The relationship between state and trait loneliness and social experiences in daily life

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1 **Abstract**

2 Loneliness, or the subjective experience of social disconnection, is often thought of as a
3 stable characteristic. However, emerging data suggest that experiences of loneliness fluctuate
4 within people over time. Understanding the momentary correlates of state experiences of
5 loneliness can help identify and address the negative consequences of such experiences. Further,
6 the relationship between trait (dispositional) and state (momentary) loneliness remains poorly
7 understood. Identifying the extent to which trait loneliness might moderate momentary
8 associations can inform understanding of their interactions and inform treatments at the within-
9 and between-person levels. In the current ecological momentary assessment (EMA) study, 32
10 adult participants (mean age = 25) reported on momentary loneliness and qualities of social
11 interactions four times per day for seven days using a smartphone application. Participants also
12 reported on trait loneliness. We found that trait and state loneliness were correlated in the same
13 directions with multiple daily social experiences. Importantly, momentary social appraisals (i.e.,
14 rejection/criticism from previous interaction(s), a preference to be alone when with others,
15 feeling connected to others when alone, and hypervigilance to future social threat) were related
16 to more state loneliness, while interacting with others and feeling happy in the moment were
17 related to less state loneliness. These relationships were not moderated by trait loneliness, with
18 one exception: People higher in trait loneliness exhibited a stronger relationship between a
19 preference to be alone when with others and more state loneliness. These results suggest that
20 social appraisals, particularly negative perceptions of social experiences, are important factors in
21 influencing state loneliness, regardless of one's general tendencies to feel lonely. On the other
22 hand, those higher in trait loneliness are more likely to feel lonely in moments when they are
23 with others but prefer to be alone.

24 **Introduction**

25 Decades of research have observed robust associations between trait loneliness, or the
26 tendency to have the aversive experience that one's social needs are not being met [1-2], and
27 poorer mental and physical health outcomes [3-5]. Self-report trait scales like the UCLA
28 Loneliness Scale [6] have been used to show the unique effects of loneliness compared to other
29 related conditions, such as objective social isolation or "aleness" [7]. Recently, researchers
30 have also studied the way that state (or momentary) experiences of loneliness fluctuate within
31 people over time, and how these fluctuations are related to daily social experiences [8-9]. What
32 remains less well understood is the extent to which the correlates of trait and state experiences of
33 loneliness differ. One can imagine that people on average may report high or low levels of trait
34 loneliness but that specific factors in daily life (whom they are interacting with, how they feel
35 about those interactions) may influence state levels of loneliness. Trait measures are unable to
36 capture this variation in daily life. It remains an open research question as to how trait loneliness
37 may interact with daily social experiences to influence momentary feelings of loneliness, as well
38 as whether a more granular analysis of state experiences of loneliness may provide information
39 above and beyond trait measures.

40 Ecological momentary assessment (EMA), also known as the experience sampling
41 method, allows researchers to study participant self-reported experiences outside of the
42 laboratory [10-11]. A key strength of EMA is the ability to draw inferences regarding the
43 temporal nature of these experiences as captured in naturalistic contexts, within and across
44 individuals. Although many studies have used EMA to understand social experiences in healthy
45 [12] and clinical populations, such as in those experiencing anxiety disorders [13] and
46 schizophrenia [14], fewer have assessed loneliness specifically (versus negative affect generally)

and/or directly examined the associations between state and trait assessments of loneliness. Overall, perceptions of social relationships appear to play a larger role than quantity of interactions in momentary experiences of loneliness. Positive social appraisals, such as perceived intimacy and quality of social relationships, are related to lower loneliness in the moment [8-9]. Alternatively, when people report lower quality social relationships or dissatisfaction with being alone, they report more state loneliness [15]. Further, state loneliness appears to predict future negative social appraisals (e.g., disliking one's social company) [16] and is related to negative emotions related to social threat, including hostility and fear [17]. Findings are inconsistent regarding the relationship between objective isolation and loneliness [9,15-16]. Of the studies that have found an association, perceptions of social experiences moderate this relationship. For example, the relationships between the desire to be alone [15] and lower self-reported quality of social relationships [9] and state loneliness are higher when people are objectively isolated.

