# By Myself and Liking It?

## Predictors of Distinct Types of Solitude Experiences in Daily Life

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Abstract

**Objective:** Solitude is a ubiquitous experience, often confused with loneliness, yet sometimes sought out in daily life. This study aimed to identify distinct types of solitude experiences from everyday affect/thought patterns and to examine how and for whom solitude is experienced positively versus negatively. **Method:** 100 community-dwelling adults aged 50-85 years (64% female, 56% East Asian, 36% European, 8% Other/Mixed heritage) and 50 students aged 18-28 years (92% female, 42% East Asian, 22% European, 36% Other/Mixed) each completed approximately 30 daily life assessments over 10 days on their current and desired social situation, thoughts, and affect. **Results:** Multilevel latent profile analysis identified two types of everyday solitude: one characterized by negative affect and effortful thought (negative solitude experiences) and one characterized by calm and the near-absence of negative affect/effortful thought (positive solitude experiences). Individual differences in social self-efficacy and desire for solitude were associated with everyday positive solitude propensity; trait self-rumination and self-reflection were associated with everyday negative solitude propensity. **Conclusions:** This study provides a new framework for conceptualizing everyday solitude. It identifies specific affect/thought patterns that characterize distinct solitude experience clusters, and it links these clusters with well-established individual differences. We discuss key traits associated with thriving in solitude.

Keywords: solitude, affect, thought patterns, time-sampling, latent profile analysis

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# By Myself and Liking It? Predictors of Distinct Types of Solitude Experiences in Daily Life

Time spent alone has a bad reputation, and perhaps for good reason. Loneliness is linked to poor health and wellbeing, notably, depressive symptoms, cardiovascular disease, and cognitive decline (Hawkley & Cacioppo, 2010). Yet, despite a need for social connection, people across the adult lifespan spend a lot of time alone, and sometimes choose time alone over time with others (Burger, 1995; Chua & Koestner, 2008; Larson, 1990; Lay, Pauly, Graf, Mahmood, & Hoppmann, 2018; Leary, Herbst, & McCrary, 2003; Long & Averill, 2003). Integrating these seemingly contradictory perspectives, this study examined the multifaceted nature of everyday solitude (defined as the absence of social interaction; Burger, 1995) and links different kinds of solitude with time-varying motivational and more stable person-specific factors. To do so, we collected approximately 30 electronic daily life assessments per person over 10 days from 100 older adults and 50 students.

Most psychological research on solitude emphasizes the negative correlates and consequences of loneliness (Long & Averill, 2003). Yet, a wealth of philosophical, spiritual, and popular work lauds the benefits of solitude for self-attunement and growth (Burger, 1995; Long, Seburn, Averill, & More, 2003). How can solitude be both lonely and nourishing? A factor contributing to this paradox may be that the extant literature does not always conceptually distinguish between solitude, aloneness, and loneliness (Larson, 1990; Lay et al., 2018; Long & Averill, 2003; Pauly, Lay, Nater, Scott, & Hoppmann, 2017). Solitude is most clearly defined by the absence of social interaction, whereas aloneness is defined by the physical absence of other people, at a given moment (Burger, 1995; Larson, 1990). One can be in solitude but not alone when reading a book in a busy coffee shop. Conversely, one can be physically alone but not in solitude when chatting on the phone with a friend. Solitude and aloneness are defined by objective situational characteristics and their definitions do not have any specific emotional

connotations (Larson, 1990). Loneliness, in contrast, is a negative emotional experience resulting from a "discrepancy between one's desired and achieved levels of social relations" (Perlman & Peplau, 1981, p. 32). By this definition, one can feel lonely alone or surrounded by other people (de Jong Gierveld, van Tilburg, & Dykstra, 2005).

**Different Types of Solitude Experiences in Everyday Life**

Solitude is a double-edged sword. On the one hand, studies of *affective experiences* have shown that, compared to being with others, being alone (and not interacting with others) is associated with increased negative affect and loneliness, and decreased positive affect and energy (Chui, Hoppmann, Gerstorf, Walker, & Luszcz, 2014; Larson, Csikszentmihalyi, & Graef, 1982; Larson, Zuzanek, & Mannell, 1985; Nguyen, Ryan, & Deci, 2017; Pauly et al., 2017). On the other hand, studies also suggest people may seek solitude for escape or relaxation, fostering emotional renewal, greater low arousal positive affect, and lower self-consciousness (Burger, 1995; Larson, 1990; Larson et al., 1982; Long et al., 2003; Pauly et al., 2017). Research on *cognitions* associated with solitude points to a similar two-sidedness. Solitude may trigger maladaptive thought patterns such as self-doubt and rumination (a preoccupation with negative thoughts and perceived threats; Long & Averill, 2003; Trapnell & Campbell, 1999). Yet, solitude may also bring benefits by fostering creativity, problem-solving, concentration, self-reflection, autonomy, and personal growth (Burger, 1995; Larson et al., 1982, 1985; Long et al., 2003).

These seemingly contradictory findings from the social psychological, lifespan developmental, and health literatures illustrate the complex nature of solitude. For the present study, we embraced this complexity by considering the broad spectrum of affective and cognitive correlates of solitude reported in previous research, while adopting a well-circumscribed definition of solitude (the absence of social interaction; Burger, 1995). Specifically, we link everyday solitude with (a) concurrent affective experiences (high and low arousal

positive/negative affect; Feldman Barrett & Russell, 1998; Kashdan & Steger, 2006; Russell, 1996; Tsai, Knutson, & Fung, 2006) and (b) concurrent thought patterns (low cognitive effort thoughts, high cognitive effort thoughts; Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006; Trapnell & Campbell, 1999). These two thought patterns have distinct neural and affective correlates (e.g. Farb, Anderson, & Segal, 2012). We expected that these diverse affective and cognitive correlates of solitude would form at least two separable solitude experience clusters: one reflecting negative experiences such as loneliness and difficult thoughts (negative solitude experiences), and the other reflecting positive experiences such as calm affect and pleasant thoughts (positive solitude experiences).

**Stable Individual Difference Correlates and Time-Varying Motivational Correlates of Everyday Solitude Experiences**

Social resources may play a key role in how we experience solitude. Individuals with large social networks, high-quality social relationships, and high social status may experience solitude more positively than individuals with fewer social resources (Adler & Stewart, 2007; Antonucci, 1986; de Jong Gierveld et al., 2005; Long & Averill, 2003; Pauly, Lay, Scott, & Hoppmann, in press; Ryff & Keyes, 1995). With respect to personal resources, individuals high in social self-efficacy may be less prone to self-doubt in the absence of social feedback, and hence better able to reap solitude's benefits (Di Giunta, Eisenberg, Kupfer, Steca, Tramontano, & Caprara, 2010). Moreover, individuals high in trait self-reflection might actively seek out and savour solitude because they enjoy having space for contemplation (Burger, 1995; Trapnell & Campbell, 1999). Hence, we expected the traits of social self-efficacy and self-reflection to be tied to propensity for positive solitude experiences in daily life.

In addition to social and personal resources, certain trait vulnerabilities might make individuals prone to negative solitude experiences. Socially anxious individuals may avoid

interaction despite a desire to connect, thereby perpetuating feelings of loneliness and anxiety; hence, we expected they may be more prone to experience solitude negatively (Ernst & Cacioppo, 2000; Spurr & Stopa, 2002). We also expected individuals high in self-rumination, who may engage in maladaptive thought patterns and experience negative affect, to be more prone to experience solitude negatively (Long & Averill, 2003; Trapnell & Campbell, 1999).

Finally, the likelihood of experiencing solitude positively versus negatively may also depend on whether an individual wants to interact with others at a particular moment. Undesired solitude is difficult to tolerate whereas solitude that is desired may be cherished (Chua & Koestner, 2008; Long et al., 2003). Furthermore, individual differences in overall desire for solitude are thought to shape momentary solitude experiences: We expected individuals with greater desire for solitude to be more prone to experiencing momentary solitude positively, compared to individuals with low desire for solitude (Burger, 1995).

**Current Study**

The purpose of this study was to examine the complexity of solitude as it naturally occurs in daily life, and to determine under what circumstances and for whom solitude may be experienced positively or negatively. We used repeated daily life assessments (‘time sampling’) to capture time-varying emotional and cognitive correlates of everyday solitude (Bolger, Davis, & Rafaeli, 2003; Hoppmann & Riediger, 2009). Using latent profile analysis on approximately 30 momentary affect and thought assessments from 150 individuals, we sought to classify solitude episodes into distinct types, expecting that there would be at least two separable types of solitude experiences (one negative; one positive). We hypothesized that individuals with large social networks and high-quality social relationships, and those high in perceived social status, social self-efficacy, and self-reflection would have a greater propensity to experience solitude positively, as compared to individuals with fewer of these resources. In contrast, individuals high

in social anxiety and self-rumination were expected to be more prone to negative solitude experiences than individuals with fewer such vulnerabilities. Finally, we expected that current desire for solitude and stronger overall (trait level) desire for solitude would be positively associated with the likelihood of experiencing solitude positively.

