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Development and validation of the loneliness and solitude scale (LSS)

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Abstract
This study sought to develop the Loneliness and Solitude Scale (LSS) a scale intended to assess and differentiate loneliness and solitude. The loneliness dimension analyses how often an individual perceives being on their own as negative, unsatisfactory, and distressful; the solitude dimension refers to the frequency with which someone interprets their solitary moment as something positive, valuable, and pleasing. The collected sample for this research was comprised of 724 Portuguese speakers' adults, demonstrating adequate psychometric indicators. Exploratory and confirmatory factor analysis showed the two dimensions, as expected. The results also indicate that the levels of Loneliness and Solitude are not dependent on gender, academic background, and age. In addition, the associations between the two factors of the LSS and emotion regulation, depression, anxiety, and stress corroborate previous literature findings. Cluster analysis allowed for further analysis, showing that stress, when controlling for emotional regulation, seems to have a weak effect on loneliness, a fact that is under some dispute in the current literature. This paper was able to develop and validate a unique measure of loneliness and solitude, centered around the unique characteristics of how individuals make use of their time spent alone. Future studies should attempt to compare this measure with other similar scales.

Keywords Confirmatory factor analysis · Exploratory factor analysis · Loneliness · Scale development · Solitude

Humans are a social species that depend on Cooperation to exist and thrive (The cooperative Human, 2018). Nonetheless, spending time alone is inevitable and necessary. Census data indicates that adults spend approximately half of their waking time alone (U.S. Bureau of labor Statistics, 2023). How are we relating to ourselves during this expressive part of our lives? Do we know how to spend time with ourselves in a way that promotes growth and life-long learning? It often seems like anything is preferable to being alone with our thoughts. To test this assertion, Wilson et al. (2014) conducted a series of studies to examine how people React to spending time by themselves. In one experiment, participants were asked if they were willing to spend money to avoid a small electric shock being administered to them, and, if so, how much. After spending 15 min alone with the option to administer it to themselves through the press of a button, many of them chose to do so, despite previously saying that they were willing to pay to avoid that shock. It seems that many of Us would rather be in physical pain than stand to be alone with ourselves. Still, not all participants chose that option, and the reason why is a question that merits an answer.

Although being alone is generally considered to be negative, one can be alone without being lonely. Aloneness is a neutral state in which there is communicative isolation (Galanaki, 2004). It does not imply physical isolation, but rather emotional distance (for instance, an individual who is surrounded by people but is not interacting with them is in

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a state of aloneness). Loneliness is an involuntary, negative state in which the individual perceives dissatisfaction with basic interpersonal and social relationships. It is associated with painful emotions and frequently arrives with sadness and tedium (Khorzina et al., 2022). Solitude is a type of chosen aloneness during which personality development and creativity may arise. During this state, the individual is not avoiding social interaction due to social anxiety or preference, but rather because they enjoy the experience of spending time alone and use it as an opportunity for self-exploration (Storr, 1988).

Winnicott (1958) theorized that fully mature adults can use solitude to overcome anxiety and re-establish emotional homeostasis. Larson and Lee (1996) investigated the capacity for solitude in 500 North American adults. Participants who reported greater comfort in being with themselves were found to be significantly less depressed and more satisfied with their lives. This relationship was found to be autonomous of a feeling of control over events, suggesting that solitary comfort may have a unique relationship with mental health. The association also appeared to be independent of social support, indicating that solitary comfort and social support are additive sources of well-being. Moreover, the association was unrelated to time spent alone, age, gender, and educational level. When considering the issue from the opposite perspective, it also seems that dealing ineffectively with aloneness can compound the problem of loneliness. For example, Hunt et al. (2018), investigated how the relationship individuals have with social media impacts their ability to be alone, finding that those who used social media most often were the ones who felt the loneliest. It seems that aloneness is a common symptom of living in individualistic societies (Barreto et al., 2021), but loneliness doesn't have to be.

Loneliness and solitude as two ends of the aloneness spectrum

Individuals who experience loneliness are more vulnerable to negative mental health outcomes, including increased symptoms of depression and anxiety (Cacioppo et al., 2015). Baseline data from a cross-sequential study examined social skills, loneliness, depression, and anxiety of more than 2000 students from two colleges in the United States tested six mediation models, separately analysing whether loneliness mediated the connection between anxiety, depression, social expressiveness, sensitivity, and perceived control. Results showed that all the variables were mediated by loneliness. These models accounted for 37–38% of the variability in depression and 17–20% in anxiety scores (Moeller & Seehuus, 2019).