EMA studies have also shown that trait loneliness may moderate the relationship between momentary social experiences and state loneliness. For example, [8] found that the higher trait loneliness a participant reported, the more negative and less positive emotion they felt when they appraised a social interaction negatively (e.g., "I feel intimidated/judged by this company"). In the same study, participants who reported more trait loneliness reported less negative emotion when they were with others whom they felt accepted by, suggesting the importance of positive social appraisals for lonely individuals [8]. In a separate study, adolescents who reported higher trait loneliness reported more state loneliness when alone than those low in trait loneliness [18]. In the same study, adolescents who reported higher trait loneliness also reported a stronger relationship between intimacy of those they were with and feeling less alone; alternatively, for individuals who did not report high levels of trait loneliness, there was no relationship between intimacy of

one's company and state loneliness [18]. People who report higher levels of trait loneliness also appear to exhibit a stronger association between their state loneliness and social media use, suggesting this relationship may be specific to people who have a tendency to feel the loneliest [19].

The above findings are consistent with the differential reactivity hypothesis, which argues that people who report high trait loneliness respond differently to their environment than nonlonely individuals [20]. Other studies have found somewhat unique relationships between state and trait loneliness and other outcomes, such as differential patterns of daily cortisol response [21]. Overall, however, the majority of the literature suggests that state feelings of loneliness fluctuate depending on one's context, and these relationships are often moderated by trait loneliness.

In the current study, we sought to identify a) the key momentary correlates of trait and state loneliness, and b) the relationship between social experiences and state loneliness at the person-level. As opposed to prior studies that only examined a handful of social factors, we decided to cast a broad net in assessing a variety of social experiences that both have and have not been previously studied and their potential relationships between trait and state loneliness. We were also interested in whether trait loneliness moderated the relationship between the social factors that were related to state loneliness.

Based on prior studies, we predicted that positive qualities of social experiences (e.g., feelings of connection, intimacy, positive anticipation for future social interactions) would be related to less state and trait loneliness, while negative appraisals (e.g., perceiving criticism/rejection, preference to be alone when with others, hypervigilance to future social threats) would be related to more state and trait loneliness. Because we included a broader range

of social factors to examine through EMA that previous studies have not examined, we did not have specific hypotheses regarding whether trait loneliness would moderate specific relationships between the majority of our social factors and state loneliness. However, based on the work in adolescents by [18], we predicted that the relationships between a) being alone and b) intimacy of prior interactions with state loneliness would be significantly moderated by trait loneliness, such that those higher in trait loneliness would show a stronger relationship between these outcomes and state loneliness compared to those lower in trait loneliness.

Materials and methods

Participants

Thirty-two participants (21 women) were recruited from a public undergraduate institution serving mostly nontraditional (e.g., older, commuter) students (see Table 1 for demographic information). Participants were eligible if they were: 18 years of age or older; fluent in English; owned/used an Android smartphone; and were willing to install and use the EMA application on their personal smartphone.

Table 1. Demographic characteristics and trait loneliness.

Characteristic	Participants (N = 32)
Mean Age (SD)	25.13 (6.95)
Age Range	19-48
% Male Gender	31%
Mean Years Education (SD)	14.31 (1.03)
% Employed	63%
% Married/Cohabiting	22%

% White	22%
% Hispanic/Latinx	44%
% Asian/Middle Eastern	16%
% Other Ethnicity	6%
% Multiple Ethnicities	13%
UCLA Loneliness Scale	45.81 (10.42)

Notes. SD = standard deviation. Years of education were calculated using the following standardized system: 12 = high school graduate/GED equivalent, 14 = two years in a college program or Associate's degree, 16 = four-year college graduate.

UCLA Loneliness Scale (UCLA-LS)

The 20-item UCLA Loneliness Scale (UCLA-LS) [6] was used to assess trait loneliness. Participants rated items (e.g., "I feel isolated from others") on a scale of how descriptive each item was of them, from one ("never") to four ("often"). The sum of all item responses was used as the total UCLA-LS score for each participant. Higher scores reflect more trait loneliness.