## Method

### Participants

One hundred community-dwelling adults aged 50-85 years ($M$ = 67.0, $SD$ = 8.7) and 50 undergraduate students aged 18-28 years ($M$ = 20.0, $SD$ = 1.8) in Metro Vancouver were recruited for a study on social engagement and wellbeing. We combined the two samples to maximize statistical power and to represent individuals across a range of ages and backgrounds. Older adults were recruited through community organizations, posters, referrals, and a database, and students were recruited through a university research subject pool. The older adult sample was 64% female, 56% East Asian, 36% European, and 8% other/mixed heritage; 72% had at least some post-secondary education. The student sample was 92% female, 42% East Asian, 22% European, and 20% other/mixed heritage. Fifty-seven percent of the older adults and 28% of the students were in a romantic relationship, and both samples were in good health ($M$ = 3.2 on 5-point subjective health scales). Nine additional participants left the study due to time constraints (4 older adults, 3 students) or difficulties with the electronic assessments (2 older adults), and two older adults were excluded due to technical issues resulting in data loss. Older adults were reimbursed with up to $100 or the iPad mini they had used in the study. Students were reimbursed with 3 course credits and up to $30 (differences in compensation between the two samples reflect that older adults were part of a longitudinal study, whereas students were not). The study was approved by the university behavioural research ethics board.

### Procedure

This study consisted of a baseline session, a time-sampling period, and an exit session. In the baseline session, participants completed questionnaires measuring individual differences (e.g. trait self-reflection) and received training in the use of portable electronic devices. Then, for a 10-day time-sampling period beginning the day after the baseline session, participants were beeped three times daily (once in the morning, once in the afternoon, once in the evening). On each occasion, participants completed a brief questionnaire concerning their thoughts, affect, and current and desired social situation using a touch screen interface on an iPod or iPad mini (iDialogPad; G. Mutz, 2011, University of Cologne, Germany). To avoid conflicts with predetermined commitments, beeps were adjusted to participants' schedules, with at least 4 hours between beeps. Participants completed an average of 30.5 valid questionnaires[1] (*SD* = 9.6, range = 4-71; some participants continued for more than 10 days[2]). Within two weeks after the time-sampling period, participants attended an exit session to complete further individual difference measures and a debriefing. Participants reported the time-sampling period was typical of their everyday lives (*M* = 3.5 on a 5-point scale) and that the study did not interfere with their daily routines (*M* = 1.8/5) or change their behaviour (*M* = 1.7/5). Data were collected year-round (August 2014–May 2016). All materials were translated into Chinese and translations were verified via independent backward-translation. Older adult participants completed the study in English (57% of participants), Mandarin (28%), or Cantonese (15%). Student participants completed the study in English.

## Measures with Basic Descriptive Data

### *Time-Sampling Measures*

***Current thoughts.*** At each beep, participants were first asked, "What were you just thinking about?" and they recorded a brief answer using the keyboard or voice recorder. They then responded to eight items concerning their current thoughts (each item used a 100-point

scale: 0 = “not at all true”, 100 = “completely true”). These items were adapted from measures of reflection and rumination (Trapnell & Campbell, 1999) and mindfulness (Baer et al., 2006). We grouped the items into two parcels reflecting (a) low cognitive effort thought and (b) high cognitive effort thought. The low cognitive effort parcel consisted of four items assessing present focus (“I was thinking about something that happened in the past” [reverse coded], *M* = 68.2, *SD* = 33.4, “I was thinking about something happening in the future” [reverse coded], *M* = 54.7, *SD* = 45.3), pleasantness (“My thoughts were pleasant”, *M* = 54.7, *SD* = 28.6), and mindfulness (“I was just watching my thoughts go by without getting caught up in them”, *M* = 43.7, *SD* = 32.6). The high cognitive effort parcel consisted of four items assessing self-focus (“My thoughts were mainly about myself”, *M* = 50.7, *SD* = 35.2), reflection (“I was exploring new or 'deep' ideas”, *M* = 31.4, *SD* = 30.5), rumination (“I was having a hard time shutting off negative thoughts”, *M* = 26.2, *SD* = 28.5), and lack of clarity (“It was difficult to describe my thoughts just now”, *M* = 25.3, *SD* = 26.5).

***Current affect.*** The next twelve items used a 100-point scale (0 = “not at all”, 100 = “very much”) to assess participants’ current affective and cognitive-emotional states. Items were drawn from previous work to capture a spectrum of positive and negative affective states of both high and low arousal (Feldman Barrett & Russell, 1998; Tsai et al., 2006), and to probe feelings of shyness (Kashdan & Steger, 2006; Spurr & Stopa, 2002) and loneliness (Russell, 1996). Items were grouped into four affect parcels representing (a) high arousal positive affect (2 items, “I am happy”, *M* = 61.1, *SD* = 25.2, “I am excited”, *M* = 36.8, *SD* = 28.3), (b) low arousal positive affect (3 items, “I am calm”, *M* = 68.7, *SD* = 24.4; “I am satisfied”, *M* = 55.5, *SD* = 27.8, “I feel close to others”, *M* = 53.6, *SD* = 29.1), (c) high arousal negative affect (4 items, “I am anxious”, *M* = 30.6, *SD* = 29.5; “I am irritated”, *M* = 23.9, *SD* = 27.3, “I feel shy”, *M* = 16.0, *SD* = 20.9; “I am worried about what other people might think of me”, *M* = 25.6, *SD* = 29.3), and (d) low

arousal negative affect (3 items, "I am sad", *M* = 22.7, *SD* = 25.9; "I am tired", *M* = 46.0, *SD* = 32.3, "I am lonely", *M* = 23.3, *SD* = 26.8).

***Current social situation.*** To collect information about participants' social situation at each beep, participants were asked, "What was your situation when you were reminded to do this questionnaire?" They responded by selecting one of the following options, which were adapted from McAdams and Constantian (1983): (a) interacting with someone, (b) others nearby but not interacting, or (c) alone. Instances when participants selected (b) or (c) were categorized as solitude episodes (absence of social interaction). Participants were also asked to indicate the activities they had been engaged in when beeped by selecting one or more of the following activity categories: social activity, physical activity, cognitive activity, volunteering, passive leisure, self-care/health care, work, other. Instances when participants had been engaged in a social activity were removed from the pool of solitude episodes to eliminate times when participants may have been talking on the phone or communicating online. Consistent with the foregoing criteria, of the 4571 valid questionnaires completed by participants, we classified 2944 (64%) as solitude episodes and used these in the analyses (*M* = 19.6 episodes per participant; *SD* = 9.0, range = 1–69). Instances when participants selected (c), "alone", were coded as episodes of aloneness. These constituted 64% of solitude episodes (*M* = 13.6 alone episodes per participant, *SD* = 9.1, range = 0–53). Analyses controlled for aloneness to disentangle being alone from being in solitude.

***Current desire for solitude.*** We also used the three social situation options from McAdams and Constantian (1983) to collect information about participants' current ideal or desired social situation. The results showed that 15% of the solitude episodes were times when participants had wanted social interaction (a), 28% were times when they had wanted others nearby but no interaction (b), and 57% were times when they had wanted to be alone (c).

Instances when participants chose options (b) or (c) were coded as desire for solitude, and instances when they chose option (a) were coded as desire not to be in solitude.