On the other hand, feelings of loneliness have been demonstrated to be negatively associated with emotion regulation, as the latter variable seems to moderate the relationship between social anxiety and loneliness, serving as a protective factor (O'Day et al., 2019). This effect seems to be independent of quality of social support (Kearns & Creaven, 2017), indicating that emotion regulation has a direct effect on perceptions and attitudes relating to aloneness. Overall, these findings suggest that emotion regulation skills modulate the aloneness experience, leading it to either becoming loneliness or solitude (Thomas, 2023), which, in turn, predicts whether being alone works as a protector or an aggravating factor for mental health issues such as anxiety and depression (Keisari et al., 2022).

Measuring solitude

One characteristic shared by most measures of loneliness and solitude is a focus on the motivational aspects of the aloneness experience, often by measuring whether people look forward to or retrospectively appreciate spending time alone to assess solitude/loneliness. For example, the Preference for Solitude Scale (Burger, 1995) determines whether someone prefers being solitary. The Capacity to Be Alone Scale observes one's ability to cope with aloneness and comfort with solitude (Larson & Lee, 1996). The Solitude Scale (Leung, 2018) aims to identify different types of solitude experiences. Thomas and Azmitia's (2019) Motivation for Solitude Scale verified whether the individual's motives for solitude are self-determined. The Brief Scale of Fear of Loneliness (BSFL) measures an attitude of avoidance accompanied by worrying thoughts and feelings of abandonment experienced when the individual finds themselves alone (Ventura-León et al., 2020). The Loneliness and Solitude Scale (LSS) differentiates itself from such measures by asking participants how they spend their alone time (positively or negatively), which is an important distinction because this approach avoids possible pitfalls related to assessing a construct that has an associated cultural stigma, as is the case for loneliness.

As argued earlier, the idea of spending time alone often comes with negative connotations, being mostly associated with loneliness rather than solitude. Such a bias might lead individuals to underreport positive solitude experiences, either due to social desirability, or even through biased recollections. The items on the LSS focus on how individuals react to experiencing aloneness, therefore getting a more direct measure of these constructs. One practical example could be that of a person who experiences high levels of anxiety in social situations, possibly due to reduced social skills. Such a person might look forward to spending time alone, but once we analyse how they

spend that time, they might feel unsatisfied or try to avoid experiencing loneliness (perhaps by using social media, for example), rather than engage with the opportunity for solitude. Our measure reflects this change in perspective by having items such as "Spending time with myself is not good enough, so I'm looking for something else to distract me", as opposed to items that reflect how often or how much the individual looks forward to being alone. Inversely, we can think of a highly creative and extroverted person, who believes that their time is better spent in the company of others, but, upon introspection, they realize that they can only be creative by balancing time spent sharing their ideas socially and time spent developing them, in solitude. This would be reflected by the individual scoring highly on items such as "Spending time with myself helps me to look at my projects more creatively.", revealing a person who does in fact make good use of their aloneness, despite not experiencing it very often. Being able to draw such distinctions could be crucial in working with people who feel socially unsatisfied, helping them to either develop or value their alone time.

Based on the topic's pertinence and the intent to better understand how people deal with aloneness, this study aimed to develop and validate the Loneliness and Solitude Scale. The instrument was designed to assess the frequency with which individuals feel an aversion to feeling alone (Loneliness) and how often being with oneself is seen as a valuable circumstance (Solitude). To achieve this goal, the following objectives are put forward:

- Develop and refine the items contained in the LSS.
- Assess the factorial structure of the LSS and test its construct validity, convergent and divergent validity, internal consistency, and reliability.
- Test the LSS's correlations with other constructs, differentiating them according to each of the instrument's factors.

Methods

Participants

This study's sample was composed of 724 Portuguese-speaking participants (M_{age}=24.21; *SD*=0.74; Min=18; Max=62). Most participants were Portuguese (79.0%), with the second most common nationality being Brazilian (16.8%). The sample contained 542 (74.9%) females, 179 (24.7%) males, and 3 participants who identified as "other". 542 (74.9%) participants were undergraduates and 176 (24.3%) were post-graduates, while 26.4% (191) participants were employed at the time of data collection. Participants were eligible for participation if they were adults, and their native language was Portuguese.