Ecological momentary assessment (EMA) of state loneliness and social experiences

Participants completed brief surveys four times per day for seven consecutive days. Surveys were administered a minimum of 60 minutes apart throughout each day at pseudorandom time points within the windows of 9:00AM-12:00PM, 12:00PM-3:00PM, 3:00-6:00PM, and 6:00PM-9:00PM. Participants were asked questions related to their current and

prior social interactions, as well as how they felt about potential future interactions. Initially, to determine whether the participant was interacting with others or not at the time of the EMA prompt, the participant was asked whether they were alone, with others not interacting, or interacting with others. Participants were also asked whether they had a social interaction/conversation with anyone in the three hours prior to each prompt. When participants reported having a social interaction in the past three hours, they were also asked questions related to the intimacy of that interaction as well as how much they enjoyed or felt rejected/criticized from the prior interaction. Regardless of whether or not participants reported being with others (either in the prior three hours or during the EMA prompt), participants were asked questions to assess current state loneliness, preference to be alone, feeling connected with others, positive social anticipation (i.e., predicting enjoying a future social interaction), hypervigilance to future social threat (i.e., predicting feeling rejected/criticized during a future social interaction), and their desire to have a future social interaction. See Table 2 for all EMA questions and forced-choice responses.

Table 2. Description of EMA prompts and response choices.

Construct	EMA Prompt	Response Choices
Intimacy of previous interaction^{1,2}	<ul style="list-style-type: none"> How intimate was this interaction? How much did you disclose or tell them about personal/private things about yourself? 	(0) Not at all, (1) Slightly, (2) Moderately, (3) Extremely

	<ul style="list-style-type: none"> How much did the other person disclose? 	
Enjoying previous interaction¹	<ul style="list-style-type: none"> How much did you enjoy this interaction? 	(0) Not at all, (1) Slightly, (2) Moderately, (3) Extremely
Rejection from previous interaction¹	<ul style="list-style-type: none"> How rejected or criticized did you feel in this social interaction? 	(0) Not at all, (1) Slightly, (2) Moderately, (3) Extremely
Momentary loneliness²	<ul style="list-style-type: none"> How lonely do you feel right now? How left out do you feel right now? 	(0) Not at all, (1) Slightly, (2) Moderately, (3) Extremely
Preference to be alone (with others, when alone)	<ul style="list-style-type: none"> Would you prefer to be alone right now? [when with others] Do you prefer being alone right now? [when alone] 	(0) Not at all, (1) Slightly, (2) Moderately, (3) Extremely
Connection with others (with others, when alone)	<ul style="list-style-type: none"> How connected or close do you feel with the person/people around you? [when with others] How connected do you feel with the people in your life, right now? [when alone] 	(0) Not at all, (1) Slightly, (2) Moderately, (3) Extremely

Positive social anticipation	How much do you think you will enjoy your next social interaction?	(0) Not at all, (1) Slightly, (2) Moderately, (3) Extremely
Desire for future social experience	How much would you like to interact with someone in the next few hours?	(0) Not at all, (1) Slightly, (2) Moderately, (3) Extremely
Hypervigilance to future social threat	How much criticism or rejection do you expect from your next social interaction?	(0) Not at all, (1) Slightly, (2) Moderately, (3) Extremely

¹ Prompt only delivered if participant reported interacting with others in the past three hours.

² Items included in this construct were averaged to provide one score.

Study procedures

The study was advertised on flyers in various college campus locations at a public university in the Bay Area of California. Interested participants contacted the research team through email. Once eligibility was confirmed, participants met with a trained research assistant and completed informed verbal and written consent. Next, participants completed a demographics questionnaire and the UCLA-LS. Then, participants were introduced to the Ethica Data application (<https://ethicadata.com/>) and the EMA portion of the study. Participants were asked to download the application on their personal Android smartphone and were trained how to use the application. One week later, participants returned to the lab to complete other procedures and received cash payment or academic credit for participating in the study. Study procedures occurred in 2016-2017.

Analytic procedures

For each EMA signal, momentary loneliness was calculated by averaging the responses to the following questions: “How lonely do you feel right now?” and “How left out do you feel right now?” Reported intimacy from a previous social interaction was calculated by averaging the responses to the following questions: “How intimate was the interaction?”, “How much did you disclose or tell them about personal/private things about yourself?”, and “How much did the other person disclose?” Multilevel models using Hierarchical Linear Modeling (HLM) Version 7.03 [22] were computed to estimate between-person reliability for these measures, using a formula to account for between- and within-person variance as well as the mean number of EMA items answered across participants [23]. The between-person reliability for the loneliness composite was .74 and the intimacy composite was .83.

Pearson correlations were calculated to assess potential relationships between trait and state loneliness and EMA-reported social variables. Additionally, as age is related to loneliness [24], we computed Pearson correlations to examine potential effects of age on all measures.