### *Individual Difference Measures*

***Social and personal resources.*** *Social network size* was measured in the exit session using the Personal Networks Questionnaire (Antonucci, 1986), which requires participants to list people in their network in three concentric circles according to how close they feel to each person. Social network size was quantified as the total number of individuals listed in all circles ($M$ = 20.3, $SD$ = 11.9). We assessed *social relationship quality* (perception of having close, supportive relationships with others) in the exit session using the 3-item "positive relations" subscale of the Ryff Scales of psychological wellbeing (short version, 5-point Likert scale; Ryff & Keyes, 1995; $M$ = 3.6, $SD$ = 0.7, $\alpha$ = 0.55). *Perceived social status* was assessed in the exit session using the MacArthur scale (Adler & Stewart, 2007). For this scale, participants circle a rung on a 10-rung ladder to indicate their social status relative to others in their community (one ladder) and in their country (another ladder), and the average is taken ($M$ = 5.5, $SD$ = 1.4, $\alpha$ = 0.61). *Social self-efficacy* (self-efficacy as it pertains to social skills) was assessed in the exit session using the 5-item Perceived Social Self-Efficacy scale, on a 5-point Likert scale (Di Giunta et al., 2010; $M$ = 3.6, $SD$ = 0.6, $\alpha$ = 0.74). The 12-item Rumination-Reflection Questionnaire (Trapnell & Campbell, 1999) was completed in the baseline session; it includes a 6-item subscale assessing *self-reflection* (tendency to enjoy reflecting on one's inner self) on a 5-point Likert scale ($M$ = 3.4, $SD$ = 0.7, $\alpha$ = 0.79).

***Personal Vulnerabilities***. *Social anxiety* was assessed in the exit session using the 6-item short version of the Social Interaction Anxiety Scale (Fergus, Valentiner, McGrath, Gier-Lonsway, & Kim, 2012; $M$ = 2.2, $SD$ = 0.8, $\alpha$ = 0.92). *Self-rumination* (tendency to ruminate over past mistakes or negative thoughts) was assessed in the baseline session using the

corresponding 6 items from the Rumination-Reflection Questionnaire (Trapnell & Campbell, 1999; $M$ = 3.4, $SD$ = 0.8, $\alpha$ = 0.82). Both measures use a 5-point Likert scale.

**Statistical Analyses**

We used a 2-stage procedure to (1) classify solitude episodes into different types based on momentary affect/thought dimensions, and (2) predict the likelihood of experiencing each type of solitude in daily life from a set of time-varying and person-level predictors. This procedure is illustrated in *Figure 1*; details are described below and in the online supplement.

***Stage 1: Multilevel Latent Profile Analysis***

For each solitude episode, participants responded to 12 affect and eight thought items. We grouped these items into 4 affect parcels (high arousal positive affect, low arousal positive affect, high arousal negative affect, low arousal negative affect) and 2 thought parcels (low cognitive effort thought, high cognitive effort thought) based on theoretical groupings of affect and thought dimensions. This parceling gives equal weight to affect/thought dimensions reflecting positive/unchallenging experiences and those reflecting negative/effortful experiences. We expected that affect and thought response patterns would reveal at least two distinct types of solitude experiences. Latent profile analysis (LPA; Masyn, 2013) was used to test this hypothesis (see top part of *Figure 1*). LPA fits a set number of latent classes to data by maximizing intra-class homogeneity and class separation. We generated several candidate models (with different model specifications and different numbers of classes), and selected a final model based on fit indices, residuals, classification diagnostics, parsimony, and theoretical considerations. Given the nested data structure (momentary affect/thoughts nested within individuals), multilevel modeling was used to account for person-level clustering in solitude class assignment (Henry & Muthén, 2010). Multilevel LPA was conducted in Mplus (Muthén & Muthén, 2007) using the parametric approach described by Vermunt (2003). Details of our LPA model specifications, modeling

decisions, and procedure for final model selection are provided in *Supplementary Materials B.*

### *Stage 2: Multilevel Latent Class Regression Analyses*

After classifying solitude episodes into different types through LPA, we used multilevel latent class regression (LCR) to test hypotheses regarding situational and individual difference factors predicting the likelihood of experiencing each type of solitude (Henry & Muthén, 2010; Masyn, 2013). Odds of experiencing a certain class of solitude, relative to a reference class, was regressed on our set of predictors, again using multilevel modeling to account for the nested data structure (see bottom part of *Figure 2*). We used the 3-step approach recommended by Vermunt (2010) to account for uncertainty in solitude class membership by incorporating probabilistic class assignments. Mplus was used for LCR analyses. Details of the multilevel LCR procedure, including model equations, are provided in *Supplementary Materials C.*

To test hypotheses regarding time-varying motivational factors, current solitude desire was added as a dichotomous Level 1 (situation level) predictor. Person-average solitude desire was added at Level 2 (person level). Hypotheses regarding individual difference factors were tested by adding resources (social network size, social relationship quality, perceived social status, social self-efficacy, self-reflection) and vulnerabilities (social anxiety, self-rumination) at Level 2. Several covariates were also added: current aloneness (dichotomous) at Level 1 and person-average aloneness, age, ethnicity, education, and relationship status at Level 2. All variables were grand mean centered. Refer to *Supplementary Materials C* for further details.

## Results

### Descriptive Findings

Bivariate correlations for person-level variables are shown in *Table SMA-1* (*Supplementary Materials A*). Individuals higher in certain personal/social resources (social relationship quality, perceived social status, and social self-efficacy) reported higher levels of

positive affect and lower negative affect, whereas individuals higher in personal vulnerability factors (social anxiety and self-rumination) reported higher negative affect and lower positive affect. Although personal/social resources tended to be negatively correlated with vulnerability factors, one exception was that self-reflection and self-rumination were positively correlated, suggesting a tendency for self-focused thought common to these two traits. Mean time alone, time in solitude, and desire for solitude were all positively correlated, in line with the idea that people seek social situations that match their desires. Correlations among mean affect/thought dimensions suggested that tendency for high- and low-arousal positive affect and low cognitive effort thought go together, whereas tendency for high and low arousal negative affect and high cognitive effort thought go together. Situation-level variable descriptives and inter-correlations are provided in *Table 1*. They are discussed in the context of the latent profile analysis results.

**Different Types of Solitude Experiences in Everyday Life: Latent Profile Analysis Results**

The first aim of this study was to identify patterns of affect and thoughts characterizing different types of solitude experiences, with the expectation that at least two distinct types of solitude would emerge. Multilevel LPA was used to classify solitude episodes into a number of classes (types) based on the 6 momentary affect/thought parcels, while accounting for person-level clustering of solitude class membership. Two model types were tested; one with and one without an additional indicator-specific random intercept (*Supplementary Materials B* provides further details on these model specifications). For each model type, a 1-class model was fitted, then a 2-class model, a 3-class model, and so on until the model was no longer identifiable. One-, 2-, and 3-class solutions were identified for both model types, but 4-class solutions were not identifiable. *Table SMB-1* (*Supplementary Materials B*) gives further information for all models generated, including class proportions, model fit indices, residuals, and classification indices, and the *Supplementary Materials B* text explains each of these indices in detail. Scree plots for the

Akaike Information Criterion (AIC) and Adjusted Bayesian Information Criterion (BIC) suggested that 2- and 3-class solutions for both model types were viable. However, the models with indicator-specific random intercepts were removed from further consideration due to their large residuals for the means, variances, and covariances. Classification indices showed that all models had good class separation and classification accuracy, but one stood out as performing best: the 2-class model with no indicator-specific random intercept (Entropy = 0.89; Average Posterior Probability = 0.98 for Class 1, 0.96 for Class 2; Odds of Correct Classification = 30.04 for Class 1, 33.79 for Class 2). Hence, the residuals and classification indices point to this 2-class model as being the best fit, supporting our hypothesis that at least two solitude classes would be distinguishable. The choice of this 2-class model over the 3-class model was also informed by model parsimony and theoretical considerations. It is generally recommended, in this situation, to pick the model with the smaller number of theoretically meaningful classes (Masyn, 2013). As we explain in the *Supplementary Materials B*, the solitude classes in the 3-class solution were not all well-separated or theoretically distinct. In our final model, two qualitatively distinct types of solitude experiences are well-identified, enabling direct tests of our hypotheses regarding positive and negative solitude experiences.

*Figure 2* shows class-specific mean ratings across the six affect and thought dimensions for the final LPA model. These and overall sample means are provided in *Table 1*. Class 1, comprising 56.7% of solitude episodes, reflected negative experiences, characterized by elevated levels of high and low arousal negative affect and high cognitive effort thought. Mean ratings on these three dimensions were around 40/100 (9-13 points above the overall sample means), and ratings for low arousal positive affect were 7 points below the sample mean. Hence, this class was labelled “negative solitude experiences”. The second class, comprising 43.3% of solitude episodes, was characterized by elevated levels of low arousal positive affect (69/100, 10 points

above the overall sample mean) and slightly elevated high arousal positive affect and low cognitive effort thought. Most notably, for this solitude class, high arousal negative affect ratings were near 0, and low arousal negative affect and high cognitive effort thought were around 20/100 (11-18 points below overall sample means). To capture contrasts between the two solitude classes, we labelled Class 2 "positive solitude experiences".