Instruments

Loneliness and solitude scale (LSS)

The LSS was designed as a bi-dimensional, 8-item self-report measure that assesses how often spending time with oneself generates positive or negative thoughts and sensations. Ten questions were initially developed based on Galanaki (2004), Long et al. (2003), Larson (1999), and Storr's (1988) definitions of Loneliness and Solitude, from which 8 were retained after consulting with an independent clinician/researcher. All items are rated on a 5-point Likert-type scale: four items (1, 3, 5, 6) correspond to the loneliness dimension, and four others (2, 4, 7, 8) examine the solitude dimension. The higher the scores in the loneliness dimension, the higher one's aversion to being alone. Greater scores in the solitude dimension reflect the participant's perspective of being alone as something essential and necessary. Cronbach's alpha was 0.79 for Loneliness and 0.85 for Solitude.

Sociodemographic questionnaire

A sociodemographic questionnaire was designed for this study to collect data about the participants' age, gender, academic background, nationality, and employment status.

Difficulties in emotion regulation scale (DERS)

The Difficulties in Emotion Regulation Scale (Gratz & Roemer (2004); translated and adapted to European Portuguese by Coutinho et al., 2010) assesses emotional deregulation in six domains: "Nonacceptance" – nonacceptance of emotional responses, "Goals"- difficulties engaging in goal-directed behavior, "Impulse" - impulse control difficulties, "Awareness"- lack of emotional awareness, "Strategies"- limited access to emotion regulation strategies, and "Clarity"- lack of emotional clarity. It contains 36 items, rated on a five-point Likert scale ranging from 1 (almost never) to 5 (almost always). In the present study, the total DERS scale presented a Cronbach's alpha value of 0.92, and the reliability values for the subscales were: Nonacceptance (0.85), Goals (0.76), Impulse (0.86), Awareness (0.76), Strategies (0.87), and Clarity (0.71).

Depression, anxiety and stress scale (DASS-21)

The Depression, Anxiety and Stress Scale (Lovibond & Lovibond, 1995; translated and adapted to European

Portuguese by Apóstolo et al., 2006) contains a set of three Likert-type subscales, with four points ranging from 0 ("did not apply to me at all") to 3 ("applied to me very much or most of the time"). Each subscale consists of seven items that assess the emotional states of depression, anxiety, and stress, with a maximum score of 42. In the present study, Cronbach's alpha values were 0.90 for depression, 0.88 for anxiety, and 0.85 for stress.

Procedures

Data was originally collected online for the Soft Skills for Life Program, held by University of Algarve (UAlg). From this collection, which occurred in 2023, a sub-set of the pre-test data was repurposed for the current study. Before filling out the form, participants were informed about all relevant ethical aspects and the General Data Protection Regulation. All participants answered the instruments in their entirety, which is a prerequisite for inclusion in the study.

Data analysis

Given the expected bi-dimensionality of the scale, CFA was used to assess a one-factor and a two-factor solution of the measure, following Hu and Bentler's (1999) recommendations, supplemented with Groskurth et al.'s (2024) dynamic cutoffs for χ^2, GFI, AGFI, NFI, CFI, RMSEA, and SRMR. The analysis of the two solutions was identical, with the exception that the items for the loneliness dimension were reversed while testing the one-factor solution. After confirming the structural validity of the instrument, convergent and divergent validity, along with the internal consistency and reliability of the LSS were assessed.

Due to the variables not following a normal distribution, a nonparametric alternative to the t-test was used to assess covariance between gender and educational background and the LSS. This was also the case for assessing the correlation of age, DASS, and DERS with the LSS, in which Spearman correlation was used. Divergent validity was evaluated by testing whether the square root of the AVE for each construct is greater than its correlations with other constructs. To complement the correlational analysis of between DASS, DERS, and LSS, the research team estimated regularized partial correlations (Wang & Zhu, 2016) of the Spearman correlation matrix between the factors of these scales. This analysis is relevant in identifying whether the considered measures relate to the LSS factors differently. Finally, model-based clustering (Fraley & Raftery, 2007) with each scale of the LSS and with the aggregate scores of the DASS and DERS, was used to define clinically distinguishable groups. This last analysis serves the purpose of testing whether the constructs are distinguishable in practice, by identifying "types of alone people" and verifying whether these individuals are differentiated by their levels of emotion regulation and clinical symptoms, as was proposed in the introduction.

All statistics were performed using the SPSS 29.0, AMOS 29.0 software packages, and R software (R Core Team, 2023), with the packages blavaan version 0.4–7 (Merkle & Rosseel, 2015), GGMncv version 2.1.1 (Williams, 2020), and mclust version 6.0.0 (Scrucca et al., 2016).

