2015). However, a preferential tendency to attend to threatening information (e.g. notice a frown over a smile) or interpret ambiguous information as threatening (e.g. attributing uncertain social cues to rejection rather than acceptance) may increase the propensity for persistent loneliness by encouraging social avoidance and inhibiting social approach (Qualter et al., 2015). Our data showed that although “social threat biases” in interpretation marked later loneliness, this correlation was explained by an initial concurrent association between these variables, along with subsequent stability of each variable across time. This was also true for a tendency to select benign (non-threatening) interpretations of social situations and stands in contrast with an account that biased interpretational style directly confers risk for later loneliness. It may be that while these interpretational styles are still consolidating across youth (Stuijfzand et al., 2018), their ability to shape later loneliness is somewhat reduced compared to in adulthood, when they are more habitual and trait-like. Although our

data somewhat undermines the potential of using therapeutic techniques to modify cognitions to reduce loneliness and related negative outcomes (Masi et al., 2011) it is important to note that a concurrent association could also arise through a mutually reinforcing and cyclical relationship between loneliness and threat interpretations. It could be that within the same time-frame (albeit at the early time-point only), loneliness affects the tendency to favour socially threatening explanations, and that this social threat focus in turn increases the tendency to perceive isolation and experience loneliness. With carefully designed experimental manipulation studies, these mutually reinforcing hypotheses can be tested and, if found to be supported, methods such as cognitive restructuring or cognitive bias modification affecting short-term lonely states could still be used to alleviate longer-term loneliness.

Our second finding was that there were significant correlations between threatening interpretations of bodily harm situations and loneliness (although with small-to-moderate effect sizes and based on a measure with relatively low internal consistency). Although models of more persistent loneliness do not clearly suggest whether the preferential processing of threat (that contributes to prolonged social withdrawal and potentially chronic loneliness cycles; Cacioppo & Hawkley, 2009) is restricted to social threats, our data suggests a more general tendency of elevated threat processing – or one that generalises to bodily threat situations. Thus, lonely young people may generally be attuned to understanding immediate and long-term bodily harm situations in more threatening or negative ways – which could explain the significant associations between loneliness and chronic pain conditions, given that pain in youth is associated with more threatening interpretations of both these situations (Lau et al., 2020). While loneliness can emerge in the context of a chronic health condition such as chronic pain, there is also data to suggest that loneliness can be longitudinal risk factor of pain (Jaremka et al., 2014). However, whether these biased interpretations also extend to situations beyond social evaluation and bodily signals requires further empirical work. Such situations could include ambiguous situations around achievements (academic and non-academic). A more generalised vigilance and endorsement of threat or negativity could mediate associations with anxiety and depression too.

Finally, there was little evidence to suggest that more threatening styles of interpretations predicted loneliness more during the pandemic phase of the study, where there were restrictions in social activity. As loneliness did not significantly increase between Time 1 and Time 2 or between Time 2 and Time 3, it may be that the onset of the pandemic was not powerful enough to precipitate cognitive vulnerability and provoke changes in loneliness. Future studies should assess these questions either in a later phase of the pandemic after which there has been prolonged alteration of social activities, or during other important transition periods, such as leaving school or starting University or work. Interestingly, loneliness predicted more threatening styles of interpretations of social and bodily situations during the pandemic phase of the study. However, this relationship arose through shared variance with mood and anxiety symptoms. While it is unclear what the mediatory pathways are between loneliness, mood and anxiety symptoms, and threatening interpretations of social situations, other research does indicate that such threat interpretations in early adulthood can influence broader emotional functioning including stress reactivity (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002, although see; Vinograd et al., 2020). Thus, to the extent that loneliness is a gateway to later mental health problems, this may be explained through its effects on emerging information-processing styles. Targeting youth loneliness directly through other evidence-based interventions (e.g. social skills training, community social action; Eccles & Qualter, 2020) can therefore be important for promoting longer-term well-being.