The class-specific descriptives in *Table 1* give further insight into the solitude class structure. For all six affect/thought dimensions, variances within each class were smaller than overall sample variances, indicating that the LPA successfully generated homogeneous classes (Masyn, 2013). A second indicator of LPA success is the extent to which classes are separable (show little overlap in indicator values). The standardized mean distances in *Table 1* reveal that, of all the affect/thought dimensions, high arousal negative affect showed the largest separation between the two classes, followed by low arousal negative affect, high cognitive effort thought, and low arousal positive affect. Hence, these 4 dimensions are the most useful for distinguishing between positive and negative types of solitude experiences. *Supplementary Materials B* gives further details on class homogeneity and class separation assessment.

The positive solitude experience class was marked by consistently low levels of negative affect and of high cognitive effort thought, whereas the negative solitude experience class captured the rest of the negative affect/high cognitive effort thought spectrum. Further insight may be gleaned from the distributions of responses on the six affect/thought dimensions; *Figure SMA-1* (*Supplementary Materials A*). The zero-inflated distributions for negative affect and high cognitive effort thought seem to indicate an underlying dichotomy, rather than continuity. That is, having little or no negative affect/high cognitive effort thought at a given moment appears to be a distinctly different experience from having some amount of negative affect/high cognitive effort thought. These different experiences are reflected in *qualitatively distinct* types of solitude

experiences.

**Stable Individual Difference Correlates and Time-Varying Motivational Correlates of Everyday Solitude Experiences: Latent Class Regression Results**

Our second aim was to link stable individual differences and time-varying motivational factors with the likelihood of experiencing positive and negative solitude at a given moment. Solitude experiences (likelihood of solitude class membership) varied both between people and within a given person across time, with most of the variability (80%) occurring at the between-person level. *Figure SMB-1* (*Supplementary Materials B*) shows the distribution of solitude experiences across people. Based on our classification of participants' momentary experiences, most participants experienced only one type of solitude over the course of the study – negative solitude experiences only (~50% of participants) or positive solitude experiences only (~25% of participants) – while the remaining participants experienced a mix of both types. This preliminary assessment suggests that the experience of different types of solitude might be better predicted by stable individual difference factors rather than time-varying factors. To test our hypotheses regarding predictors of distinct types of solitude experiences, log-odds of experiencing positive over negative solitude were regressed on several situation- and person-level variables using multilevel LCR (see *Table 2)*[3].

Counter to expectations, social network size, social relationship quality, and perceived social status were not significantly associated with propensity for positive solitude experiences. As hypothesized, however, perceived social self-efficacy was linked with greater propensity for positive solitude experiences, $b = 0.87$, $SE = 0.44$, $p = .048$ (variable $\gamma_{011}$ in *Table 2*). A 1-point increase in social self-efficacy meant 139% greater odds of positive solitude experiences. The association between trait self-reflection and solitude experiences was the opposite of that expected; self-reflection was linked with greater propensity for *negative* solitude experiences, *b*

= -0.62, *SD* = 0.31, *p* = 0.045 ($\gamma_{012}$ in *Table 2*). A 1-point increase in self-reflection meant 86% greater odds of experiencing negative solitude. As expected, trait self-rumination was linked with greater propensity for negative solitude experiences, *b* = -0.62, *SE* = 0.31, *p* = .049 ($\gamma_{014}$ in *Table 2*). A 1-point increase on the self-rumination scale meant 86% greater odds of negative solitude experiences. The expected association between social anxiety and negative solitude experience propensity, however, was not found.

We expected solitude desire to be linked with positive solitude experiences at the situation level (current solitude desire) and at the person level (person-mean solitude desire). Only the person-level association was significant, *b* = 3.99, *SE* = 1.27, *p* = .002 (variable $\gamma_{03}$ in *Table 2*). A 10% increase in person-mean solitude desire (how often a person in fact wanted to be in solitude, when they were in solitude) meant a 49% increase in their odds of experiencing positive solitude. Notably, person-mean solitude desire was only associated with positive solitude experiences, and not with experiencing more positive affect or less negative affect in general; as shown in *Table SMA-1* (*Supplementary Materials A*), correlations of person-mean solitude desire with scores on the six affect/thought dimensions were weak or nonsignificant. This specific link between solitude desire and propensity for experiencing positive over negative *solitude* provides initial evidence of the solitude classes' construct validity.

## Discussion

This study's aim was to embrace the complexity of everyday solitude by examining distinct types of solitude experiences and by asking how and for whom solitude might be experienced positively versus negatively. We captured instances of solitude (defined as the absence of social interaction) by asking older and younger adults to report their thoughts, affect, and current and desired social situations three times daily over 10 days. Multilevel latent profile analysis identified two types of solitude experiences, one positive and one negative,

characterized by distinct patterns of affect and thought. Individuals higher in social self-efficacy and overall desire for solitude were more prone to positive solitude experiences, and those higher in self-rumination and self-reflection were more prone to negative solitude experiences. We discuss findings in the context of the social psychological and lifespan developmental literatures.

**How is Solitude Experienced in Daily Life? Distinct Types of Solitude Experiences**

This study used a valence-neutral definition of solitude (absence of social interaction) to capture qualitatively distinct solitude experience clusters based on co-occurring affect and thought patterns. Our findings showed that solitude is indeed a multifaceted construct that is best described by two distinct clusters: a "negative solitude experience" cluster characterized by negative affect and more effortful, complex, or self-focused thought and a "positive solitude experience" cluster characterized by positive affect, simple, pleasant, or present-focused thoughts, and the near-absence of negative affect. Importantly, our approach takes into account that a given person may sometimes experience solitude negatively and sometimes positively. To illustrate, consider a person named Anthony, who lives by himself and who, after commuting on a crowded subway, is home alone at day's end. Whether on the subway or at home, he is in solitude. Sometimes, Anthony may be preoccupied by worries or ruminations, his solitude marred by anxiety, sadness, or loneliness. This negative kind of solitude occurred most frequently in our study (about 57% of solitude instances), reflecting the negative contours of solitude (Long & Averill, 2003). On the other hand, Anthony may also experience the kind of solitude that helps him relax after a demanding day; at those times, he might be feeling calm and be enjoying the present moment, free of loneliness, anxiety, or intrusive thoughts. This positive kind of solitude experience represented a little under half (43%) of solitude instances in the present study, reinforcing the idea that solitude can be nourishing (Burger, 1995).

By examining solitude experiences as they occur in older and younger adults' daily lives,

our study extends previous work using retrospective reports from student samples (Long et al., 2003). Our solitude experience clusters suggest that, at the moment when it occurs, deep contemplation is a feature of negative solitude experiences. However, our label does not imply negative solitude experiences are inherently unhealthy, maladaptive, or indicative of a lonely existence (Cacioppo, Cacioppo, & Boomsma, 2014). Indeed, the challenges of introspection are thought to be among solitude's key benefits to the extent that they foster problem-solving and self-growth (Burger, 1995; Long & Averill, 2003). For example, Long and colleagues (2003) identified three kinds of solitude (outer-directed, inner-directed, and loneliness), based on reports of the importance of different kinds of solitude experiences, and suggested that inner-directed solitude may be remembered as a difficult process of self-reflection leading to inner peace. Unlike this previous work, our study captured snapshots of solitude as they occurred, before being subject to retrospection and subjective importance ratings, and before individuals might have benefited from working through tough problems in solitude. Moreover, many of our momentary affect/thought measures emphasized self-focused aspects of experience, rather than outer-directed aspects such as spirituality and connectedness to others. Hence, it may not be surprising that the negative and positive solitude experience types we uncovered do not directly map onto those identified in previous research (Long et al., 2003).

**For Whom and under What Circumstances is Solitude Likely to be Negative or Positive?**

Solitude has been described as a "unique experiential niche" in which some people are more likely to thrive than others (Larson, 1990, p. 156). Indeed, the present study points to systematic individual differences in solitude experiences: one-half of our sample experienced only negative solitude, another quarter experienced only positive solitude, and the rest experienced a mix of negative and positive solitude. We further identified key individual difference factors underlying propensity to experience solitude negatively versus positively.

As expected, having high social self-efficacy was associated with experiencing solitude positively. This finding adds to the literature linking high self-esteem, communication skills, and secure attachment style with lower loneliness (de Jong Gierveld et al., 2005; Ernst & Cacioppo, 2000; Larson, 1990; Long & Averill, 2003). Counter to expectations, social network size, social relationship quality, and perceived social status were not significantly associated with positive solitude experience propensity. Building on previous work showing that strong social ties protect against negative solitude experiences (Pauly et al., in press), we suggest that, accounting for the quality of one's social relations, having high confidence in one's own social skills (social self-efficacy) may be a key to experiencing solitude positively.