Results

Development and pre-validation

When developing an instrument, it is important to consider the target population. In this case, it was important to understand if the Portuguese show any relevant particularities that could influence how the instrument's contents are understood. Firstly, Portugal's recent history shows a shift from collectivistic to individualistic modes of living (Leite et al., 2010), which were not accompanied by infrastructural changes, leading to an increased disassociation between physical and emotional closeness. As such, it was imperative that the instrument did not allude to distance when describing the concept of being alone. For example, the LSS asks participants to rate their agreement with statements beginning with "Spending time with myself…", instead of using similar terms like "Being apart from other people" so as not conflate the aloneness with physical distance. Similarly, Leito et al. (2010) showed that, although Portuguese individuals generally do not feel the need to involve friends when making plans to go somewhere, despite most of the sample feeling satisfied with the quality of their friendships. As such, the items on the LSS do not imply togetherness through activities. For example, item 3 "Spending time with myself is not satisfying, as I would like to be with other people" is worded so as to explicitly mention other people rather than, alternatively, "…I would like to be doing other, more social, activities". Such a differentiation avoids confusion, as one can be doing social activities with strangers, for example, therefore not measuring the unsatisfied need for closeness that the LSS intends to assess.

With this understanding in mind, development of the instrument began with the creation of various items that expressed both loneliness and solitude, based on previous literature (Galanaki, 2004; Larson, 1999; Long et al., 2003; Storr, 1988). After discussion among the investigation team, 10 items were selected and presented to a clinician-researcher, experienced in the field, who suggested that 2 items were removed ("Spending time with myself is something I choose to do" and "Spending time with myself makes

Table 1 Fit indices for the proposed structures of the LSS

Fit Index	One-Factor Model	Two-Factor Model
Chi-square/df	6.329	2.342
GFI	0.962	0.987
AGFI	0.924	0.972
NFI	0.971	0.990
CFI	0.976	0.994
RMSEA	0.087	0.044
SRMR	0.041	0.017

me feel excluded"). The remaining 8 items were presented to a group of 12 Portuguese adults, who gave feedback on the items, through an open-ended interview, sharing whether the questions were clear and made sense to them, the rating format was reasonable, or if they found the measure problematic in any other way. Interviewees were also asked if there was any element of the experience of aloneness that was not being captured by the items. Participants generally expressed satisfaction with the measure, with none of them suggesting any noticeable changes to the instrument.

Structural validity

A confirmatory factor analysis (CFA) was conducted for a one-factor and a two-factor solution. Before performing the CFA, the assumption of multivariate normal distribution was tested. Curran et al. (1996) proposed that asymmetry values smaller or equal to two ($|sk| \leq 2$) and kurtosis values equal to or smaller than seven ($|ku| \leq 7$) point to the respect of this assumption. Multivariate outliers were assessed based on Mahalanobis's distance. Therefore, for 8 variables and $\alpha = 0.001$, a cutoff of 26.12 was calculated, and any participants with a Mahalanobis distance greater than that value were considered outliers and removed ($n = 15$). After assessment of normality and outliers, the adjustment of the two models was tested and compared. Maximum likelihood estimation, complemented with Bollen-Stine bootstrapping, was used due its comparatively higher performance when normality is not violated (Li, 2016), as is the case with the current sample. Fit indices for the one and two-factor model can be found in Table 1. In both models, residual errors between items 3 and 5 were set to correlate, due to them both being negatively coded, as was the case for items 1 and 6, due to the possibility that boredom could be considered a negative emotion, leading to an increased correlation between the items.

The chi-square significance was statistically significant in both the one-factor ($\chi 2 = 113.91$; $df = 18$; $p = .000$) and the two-factor ($\chi 2 = 39.81$; $df = 17$; $p = .001$) solutions, which is to be expected due to the high sample size. Comparing fit indices for the two proposed models suggests that a two-factor solution shows better fit for all considered indices. As such, only the two-factor model will be considered for the following analyses, as it obtained acceptable values for all metrics, such as GFI, AGFI, NFI, and CFI > 0.95, RMSEA < 0.06, and SRMR < 0.08 (Hu & Bentler, 1999). Groskurth et al. (2024) suggest dynamic cutoffs based off the sample's characteristics. Given their simulation data, a sample of 500 participants with 6 indicators and a loading magnitude of 0.80 (this was the simulation considered by the research team to most closely resemble the present data), should show a Chi-square/df < 2.043, CFI > 0.992, RMSEA < 0.046, and SRMR < 0.025. The present data are generally within these cutoffs for all the considered indices, with the exception of the Chi-square/df, although this metric is the one most affected by sample size. Overall, the proposed model seems to show good fit to the data.