EMA-reported outcomes that were significantly correlated with state loneliness were further analyzed. Approximately 14% of the observations were missing (118 out of a possible 896 observations), with participants reporting on an average of 86% of prompts (lowest EMA response for a participant: 57%). As no specific patterns were identified for the missing data, missing values were treated as missing completely at random, and parameters were estimated with full-information maximum likelihood. EMA responses were treated as repeated measures (Level 1) that were nested within persons (Level 2). Time point (of a possible 28 EMA signals over the course of seven days) was included in each model as a Level 1 predictor, although these results are not reported. All Level 1 predictors of interest were group-mean centered and Level-2 predictors were grand-mean centered. Person-level intraclass correlations (ICC) suggested >

10% of the variance in state loneliness was explained within persons, indicating appropriateness of multilevel analyses. Due to the exploratory nature of our analyses and our relatively modest sample size, we examined each predictor (e.g., intimacy of prior interactions) in its own, separate model. First, we examined each Level-1 predictor (e.g., intimacy of prior interactions) and its relationship to state loneliness. Next, we re-ran each model including trait loneliness (UCLA-LS score) as a Level 2 moderator on each Level-1 predictor (i.e., included trait loneliness as a Level 2 predictor on the slope). Effect sizes (Cohen's d) were calculated using the t method for power analysis (https://koumurayama.shinyapps.io/tmethod_mlm/), where d reflects “the effect size of the averaged regression slopes considering the between-cluster differences of the slopes (e.g., individual differences in the slopes among participants)” (p. 34) [25].

Results

Demographics and self-report measures

See Table 1 for demographic information and mean trait loneliness (from the UCLA-LS). Participants reported a range of UCLA-LS total scores from 31 to 68. Age showed a small, non-significant correlation with trait loneliness ($r = -.25, p = .17$).

EMA-reported social outcomes

See Table 2 for descriptions of EMA prompts and Table 3 for EMA item mean scores. Overall, participants spent approximately 39% of their time interacting with others during EMA signals and reported a previous social interaction (in the past three hours) 85% of the time. Participants also reported being alone approximately 32% and being with others but not interacting 29% of the time during EMA signals. Participants spent the same amount of time alone as with others not interacting ($p = .49, d = 0.18$), although reported spending slightly more

time interacting with others than being alone ($p = .32$, $d = 0.43$). When in the presence of others, participants reported spending more time interacting than not interacting ($t(31) = 1.95$, $p = .06$, $d = 1.00$).

Table 3. EMA item mean scores.

Characteristic	Total (Mean or % (SD)) ($N = 32$)
State loneliness	0.37 (0.45)
Interaction in past three hours (%)	85% (15)
Intimacy of previous interaction	1.11 (0.60)
Enjoyment of previous interaction	1.96 (0.43)
Rejection from previous interaction	0.30 (0.36)
Alone (%)	32% (19)
With others, not interacting (%)	29% (14)
Interacting with others (%)	39% (19)
Preference to be alone (when with others)	0.80 (0.58)
Feeling connected to others (when with others)	1.63 (0.62)
Preference to be alone (when alone)	1.67 (0.78)
Feeling connected to others (when alone)	1.34 (0.60)
Positive social anticipation	1.80 (0.50)
Desire for future social interaction	1.51 (0.56)
Hypervigilance to future social threat	0.43 (0.57)

Note. SD = standard deviation.

Participants reported low state loneliness overall ($M = 0.37$ on a scale from zero to three). Exploratory analyses were conducted to examine the proportion of time participants' state loneliness score was above zero. Participants reported a state loneliness score above zero on an average of 32% of completed EMA prompts ($SD = 29\%$), with six participants never reporting state loneliness above zero. Exploratory comparisons were made examining average state loneliness by participant and their trait loneliness score (UCLA-LS). Interestingly, one of the participants with the lowest trait loneliness scores reported the highest average state loneliness during the study. See Fig 1 examining daily reports of state loneliness for the participants with the lowest and highest trait loneliness scores.

Fig 1. Daily state loneliness for two participants with high and low levels of trait loneliness.

We also examined potential relationships between EMA-reported outcomes and age. Older age was significantly related to more intimacy from prior interactions ($r = .39, p = .03$). All other correlations with age were nonsignificant (all p values $> .10$).