In contrast to what we hypothesized, trait self-reflection was associated with greater propensity to experience solitude negatively. This finding raises the possibility that self-reflection that increases self-attunement may be conducive to positive solitude experiences (Burger, 1995; Long & Averill, 2003; Leary et al., 2003), whereas if it focuses on self-critical thinking, it may backfire and contribute to loneliness (Cacioppo et al., 2014). Indeed, engaging in the kind of deep introspection that is conducive to self-growth may in fact be a challenging, unpleasant experience in the moments of solitude when it occurs. The present study's solitude cluster findings support this interpretation, revealing that high cognitive effort thought is a defining characteristic of negative, rather than positive, momentary solitude experiences.

The present study also examined individual differences in the propensity to experience solitude negatively. Findings showed that self-rumination was associated with greater likelihood of having negative solitude experiences. In solitude, thoughts often turn inward, and if an individual habitually has uncontrollable negative thoughts, these may negatively colour their experience (Long et al., 2003). We also expected highly socially anxious people to be more prone to negative solitude; however, we found no significant association. It may be that for

socially anxious individuals, feelings of loneliness and social inadequacy in solitude (Ernst & Cacioppo, 2000) are balanced by feelings of calm and relief from social pressures (Long & Averill, 2003; Spurr & Stopa, 2002), thereby neutralizing any negative effects. It may also be that our sample's social anxiety scores ($M$ = 2.2 on a 5-point scale) were too low to show an impact on solitude experiences.

Finally, this study embraced that some people desire solitude more than others, and that this desire may ebb and flow in daily life. As expected, people with greater overall desire for solitude were more prone to experience solitude positively. However, fluctuations in solitude desire were not associated with positive solitude experiences at the momentary level. Solitude desire hence seems to operate primarily as an individual difference factor. This finding aligns with previous research linking retrospective reports of overall preference for solitude to solitude enjoyment (Burger, 1995) and extends it to a broader range of affect and thought dimensions accompanying solitude experiences. We also build on research based on retrospective reports of positive and negative solitude experiences (Long et al., 2003) by showing how, when participants are not explicitly asked to think about solitude experiences, their overall solitude desire still shapes their thoughts and affective states reported in the moment. Overall solitude desire was linked specifically with positive solitude experiences, but was not associated with greater positive or lesser negative affect in general; this specificity constitutes further evidence for the existence of two distinct types of solitude experiences.

This study revealed that high social self-efficacy, overall solitude desire, and low self-ruminative and self-reflective tendencies are particularly key to thriving in solitude. By linking these traits to daily life solitude, we took a first step toward validating the two types of solitude (negative and positive) that emerged from older and young adults' lived experiences.

**Limitations and Future Directions**

Our aim was to examine the complexity of solitude as it occurs in everyday life, and findings need to be interpreted in light of certain limitations. We sought to capture snapshots of naturally occurring experiences without interfering with participants' daily routines, and hence chose a sampling frame that took into account participants' pre-existing commitments. Doing so led to high compliance: Participants completed an average of 25 out of 30 possible assessments within the 10-day sampling frame. This approach could have resulted in oversampling of solitude instances. However, solitude rates in our study were similar to those in other time-sampling studies using quasi-random (Pauly et al., 2017) and random sampling frames (Larson et al., 1982, 1985), which gives us confidence that we captured naturally-occurring solitude episodes.

This study included older and younger adults across a broad cultural and social spectrum. We specifically aimed to include older adults who are less well-represented in research, such as recent immigrants and individuals of various socioeconomic statuses. As a result, more than half of our older adult sample were East Asian immigrants to Canada, and approximately half had incomes falling below the provincial low-income threshold. Although this limits generalizability, our study provides insight into the experiences of a large and growing population of older adult immigrants often missed in psychological research. Cultural factors may also shape solitude. Individuals of East Asian heritage may experience solitude more positively as it is conducive to self-reflection and low-arousal leisure activities, activities that are valued more in East Asian than in Western cultures (Averill & Sundararajan, 2014; Tsai, 2007). Although we found no cultural differences in solitude experiences in the current set of analyses, more research is needed to compare solitude experiences across cultures. Finally, our older adult sample comprised mostly retired individuals, and our young adult sample comprised undergraduate students, with recognized limits to generalizability (Henrich, Heine, & Norenzayan, 2010). Life phase specific goals and social roles may make solitude a particularly common experience for both older adults

and students (Larson, 1990; Lay et al., 2018; Pauly et al., 2017). In contrast, working adults with children at home may have less time or freedom to pursue solitary activities (Lay et al., 2018). To account for such life phase factors, our findings need to be replicated in samples representing the full adult lifespan.

**Conclusions**

Solitude need not be lonely. Our findings show that solitude is a multifaceted construct that can have positive as well as negative connotations. By combining momentary affect and thought assessments in moments of solitude, we identified two types of solitude experiences, one negative and one positive, and linked them with well-established individual difference factors. Key characteristics of people likely to thrive in solitude were being high in social self-efficacy and desire for solitude, and being low in self-rumination and self-reflection. To further understand this emerging and important phenomenon, potential causal mechanisms (such as the role of self-rumination in producing negative solitude experiences) need to be tested experimentally (e.g. Nguyen et al., 2017). The role of motivational factors in solitude experiences could also be examined using established measures of affinity for solitude (e.g. Preference for Solitude; Burger, 1995). Positive and negative solitude experiences may also differentially shape longer term outcomes; this could be tested by examining time-ordered associations between solitude experiences and subsequent changes in wellbeing. This study provides initial evidence of solitude's multifacetedness and identifies factors that may help make the best of it – a potential starting point for future work on this ubiquitous phenomenon.

**Declaration of Conflicting Interests**

The author(s) declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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**Footnotes**

[1] In cases when the participant completed two questionnaires within 90 minutes of one another, we deleted both questionnaires. An additional 180 time-sampling questionnaires (3.8%) were thereby excluded from analyses.

[2] Nearly two-thirds of participants continued completing time-sampling questionnaires after the end of the 10-day study period, hence, the average number of questionnaires completed (30.5) exceeds the expected number (3 daily questionnaires x 10 days = 30 questionnaires). Study analyses (LPA and LCR) were conducted after excluding these extra questionnaires, but this did not substantively change the reported findings. Hence, we kept all completed questionnaires in the reported analyses.

[3] Additional models that included current activities (working, passive leisure), time of day, daily precipitation, and daily hours of sunlight as predictors were also examined to test whether these situation-level factors may be associated with likelihood of experiencing positive or negative solitude. None of these variables showed significant associations with solitude experiences, hence, we excluded them from the reported models.

## Tables

Table 1. Overall sample descriptives for momentary affect and thought dimensions and class-specific means, standard deviations, and standardized mean class distances for final 2-class model from latent profile analysis (n = 2944 solitude episodes)

| Affect/thought dimension | *M* | *SD* | Correlations 2 | 3 | 4 | 5 | 6 | CLASS 1 *M* | CLASS 1 *SD* | CLASS 2 *M* | CLASS 2 *SD* | Standardized mean distance Situation level | Person level |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. High arousal positive affect | 48.94 | 22.09 | .63 | .32 | -.26 | -.43 | -.08 | 46.04 | 21.92 | 52.73 | 21.72 | 0.31 | 0.40 |
| 2. Low arousal positive affect | 59.28 | 21.43 | | .36 | -.48 | -.51 | -.26 | 51.86 | 20.17 | 68.99 | 19.01 | 0.87 | 1.00 |
| 3. Low cognitive effort thought | 52.99 | 15.58 | | | -.29 | -.31 | -.24 | 50.56 | 15.24 | 56.17 | 15.44 | 0.37 | 0.75 |
| 4. High arousal negative affect | 24.02 | 20.39 | | | | .67 | .56 | 37.57 | 16.47 | 6.28 | 7.02 | 2.53 | 3.89 |
| 5. Low arousal negative affect | 30.69 | 21.32 | | | | | .43 | 41.72 | 19.51 | 16.26 | 13.55 | 1.50 | 2.02 |
| 6. High cognitive effort thoughts | 33.38 | 19.40 | | | | | | 42.34 | 17.81 | 21.65 | 14.53 | 1.26 | 1.63 |

*Note.* All variable correlations are significant, $p < .001$. In this final model, indicator variances and covariances vary across classes, with no indicator-specific random intercept. All affect and thought dimensions are on 100-point scales. Standardized mean distance is an adaptation of Cohen's *d* indicating degree of class separation, calculated for each class indicator (parcel). Values greater than 2 indicate < 20% overlap in class distributions; values less than 0.85 indicate > 50% overlap in distributions. Situation level standardized mean distances are calculated for each affect/thought dimension across all solitude episodes; person level values are calculated for *person-means* of each affect/thought dimension.