There are a number of other additional findings that deserve brief comment. First, females endorsed threatening interpretations of social situations more than males, adding to and somewhat challenging existing literature on gender differences in responses to social rejection

(e.g. London et al., 2007; Marson, Hare & Allen, 2015). Second, despite the onset of the COVID-19 pandemic between time-points 2 and 3, there was a decrease in negative interpretations of bodily harm. Tentatively, the focus on COVID-19 specific symptoms and infections could have attenuated fears and worries, and associated negative interpretations of more general health problems and illnesses. Alternatively, it could be that as this was a sample of young people, concerns around health were less salient compared to changes in academic routines. It should be noted though that the internal consistency of this subscale was lower than the threatening and benign interpretations of social situations. Thus, this decrease needs to be interpreted with caution.

There were a number of additional limitations in the present study. All measures relied on self-reports, and as this study was known by participants to measure thinking styles in relation to loneliness, demand effects may confound these associations. While loneliness, depression and anxiety symptoms are subjective experiences, commonly captured by self-reports, interpretational style can be assessed with more covert methods (e.g. making sentences with homophones/homographs with threatening and non-threatening meanings such as mug, pain/pane, patient, or unscrambling sentences that have threatening or non-threatening meanings). Inclusion of these more covert measures of interpretational style could address the possibility of demands effects including any “carryover” effects of responding to the same scenarios due to repeated administration. Covert or “online” measures could also capture more involuntary aspects of ambiguity resolution, potentially informing the association between interpretation bias and loneliness (Hirsch, Meeten, Krahé, & Reeder, 2016). Two other limitations related to the specific subs-scales. The inter-item reliability of the benign bodily threat subscale was low. This may be because of the merging of long-term health and illness items to items around immediate bodily injury. As mortality and illness may be less salient for young people such as those in our sample, cognitions around these items are less consistent and stable, affecting overall reliability. Future research should aim to more carefully identify health and illness situations that are age appropriate and interrogate their reliability. Additionally, within the social evaluation situations, the ‘benign’ subscale included benign but also overtly positive resolutions (this contrasted with ‘benign’ interpretations of bodily harm situations, which were usually more neutral in their resolutions). Again, future research could distinguish more between benign/neutral versus benign/positive resolutions of ambiguous social situations and their linkages with loneliness. Our sample size was somewhat restricted. Despite showing little attrition across our three waves, we estimated somewhat more parameters in our cross-lagged models than is suggested by the rule of thumb of 10 participants per path estimate. Similarly, our sample size meant that we could not estimate a single model that included both threatening and benign interpretation scores. Although one option is to create a bias index or difference score between these, we and others have previously demonstrated that these are not necessarily opposite ends of the same spectrum, and instead, are independent dimensions with differential associations with emotional symptoms (e.g. Heathcote, Jacobs, Eccleston, Fox, & Lau, 2017; Hindash & Amir, 2012; Lau et al., 2020). Thus, young people with high levels of loneliness who show increased endorsement of threatening interpretations may not necessarily show a corresponding reduction in endorsement of benign interpretations. Ideally, these should be analysed as separate variables and future research involving larger samples may serve to disentangle whether these reflect shared or distinct effects on loneliness. Third, our participants were all students from London. London has been labelled as the loneliness capital of the UK after a national survey in 2013 showed that 52% experienced varying degrees of loneliness versus the national UK average of 45% (Pyle & Evans, 2018). Students also fall within the age range where peak loneliness levels have been reported. Mean levels of loneliness in our sample were similar to mean scores reported in College students (Russell, 1996), which limits generalisability of our findings to other samples. Although mean loneliness scores in students could be

higher than in other non-student populations, nonetheless, we did not select for high loneliness scores, which could impact on some of the null findings reported here.

In summary we did not find evidence to support our hypotheses that threatening interpretations of social evaluation situations predicted loneliness across time. Instead, to the extent that threat interpretations marked later loneliness, this was explained by a concurrent association and subsequent stability of these variables.

CRediT authorship contribution statement

JenniferY.F. Lau: conceived of the hypothesis explored in the manuscript, Funding acquisition, Supervision, Writing – original draft, Writing – review & editing. **Rimsha Shariff:** conceived of the hypothesis explored in the manuscript, Data curation, Project administration, Methodology, Writing – original draft, Writing – review & editing. **AlanJ. Meehan:** Formal analysis, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.brat.2021.103829>.

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