Convergent validity

Table 2 contains general information on the LSS's items and each subscale's reliability. Based on Fornell and Larcker's (1981) cutoff (0.50), only Solitude shows acceptable convergent validity, meaning that Loneliness's items share less covariance with the latent construct than with measurement error, explaining less than half the construct's variance. Comparing AVE with shared variance (AVE-SV), yields similar results, as SV = 0.53. Due to their low factor loadings, Loneliness's AVE was calculated when item 1

Table 2 *Loadings for Means, standard Deviations, factor Loadings, and reliability values for all LSS items*

Items	M	SD	Factors Loadings	Alpha/Alpha if Item Removed	CR	AVE
Loneliness				0.73	0.71	0.42
1	3.9	0.98	0.31	0.71		
3	3.21	1.15	0.86	0.62		
5	3.37	1.28	0.88	0.61		
6	3.96	0.99	0.28	0.72		
Solitude				0.92	0.93	0.76
2	3.28	1.18	0.87	0.90		
4	3.42	1.16	0.87	0.91		
7	3.55	1.37	0.91	0.89		
8	3.12	1.33	0.84	0.91		

M = Mean, *SD* = Standard Deviation, *Alpha* = Cronbach's Alpha, *CR* Composite Reliability, *AVE* Average Variance Extracted, $p < .001$.

Table 3 *Correlations, cronbach's Alpha, and p-values for the correlations between the scales*

	Lon	Sol	Anx	Str	Dep	NnA	Goa	Imp	Awa	Stg	Cla
Loneliness	0.789										
Solitude	**−0.791**	0.921									
Anxiety	**0.373**	**−0.233**	0.886								
Stress	**0.304**	**−0.112**	**0.766**	0.812							
Depression	**0.316**	**−0.114**	**0.724**	**0.758**	0.902						
Non Acceptance	**0.499**	**−0.369**	**0.406**	**0.395**	**0.410**	0.784					
Goals	**0.197**	0.007	**0.349**	**0.457**	**0.489**	**0.393**	0.759				
Impulse	**0.631**	**−0.515**	**0.495**	**0.503**	**0.421**	**0.582**	**0.374**	0.861			
Awareness	**0.446**	**−0.559**	**0.143**	0.001	**0.096**	**0.220**	**−0.016**	**0.324**	0.760		
Strategies	**0.553**	**−0.375**	**0.559**	**0.590**	**0.589**	**0.667**	**0.597**	**0.709**	**0.264**	0.864	
Clarity	**0.539**	**−0.463**	**0.442**	**0.379**	**0.434**	**0.494**	**0.268**	**0.572**	**0.533**	**0.567**	0.717

Lon: Loneliness. Sol: Solitude. Anx: Anxiety. Str: Stress. Dep: Depression. NnA: Nonacceptance. Goa: Goals. Imp: Impulse. Awa: Awareness. Stg: Strategy. Cla: Clarity. The values below the diagonal represent the correlations. The values in the diagonal are Cronbach's alphas of the measures. The values above in bold are considered statistically significant ($p \leq .001$).

Table 4 Relations between sociodemographic variables and the factors of the LSS

Variables		Estimates					
		n	M	SD	Test Statistic	Effect Size	*p*
Gender							
Loneliness	Male	179	12.6	4.3	53.308	0.13 [0.00; 0.24]	0.046
	Female	542	11.9	4.4			
Solitude	Male	179	13.0	4.3	45.297	0.07 [0.00; 0.19]	0.183
	Female	542	13.5	4.6			
Academic Level							
Loneliness	Graduation	542	12.2	4.4	49.822	0.06 [0.00; 0.18]	0.373
	Postgraduation	176	11.8	4.4			
Solitude	Graduation	542	13.3	4.5	49.167	0.02 [0.00; 0.15]	0.521
	Postgraduation	176	13.5	4.7			
Age							
Loneliness		724	12.1	4.4	–1.314	–0.049 [–0.13; 0.04]	0.381
Solitude		724	13.4	4.5	0.717	0.03 [–0.05; 0.09]	0.473

n: sample size. M: mean. SD: standard deviation. p: p-value.

(AVE = 0.537, C.R. = 0.751) or 6 (AVE = 0.531, C.R. = 0.743) were removed. Despite their removal significantly improving the factor's convergent validity, these were retained so as to not negatively impact its internal consistency.