Table 2. Multilevel latent class regression predicting log-odds of experiencing positive solitude over negative solitude (N = 150 individuals, n = 2944 solitude episodes) using maximum likelihood estimation with robust standard errors

| | | Log-odds of positive (Class 2) over negative (Class 1) solitude experiences | | | |
|---|---|---|---|---|---|
| | Parameter | Coefficient, $logit(P_{ij})$ | *SE* | Relative odds | *p* value |
| **LEVEL 1** | $\beta_{1j}$ Aloneness, | 0.09 | *(0.06)* | Class 2, 1.09 : 1 | .152 |
| | $\beta_{2j}$ Solitude desire, | 0.19 | *(0.11)* | Class 2, 1.21 : 1 | .085 |
| **LEVEL 2** | $\gamma_{00}$ Intercept | **-0.48** | ***(0.22)*** | **Class 1, 1.62 : 1** | **.025** |
| | $\gamma_{01}$ Overall time in solitude | 0.77 | *(1.17)* | Class 2, 2.16 : 1 | .506 |
| | $\gamma_{02}$ Person-mean aloneness | 0.57 | *(0.83)* | Class 2, 1.77 : 1 | .489 |
| | $\gamma_{03}$ Person-mean solitude desire | **3.99** | ***(1.27)*** | **Class 2, 54.05 : 1** | **.002** |
| | $\gamma_{04}$ Age (years) | 0.01 | *(0.01)* | Class 2, 1.01 : 1 | .639 |
| | $\gamma_{05}$ Ethnicity | -0.30 | *(0.52)* | Class 1, 1.35 : 1 | .564 |
| | $\gamma_{06}$ Education | 0.91 | *(0.75)* | Class 2, 2.48 : 1 | .223 |
| | $\gamma_{07}$ Relationship status | -0.23 | *(0.60)* | Class 1, 1.26 : 1 | .697 |
| | $\gamma_{08}$ Social network size | -0.01 | *(0.02)* | Class 1, 1.01 : 1 | .753 |
| | $\gamma_{09}$ Social relationship quality | 0.74 | *(0.40)* | Class 2, 2.10 : 1 | .065 |
| | $\gamma_{010}$ Perceived social status | 0.12 | *(0.17)* | Class 2, 1.13 : 1 | .472 |
| | $\gamma_{011}$ Social self-efficacy | **0.87** | ***(0.44)*** | **Class 2, 2.39 : 1** | **.048** |
| | $\gamma_{012}$ Self-reflection | **-0.62** | ***(0.31)*** | **Class 1, 1.85 : 1** | **.045** |
| | $\gamma_{013}$ Social anxiety | -0.54 | *(0.34)* | Class 1, 1.72 : 1 | .115 |
| | $\gamma_{014}$ Self-rumination | **-0.62** | ***(0.31)*** | **Class 1, 1.86 : 1** | **.049** |

*Note.* Coefficients are unstandardized. Overall time in solitude is proportion of all beeps when participant was in solitude. Person-mean aloneness (solitude desire) is proportion of solitude instances when participant was alone (desiring solitude). Ethnicity is 1 = European, 0 = not European; education is 1 = some post-secondary, 0 = none; relationship status is 1 = in a relationship, 0 = not. Social network size is total number of people listed. Social status is on a 10-point scale. All other variables are on 5-point scales. See *Supplementary Materials C* for model details. Bayesian multiple imputation (Muthén & Muthén, 2007) was used to impute missing data for age ($N$ = 5), relationship status (3), social status (5), social self-efficacy (3), and social anxiety (3). Adding participant sample (0 = students, 1 = older adults) to the model did not change reported findings, hence, we omitted this variable for parsimony.

**Figures**

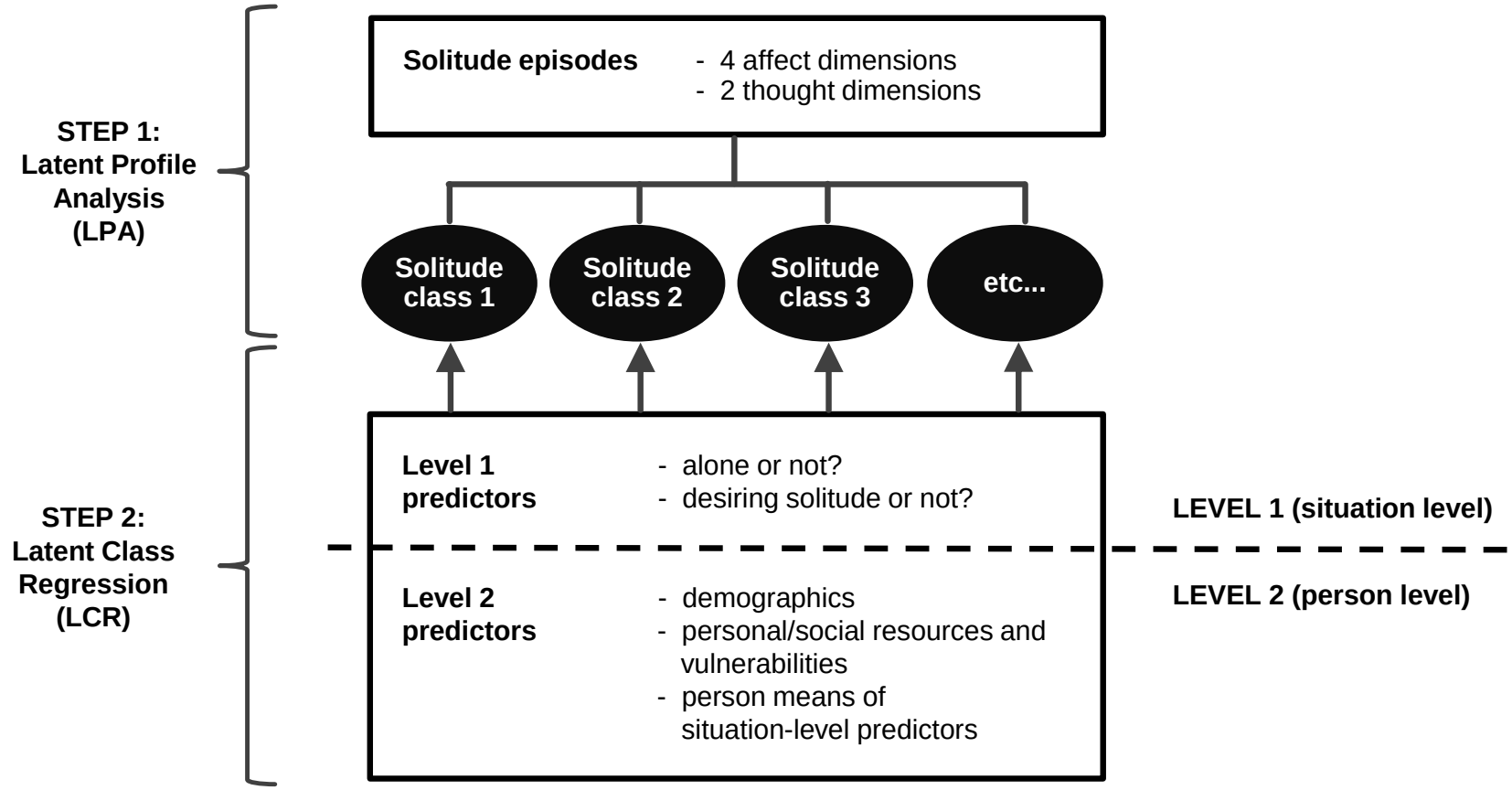


*Figure 1*. Conceptual model and data analytic stages: Identification of distinct solitude experience classes based on affect/thought dimensions (multilevel latent profile analysis) and prediction of solitude experience class membership from situation- and person-level characteristics (multilevel latent class regression)