Trait versus state loneliness and other measures: Correlations

We examined correlations between our two separate assessments of loneliness (trait loneliness as reported on the UCLA-LS versus state loneliness based on EMA-reported average) with the EMA-reported social outcomes (see Table 4). Trait and state loneliness were significantly positively correlated with one another ($r = .37, p < .05$). Trait and state loneliness were significantly positively correlated with the following EMA-reported outcomes: rejection/criticism from a prior social interaction; a preference to be alone when with others; feeling connected to others when alone; and hypervigilance to future social threat. Additionally, trait and state loneliness were significantly negatively correlated with state happiness. State loneliness was positively correlated with percentage of time participants reported being alone

and negatively correlated with interacting with others, while trait loneliness was not. State loneliness also showed a small positive correlation with intimacy of prior interactions ($p = .05$). Alternatively, trait loneliness was positively correlated with percentage of time participants spent around others not interacting and negatively correlated with feeling connected when with others, while state loneliness was not. The following were not significantly correlated with either state or trait loneliness: whether someone had an interaction in the past three hours; enjoyment of prior interaction(s); preference to be alone (when alone); positive social anticipation; and desire for future social interactions.

Table 4. Correlations with EMA-reported social outcomes.

	Trait loneliness	State loneliness
State loneliness	.37*	1
Interaction in past 3 hours	.10	.16
Intimacy of previous interaction	-.07	.34~
Enjoyment of previous interaction	-.06	-.003
Rejection from previous interaction	.53**	.59***
% Alone	-.04	.49**
% With others, not interacting	.39*	-.06
% Interacting with others	-.26	-.44*
Happiness	-.43*	-.61***
Preference to be alone (with others)	.48*	.41*
Feeling connected (with others)	-.54**	-.13
Preference to be alone (alone)	.25	.001
Feeling connected (alone)	.54**	.54**

Positive social anticipation	-.29	-.13
Desire for future social interactions	-.18	-.12
Hypervigilance to future social threat	.53**	.52**

Notes. $\sim p < .10$, $*p < .05$; $**p < .005$, $***p < .001$

State loneliness and social factors with trait loneliness as a moderator: Multilevel analyses

In separate models, we examined the relationships between EMA-reported predictors that were significantly or marginally significantly correlated with state loneliness, including: intimacy of previous interaction(s); rejection/criticism from previous interaction(s); happiness; being alone; interacting with others; preferring to be alone when with others; feeling connected to others when alone; and hypervigilance to future social threat. See Table 5 for these results. Next, we re-ran each model including trait loneliness (UCLA-LS total score) as a Level 2 moderator. State loneliness data were zero-inflated (i.e., participants reported that they did not feel lonely on the majority of EMA prompts); thus, Poisson (constant exposure, unit-specific) analyses were conducted in HLM for all analyses. Since age was not significantly related to the majority of the EMA-reported outcomes, including our main outcome (state loneliness), we did not include it as a covariate in subsequent analyses.

Table 5. Multilevel model analyses: Time-varying covariates of state loneliness.

Predictor	<i>b</i>	<i>SE</i>	<i>t</i> (31)	95% CI	<i>p</i>	Cohen's <i>d</i>
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Intimacy of previous interaction(s)	-0.09	0.08	1.07	-0.25, 0.07	.29	0.19
Rejection/criticism from previous interaction(s)	0.25	0.06	4.14	0.13, 0.37	<.001**	0.73
Happiness	-0.17	0.05	3.61	-0.27, -0.08	.001*	0.64
Alone	0.14	0.11	1.30	-0.08, 0.36	.20	0.23
Interacting with others	-0.39	0.14	2.86	-0.66, -0.12	.007*	0.51
Preference to be alone (when with others)	0.51	0.07	7.41	0.37, 0.65	<.001**	1.31
Feeling connected to others (when alone)	0.53	0.13	4.00	0.28, 0.78	<.001**	0.71
Hypervigilance to future social threat	0.54	0.07	7.64	0.40, 0.68	<.001**	1.35

Notes. CI = confidence intervals; SE = standard error. Each predictor was included in its own, separate model. * $p < .05$; ** $p < .001$.