Internal consistency and reliability

The Cronbach alpha value for the eight items was 0.90, the McDonald's ω was 0.91, and the intra-class correlation coefficient was 0.89 ($p < .001$), indicating high reliability (Nunnally & Bernstein, 1994). Finally, composite reliability values for Loneliness (CR = 0.71) and for Solitude (CR = 0.93) were above the 0.70 benchmark (Kline., 2015), indicating solid internal consistency and reliability.

Divergent validity

Table 3 presents the correlations, their corresponding *p*-values, and the Cronbach's alpha of each psychometric measure assessed in this study. The values below the diagonal represent the correlations. The values in the diagonal are Cronbach's alphas of the measures. All correlations were significant, except for those that are not bold (i.e., Goals and Solitude, Awareness and Stress, and Awareness and Goals). It is also possible to conclude that, despite being strongly correlated, Loneliness and Solitude present considerably different correlation patterns from the other measures. By considering the square root of the AVE as the cutoff points for divergent validity for Solitude (< 0.65) and Loneliness (< 0.87), both constructs can be considered as having good divergent validity.

Relations between factors

In Table 4, the research team assessed the relationship between sociodemographic variables (i.e., gender, academic background, and age) and the LSS's factors.

For gender and academic background, Shapiro-Wilk normality tests showed that the LSS factor scores did not follow a normal distribution within the groups. Therefore, the

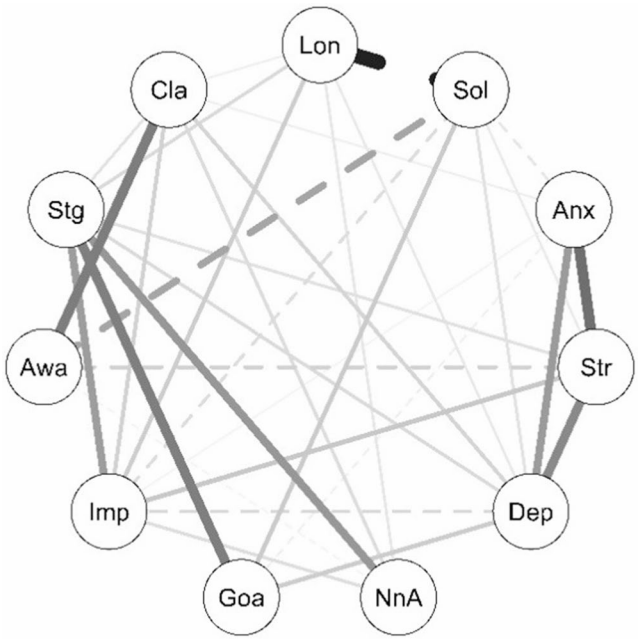

Fig. 1 Regularized partial correlation between the measures. *Note*. Lon: Loneliness. Sol: Solitude. Anx: Anxiety. Str: Stress. Dep: Depression. NnA: Nonacceptance. Goa: Goal. Imp: Impulse. Awa: Awareness. Stg: Strategy. Cla: Clarity. The strength of the partial correlations is defined by the width of the edges, as well as on their colors: darker colors represent stronger correlations. Solid lines represent negative relations and dashed lines represent positive relations

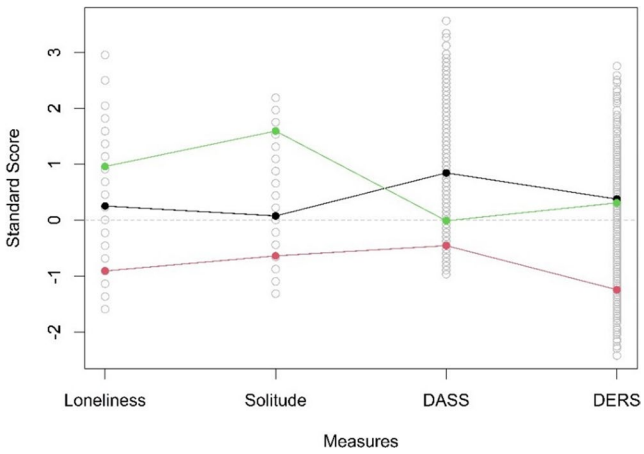

Fig. 2 The distribution of the scores and the expected scores for each cluster. *Note*. DASS: Depression, Anxiety and Stress Scale; DERS: Difficulties in Emotion Regulation Scale

Wilcoxon rank sum test with continuity correction was used to compare the groups, with the effect size being assessed with Cohen's U_1, which measures the proportion of overlap between both groups. Regarding the correlation between the factors of the LSS and age, Spearman's rank correlation was used. None of the tests were statistically significant at the 0.05 threshold, except for the median difference of Loneliness between participants who identified as males and those who identified as females. However, this result was barely significant, with p=.046. Given that six different tests of statistical significance were performed, by applying a Bonferroni correction of the 0.05 threshold to be considered significant, the p-values should be below 0.008.