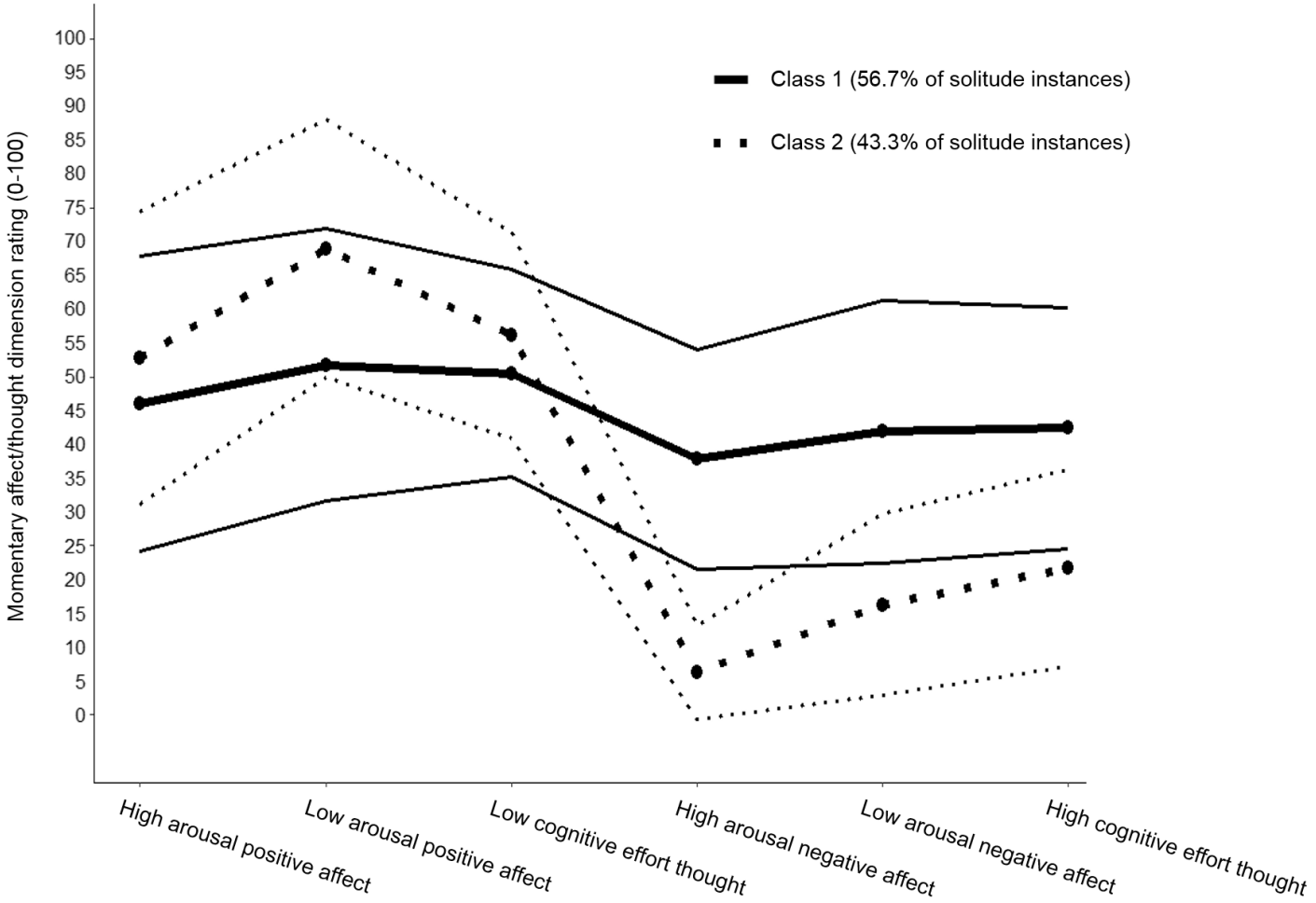


Figure 2. Two types of solitude experiences: Class-specific means of momentary affect and thought dimensions for final 2-class model from latent profile analysis ($N$ = 150 individuals, $n$ = 2944 solitude episodes)

*Figure 2 caption.* Thicker lines show class-specific means, and thinner lines show standard deviations, for the 6 momentary affect/thought dimensions in the final LPA model (indicator variances/covariances vary across classes, no indicator random intercept).

## Supplementary Materials A: Variable Descriptive Information

Table SMA-1. Intercorrelations of person-level variables and person-averaged momentary variables (N = 150 individuals)

| | Correlations | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 1. Age | .09 | **-.30** | **.26** | -.10 | .09 | .10 | .05 | **-.33** | **-.44** | **-.58** | .01 | -.03 | .01 | **.40** | **.47** | **.43** | **-.31** | **-.38** | -.07 |
| 2. Ethnicity | | **.17** | -.14 | **.25** | .16 | **.23** | .02 | -.10 | **-.18** | **-.17** | .10 | .06 | -.15 | -.01 | .12 | -.07 | -.10 | .00 | **-.24** |
| 3. Education | | | -.11 | **.25** | .00 | .09 | .02 | **.22** | .03 | .20 | .01 | .10 | .09 | **-.19** | **-.27** | **-.19** | .07 | .05 | -.10 |
| 4. Relationship status | | | | -.06 | **.27** | .15 | .14 | **-.18** | **-.28** | **-.25** | **-.45** | **-.27** | -.16 | **.24** | **.25** | **.10** | **-.17** | **-.21** | .07 |
| 5. Social network size | | | | | .12 | .15 | .14 | .13 | .09 | .10 | -.10 | -.12 | **-.19** | -.02 | -.05 | -.01 | .08 | .06 | -.03 |
| 6. Social relationship quality | | | | | | **.31** | **.42** | -.01 | **-.30** | **-.19** | **-.17** | -.12 | -.12 | **.32** | **.38** | .11 | **-.34** | **-.32** | -.12 |
| 7. Perceived social status | | | | | | | **.25** | .01 | **-.27** | -.12 | -.06 | -.07 | -.06 | **.17** | **.24** | .05 | **-.25** | **-.24** | **-.19** |
| 8. Social self-efficacy | | | | | | | | **.17** | **-.19** | -.02 | **-.20** | **-.23** | **-.25** | **.38** | **.28** | .10 | **-.24** | **-.24** | -.12 |
| 9. Self-reflection | | | | | | | | | .15 | **.48** | .04 | -.10 | -.14 | -.02 | -.09 | **-.17** | **.25** | **.22** | **.18** |
| 10. Social anxiety | | | | | | | | | | **.47** | .09 | .13 | .09 | **-.30** | **-.37** | **-.29** | **.44** | **.37** | **.19** |
| 11. Self-rumination | | | | | | | | | | | .10 | .11 | .05 | **-.30** | **-.43** | **-.30** | **.43** | **.42** | **.28** |
| 12. Mean time alone | | | | | | | | | | | | **.58** | **.40** | -.03 | -.05 | .00 | .02 | -.02 | -.12 |
| 13. Mean time in solitude | | | | | | | | | | | | | **.60** | -.10 | -.14 | -.05 | .01 | .00 | -.09 |
| 14. Mean desire for solitude | | | | | | | | | | | | | | -.12 | -.09 | .11 | -.10 | **-.20** | -.14 |
| 15. Mean high arousal positive affect | | | | | | | | | | | | | | | **.69** | **.43** | **-.29** | **-.46** | -.07 |
| 16. Mean low arousal positive affect | | | | | | | | | | | | | | | | **.43** | **-.53** | **-.58** | **-.32** |
| 17. Mean low cognitive effort thoughts | | | | | | | | | | | | | | | | | **-.38** | **-.48** | **-.26** |
| 18. Mean high arousal negative affect | | | | | | | | | | | | | | | | | | **.81** | **.68** |
| 19. Mean low arousal negative affect | | | | | | | | | | | | | | | | | | | **.57** |
| 20. Mean high cognitive effort thoughts | | | | | | | | | | | | | | | | | | | |

*Note.* Bolded values are significant at $\alpha = .05$. Age is in years; ethnicity is 1 = European, 0 = non-European; education is 1 = at least some post-secondary, 0 = no post-secondary; relationship status is 1 = in a relationship, 0 = not in a relationship. Social network size is total number of individuals listed. Perceived social status is on a 10-point scale. Social relationship quality, social self-efficacy, self-reflection, social anxiety, and self-rumination are on 5-point scales. Mean time alone is proportion of all (4571) momentary assessments when participant was alone; mean time in solitude is proportion of assessments when participant was in solitude; mean desire for solitude is proportion of assessments when participant desired solitude. Mean affect and thought dimensions are person-averages of all momentary assessments, on 100-point scales.