Overall, we found that reporting rejection/criticism from previous interaction(s), a preference to be alone when with others, feeling connected to others when alone, and hypervigilance to future social threat were significantly related to more state loneliness. We also found that momentary happiness and interacting with others were both significantly related to less state loneliness. Intimacy of prior interaction(s) and whether a participant was alone were unrelated to state loneliness.

We then re-ran these models to examine whether trait loneliness moderated any of these relationships (see S1 Table including all results). Trait loneliness showed a small moderation effect between a preference to be alone when with others and state loneliness, where those higher in trait loneliness showed a stronger relationship between variables ($b = 0.01$, $SE = 0.006$, $t(30) = 2.01$, 95% CI = -0.002, 0.02, $p = .05$, $d = 0.34$) (see S1 Fig and S2 Fig for scatterplots of these results for participants below and above the median of UCLA-LS trait loneliness score). Trait loneliness also showed a small, nonsignificant moderation effect between the relationship between being alone and state loneliness ($b = -0.02$, $SE = 0.01$, $t(30) = 1.90$, 95% CI = -0.04, -0.0004, $p = .07$, $d = 0.33$); those higher in trait loneliness showed a stronger relationship between being alone and reporting more state loneliness, although the original model for this relationship was nonsignificant. Trait loneliness was not a significant moderator for any other models, p 's > .25.

Discussion

In the current study, we examined the relationships between EMA-reported social experiences and trait and state levels of loneliness. We found that negative social appraisals (including rejection/criticism from a prior social interaction and hypervigilance to future social threat) were positively correlated with both trait and state loneliness. This is in line with prior EMA studies on loneliness [16-17]. Interestingly, the majority of positive social appraisals we studied (including whether someone enjoyed a prior interaction or were looking forward to a future interaction) were unrelated to both state and trait loneliness. This suggests that, at least in our sample, positive perceptions of social experiences were unrelated to tendencies to feel lonely. Of the few differential relationships we found between state and trait loneliness, we found that feeling connected to others when alone was related to more trait and state loneliness,

while feeling connected when with others was related to less trait loneliness only. This suggests that feeling close to people in one's life when alone—potentially missing or yearning for those connections—is related to both trait and state levels of loneliness, while being around others one feels connected with might be particularly beneficial for people who report high levels of trait loneliness. Trait loneliness was also uniquely positively correlated with percentage of time participants spent with others but were not interacting; this suggests that social experiences that are less involved (e.g., passively being around others) may be more frequent for people with high trait loneliness. Alternatively, state loneliness, but not trait loneliness, was positively correlated with percentage of time participants reported being alone and negatively correlated with time spent interacting with others, suggesting the importance of in-the-moment interactions and their influence on momentary loneliness.

In our multilevel analyses, the majority of relationships between EMA-reported social experiences and state loneliness were not moderated by trait loneliness. Contrary to our predictions and prior findings in adolescents [18], intimacy reported from previous interactions and being alone were unrelated to state loneliness. Those higher in trait loneliness showed a stronger relationship between being alone and reporting more state loneliness, but this relationship was small in magnitude and did not reach statistical significance. We may have had insufficient power to detect these effects within our sample, or possibly these relationships were different because our sample included adults (rather than adolescents).

Additionally, the relationship between preference to be alone when with others and higher state loneliness was slightly stronger among those with higher trait loneliness. While not previously studied in prior EMA studies of loneliness, a preference to be alone when with others is often a proxy for stress during social situations in studies in clinical populations [14] and may

reflect unsatisfying or low quality social experiences or negatively biased social perceptions. This is line with previous EMA studies that have found a relationship with other types of negative social appraisals and state loneliness [8]. Additionally, this appears to support the sociocognitive model of loneliness, which posits that hypervigilance (or sensitivity) to social threat is both a contributing factor to and consequence of loneliness [2]. This model suggests that loneliness is related to feeling unsafe, which can lead to a bias of perceiving others as more threatening. Future studies can help disentangle the relationship between negatively biased social appraisals versus social interactions that are more objectively negative (e.g., social ostracization or conflict-laden relationships) and their relationships with loneliness, which we were unable to do within this study.