Complementary to the correlation analysis, the regularized partial correlation between the measures represented in Fig. 1 provides another view on the differential pattern of associations between Loneliness and Solitude with the other measures. In Fig. 1, the strength of the partial correlations is defined by the width of the edges and their colors: darker colors represent stronger correlations. Solid lines represent negative relations, and dashed lines represent positive relations. Notably, it is possible to see a very strong negative partial correlation between Loneliness (Lon) and Solitude (Sol). Impulse control (Imp) shows a positive partial correlation with Loneliness and a negative partial correlation with Solitude. On the other hand, both factors present positive partial correlations with Depression (Dep), and no other partial correlations are shared between Loneliness and Solitude.

Model-based clustering

To assess how possible combinations of the scores of the scales would result in different clinical groups, model-based clustering was performed with each LSS factor and the aggregate scores of the DASS and DERS, as measures of overall ill-being (depression, anxiety and stress) and emotion dysregulation. The results of this analysis are represented in Fig. 2. Based on the elbow point and interpretability of the clusters, a three-cluster solution was selected. The gray points in the background represent the distribution of the standardized scores of each scale. The green, black, and red lines, with the corresponding-colored points, represent the expected average score for each group estimated with the model-based clustering method. The Solitude scale was inverted, so scores above zero can be interpreted similarly on all scales: higher scores represent worse mental health.

The cluster represented by the red line shows a group of individuals with low Loneliness, Solitude, Anxiety, Stress, Depression, and emotional deregulation. The cluster represented by the black line is close to the median score of Solitude, slightly above the median scores of Loneliness and DERS, but shows a high score on the DASS. The last cluster, represented by the green line, represents the individuals with higher Loneliness and Solitude, close to median DASS, and slightly above median scores on the DERS.

Discussion

This study analyzed the frequency of Loneliness and Solitude perception in 724 adults from Lusophone countries. It showed generally adequate psychometric properties, validating the Loneliness and Solitude Scale (LSS). Our results indicate that levels of Loneliness and Solitude are not dependent on gender, academic background, and age. Additionally, the associations between the proposed variables with emotion regulation, depression, anxiety, and stress corroborate previous findings (Cacioppo et al., 2015; Kearns & Creaven, 2017; Moeller & Seehuus, 2019; O'Day et al., 2019). Finally, we used model-based clustering analysis to identify profiles with clinical implications from the psychometric measures.

The psychometric properties of this scale were confirmed in this study. The measurement model analysis results indicated a good fit for the two-factor model. The findings suggest that Loneliness and Solitude, although related, are different constructs. Although some items showed low factor loadings, they were retained to avoid issues related to overly brief instruments, such as excess homogeneity, leading to one or two items "defining" the outcome of the measurement. Yet, it is important to point out that removing items 1 or 6 increased the subscale's AVE to 0.537 (C.R.= 0.751) and 0.531 (C.R.= 0.743), respectively. Brief measures are often incapable of achieving optimal outcomes in all metrics, and future researchers who choose to utilize or adapt the LSS might have to decide between optimizing for construct validity and reliability, by retaining all loneliness items, or for convergent validity, by removing one of these items.

It is also important to discuss the low factor loadings of items 1 ("Spending time with myself is boring.") and 6 ("Spending time with myself causes me negative emotions, like sadness."), as this seems to imply that the Portuguese population might not necessarily associate loneliness with negative emotions, despite yearning for closeness, as shown by the remaining items. Within Portuguese culture, particularly older people, high value is placed within the quality of one's bonds, particularly romantic and familial connections, but not so much the maintenance of the bonds themselves (Leite et al., 2010). This fact, together with the current findings, could indicate that loneliness's effect on the individual might be particularly related to whether the individual feels like they could reach out to a friend, family member, or loved one, rather than how often they do reach out, or are reached out to. Leite et al.' (2010) study also notes a gender difference, particularly in how expressive they are about their affection, a factor worth exploring in future research.