Overall, our findings are in line with previous work that suggests that appraisals alone can influence state loneliness [9,15]. Contrary to prior findings, however, trait loneliness on the whole did not appear to moderate these relationships. These findings appear in conflict with the differential reactivity hypothesis [20] in that trait loneliness did not affect participants' perceptions of their social context when taking state loneliness into account. This is particularly evident in the fact that the participant who reported the lowest levels of trait loneliness reported the highest range of state loneliness (see Figure 1). However, it should be noted that while our participants reported a range of trait loneliness scores, we did not actively recruit for people high in trait loneliness; thus, studies that include more chronically lonely individuals may find that trait loneliness has a stronger influence on the relationship between social experiences and state loneliness. Further, our sample size was relatively small and may have been underpowered to see potential significant effects. Despite these caveats, our findings suggest that focusing on modifying unhelpful perceptions of social experiences and improving one's ability to positively

appraise interactions may have beneficial outcomes, even if one reports high levels of trait loneliness. Evidence-based psychosocial treatments, such as cognitive behavioral therapy (CBT), teach skills related to cognitive restructuring, or changing one's unhelpful or maladaptive thoughts to change one's emotions and behaviors [26]. These and other strategies could be taught and implemented in a mobile health intervention to provide just-in-time support [27] to people who want to lessen the impact of momentary perceptions of social threats, regardless of the objective nature of their social experiences. Components of CBT have been adapted into digital health interventions to address a variety of mental health concerns [28], making it feasible to address appraisals of social interactions through similar methods. For example, if a person reports a preference to be alone when around others in a mobile health smartphone application, a push notification could remind them about prior enjoyable social experiences or that they often feel less lonely when they interact with others.

Several limitations of the current study are worth noting. As previously discussed, we did not specifically recruit for participants with high (or low) levels of trait loneliness. A larger sample with a wider range of trait loneliness scores may show different results. We were unable to differentiate the experience of loneliness from other negative affective experiences, as we did not assess other negative emotions in our study. Additionally, we did not assess factors specific to relational conflict (e.g., arguments with loved ones) that have been found to be related to loneliness in other studies across the lifespan [29]. Studying dyads (e.g., friends, family members) using EMA in future work would better capture the dynamic nature of social experiences and assess differences in perceptions of social experiences between close others. In assessing interactions, we did not specify to participants what types of interactions to report (e.g., in-person, online, etc.). Future researchers may wish to understand differences in loneliness as it

relates to remote versus in-person interactions. Our analyses did not include passive sensing metrics as objective indicators of social experiences, such as examining the number of text messages sent/received. Future researchers who use smartphones to capture EMA data can utilize these metrics to better understand the relationship between subjective and objective indicators of loneliness and isolation. Further, our sample was relatively young (mean age = 25) and majority female from a college student population; while we examined potential age differences, we cannot rule out the influence that these or other factors may have had on our results. Finally, participants in our sample reported state loneliness infrequently, with an average of two-thirds of EMA responses indicating no loneliness at all. While we conducted analyses to adequately address the low frequency of loneliness responses, these results await replication in populations with higher rates of state loneliness and/or those who experience chronic social isolation (e.g., mental health populations).

Conclusions

Our findings suggest that addressing one's social appraisals may be beneficial for improving state loneliness, regardless of one's trait tendencies to feel lonely. Multiple perceptions of social experiences (including rejection/criticism from previous interaction(s), a preference to be alone when with others, feeling connected to others when alone, and hypervigilance to future social threat) were related to more state loneliness, while interacting with others and happiness were related to less state loneliness. Participants higher in trait loneliness exhibited a stronger relationship between a preference to be alone when with others and more state loneliness compared to those lower in trait loneliness, suggesting that people with high trait loneliness may be more sensitive to social threats in their environment. Replicating these findings through using passive sensing metrics, assessing dyads, and with other populations

with more frequent experiences of state loneliness (e.g., clinical populations) are all important future directions.

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Supporting Information

S1 Fig. Relationship between preference to be alone (when with others) and state loneliness for participants below the median of the UCLA Loneliness Scale trait score. *Notes.* UCLA Loneliness Scale median = 45.

S2 Fig. Relationship between preference to be alone (when with others) and state loneliness for participants above the median of the UCLA Loneliness Scale trait score. *Notes.* UCLA Loneliness Scale median = 45.

S1 Table. Multilevel model analyses: Time-varying covariates of state loneliness with trait loneliness as the moderator. *Notes.* CI = confidence intervals; SE = standard error. Each predictor was included in its own, separate model. $*p < .05$; $**p < .001$.

S1 File. Data. Ecological momentary assessment data.

S2 File. Data. Demographics and mean outcomes.