No correlation between age and either loneliness or solitude was found. This is an interesting finding because, among the Portuguese, older people, particularly the divorced or widowed, are the main at-risk groups for loneliness (Neto, 2014). One possible explanation for this incongruency might be that this measure is tapping into how individuals experience aloneness (loneliness or solitude), rather than how much they experience either or both forms of aloneness, as was initially proposed. Thus, while experiencing loneliness or solitude may change with age, one's perspective on these experiences might be somewhat stable throughout life. Further investigation into this hypothesis is recommended. These results challenge the current understanding of loneliness among Portuguese people, particularly older adults. As countries become more industrialized and tight-knit communities become more distant, it is important to understand what makes one feel connected to each other even as they become less able to physically spend time together, and the Portuguese context offers a unique opportunity to explore these themes, as does the LSS.

Difficulties in emotion regulation were moderately correlated with Loneliness and Solitude. Correlations seemed to be generally stronger for the loneliness subscale. The regularized partial correlations also showed that the groupings of correlations were different for Loneliness and Solitude. Overall, these results indicate that despite being strongly correlated, these measures have different roles in mental health dynamics, which is congruent with previous literature (Borsboom & Cramer, 2013; Bringmann et al., 2015).

The model-based clustering yielded some interesting results. Firstly, although loneliness and solitude did not form a single cluster, they generally covaried, possible because there is an underlying factor (aloneness) between the two. This could mean that it is quite hard, or perhaps impossible, to fully stave off loneliness while being alone. Although this statement might seem apparent, this could be the difference between understanding solitude as a positive construct or as an effective coping mechanism for loneliness. More surprisingly, two of the clusters showed identical emotion dysregulation (DERS), while presenting different levels of ill-being (DASS), solitude, and loneliness. This could indicate that solitude serves as a protective factor for ill-being in the face of emotion dysregulation, or, inversely, that only in the face of ill-being do those with emotion dysregulation seek aloneness. Future studies should attempt to establish such causal inferences.

Limitations and future directions

One of this study's main limitations is the analysis of convergent validity. When the LSS was being developed, and the data was being collected, the Brief Scale of Fear of Loneliness (BSFL; Ventura-León et al., 2020) and the

Positive Solitude Scale (Palgi et al., 2021) had not yet been published. In that sense, using more general Loneliness scales could have improved convergent validity analysis. Thus, it is recommended that future studies investigate the LSS with a more heterogeneous (in terms of country and context) sample and compare it to other loneliness and solitude-related measures.

Discriminant validity also presents an important concern, as the solitude dimension in particular showed rather low AVE, although the solitude and loneliness dimensions seemed to be better understood as separate constructs, rather than a healthy/unhealthy aloneness spectrum. As such, the relationship between the two merits further investigation, perhaps by fitting these constructs in moderation or mediation models. Finally, it would have been important to test this measure's invariance, perhaps across gender, as literature indicates that loneliness is not constant among different demographics (e.g. U.S. Bureau of Labor Statistics, 2023), particularly in Portugal, where women tend to be more expressive about this issue (Leite et al., 2010). While there were group comparisons intended to test how different demographics experienced aloneness, the fact that most of the sample was composed of female university students could bias these results and limit the generalization of the overall results. Future studies could work from these results to investigate to what extent loneliness and solitude are affected by cultural differences.

The present study aimed to provide an alternate operationalization of loneliness and solitude. Primary findings support a brief two-factor measure that assesses and differentiates adaptative and maladaptive expressions of aloneness. Correlational findings support the hypothesis that the LSS taps into unique aspects of the aloneness experience, although future studies should try to compare this measure with others to fully explore this possibility.

Author contributions All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Roberto Chiodelli, Ilana Andretta, Tamara Russell, Luana Thereza Nesi de Mello, and Saúl Neves de Jesus. The first draft of the manuscript was written by Roberto Chiodelli, Vivien Iacob, and João Nuno Ribeiro Viseu, and João Paulo Teixeira Antunes and Saúl Neves de Jesus developed the original draft up to the final version of the manuscript. João Paulo Teixeira Antunes made the formatting changes necessary for submission. All authors read and approved the final manuscript.

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Data availability The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study, including the ethical standards, was approved by the Scientific Commission of the Faculty of Human and Social Sciences, University of Algarve, Portugal, with the reference number EDOC/2018/19967. Informed consent was obtained from all individual participants in the study.

Conflict of interest The authors have no financial or non-financial conflict of interest to report.

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