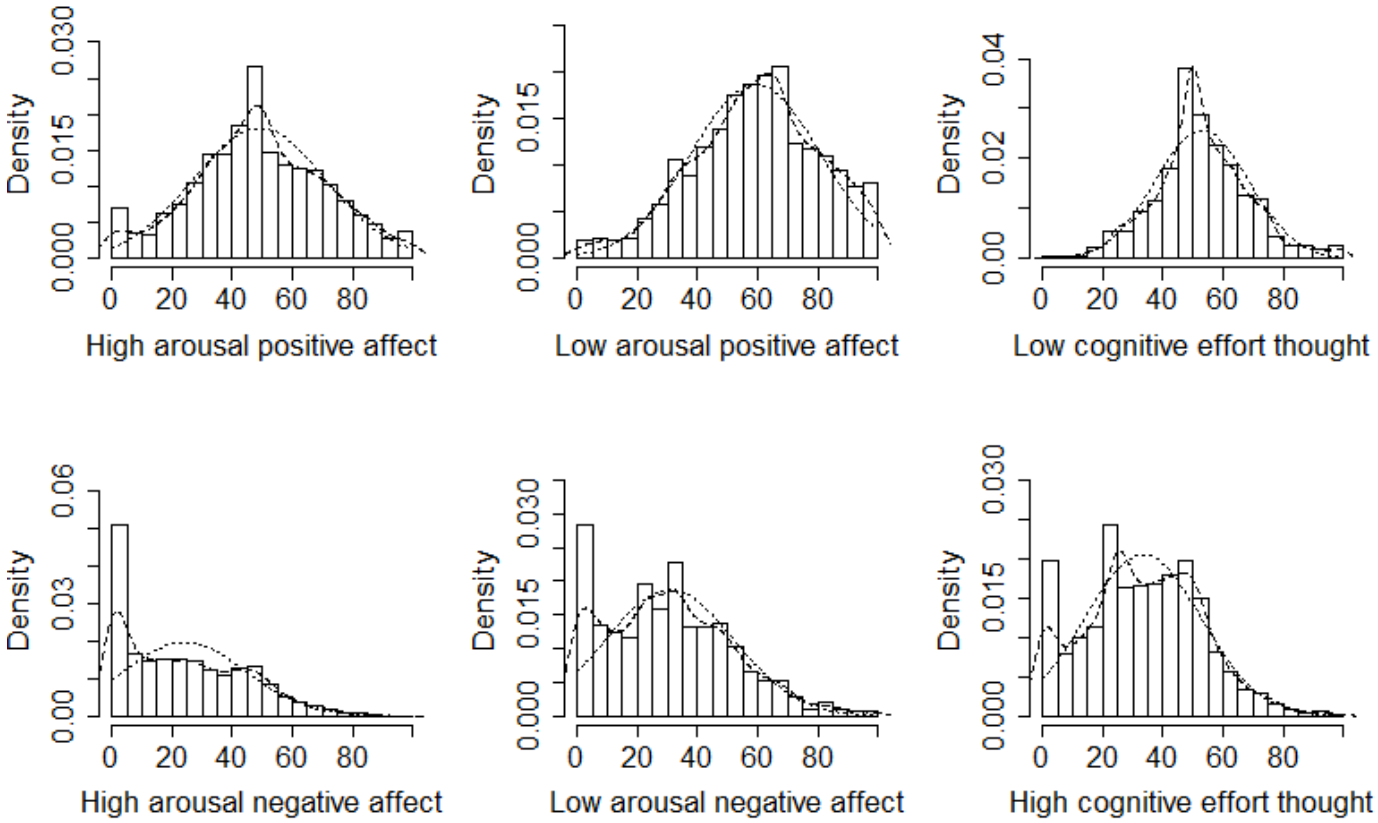


*Figure SMA-1.* Distributions of momentary affect and thought dimensions (n = 2944 solitude episodes)

## Supplementary Materials B: Multilevel Latent Profile Analysis Procedure and Results

Of the 4571 momentary assessments collected from our 150-participant sample, 2944 were classified as solitude episodes. We used multilevel latent profile analysis (LPA) to classify these solitude episodes into a set of latent classes or solitude experience types, based on their momentary affect-thought profiles (4 affect dimensions and 2 thought dimensions). A final model (set of solitude classes) was selected based on model fit indices, residuals, classification diagnostics, parsimony, and theoretical considerations. We used the following procedure, based on recommendations for LPA model selection and class enumeration provided by Masyn (2013).

Step 1: Identify a set of model types to test

In a multilevel LPA context, choosing which model types to test involves making decisions about (1) the covariance structure of the class indicators (momentary affect/thought dimensions), and (2) how to account for the nested structure of the data (solitude episodes and momentary affect/thought indicators nested within people).

For all reported models, indicator variances and covariances were allowed to vary within and between classes (Masyn, 2013). We had no reason to believe that (a) different indicators would have the same variance within a solitude class, that (b) the same indicator would have the same variance across solitude classes, or that (c) indicators would all have the same covariances within or across classes. Hence, we did not impose any such constraints on the indicator covariance structure.

Multilevel LPA also accounts for the nested data structure by allowing the latent class means (defining Level 1 solitude class membership) to vary across Level 2 units (people). In other words, each of the K-1 latent class variables for a K-class model has its own random intercept (Henry & Muthén, 2010). This allows us to model person-level influences on solitude

class membership, that is, to account for the possibility that people may vary in their propensity to experience one type of solitude over another. All of our reported models account for the nested data structure in this way. In addition, multilevel LPA allows the option of adding another random intercept for the thought/affect indicators themselves. This *indicator-specific random intercept* enables us to model person-level clustering of momentary affect/thought dimensions, independently of solitude class membership (Henry & Muthén, 2010). In other words, people might differ in their mean levels of high arousal positive affect, high cognitive effort thought, etc. in ways that are *not* accounted for by classifying their momentary affect/thought profiles into distinct types of solitude experiences. We found it reasonable to suppose that, in addition to solitude class propensities varying between people, momentary affect and thoughts might also vary between people, and that accounting for this between-person variability in indicator means might improve model fit. Hence, we tested two model types: one without an indicator-specific random intercept and one with an indicator random intercept (in the form of one common random factor for the 6 affect/thought dimensions; Henry & Muthén, 2010). We report 1-, 2-, and 3-class solutions for these two model types.

A final consideration in multilevel LPA is whether to use a parametric or a non-parametric approach to model the random latent class means. In the *parametric* approach (the approach we use here), the latent class means at Level 1 are assumed to be normally distributed across Level 2 units (Henry & Muthén, 2010; Vermunt, 2003). In other words, this assumes individuals are normally distributed in terms of their mean propensity to experience one type of solitude over another. The *non-parametric* approach, in contrast, does not make the assumption of normally distributed random class means. Instead, the K-1 random means from the K Level 1 classes are used as indicators of a second set of latent classes at Level 2 (Henry & Muthén, 2010;

Vermunt, 2003). This means that, in addition to having distinct solitude classes at Level 1 (situation level), we would also have distinct solitude-propensity classes at Level 2 (person level), e.g. "people who always experience positive solitude" and "people who experience a mix of positive and negative solitude". We had no a priori hypotheses regarding different types or latent classes of *people* (above and beyond different types of *solitude experiences*). Hence, fitting and comparing non-parametric models is not necessary to answer our research questions, and is beyond the scope of this manuscript. For all reported models, we used the parametric approach; this allows us to test our hypotheses by identifying solitude classes and examining situation-level and person-level predictors of experiencing these different types of solitude experiences.

Step 2: Generate 1-class, 2-class, 3-class, etc. models for all model types

For each of the two model types, we generated a series of models, starting with a 1-class model, and increasing the number of classes until the model was no longer well-identified. The results are summarized in *Supplementary Materials B, Table 1*. For model type 1 (variances/covariances vary across classes, *no* indicator random intercept), we generated a 1-class, a 2-class, and a 3-class model, and the 4-class model was not identifiable. We did the same for model type 2 (variances/covariances vary across classes, *with* indicator-specific random intercept): 1-class, 2-class, and 3-class solutions were generated, and the 4-class solution was not identifiable. Notably, for both model types, the 3-class solutions presented convergence issues, whereas the 2-class solutions did not.

Step 3: Compare fit indices (Scree plots)

We examined fit indices for each of the six models generated (1-, 2-, and 3-class solutions for model type 1, and 1-, 2-, and 3-class solutions for model type 2). The Aikike Information Criterion (AIC) and Adjusted Bayesian Information Criterion (BIC) for each model

are presented in *Supplementary Materials B, Table 1*; these allow us to compare models of the same type, with differing numbers of classes (i.e. they do *not* allow us to compare solutions for model type 1 vs. model type 2). Smaller values indicate better model fit. Because only 1-, 2-, and 3-class solutions were identifiable, the AIC and BIC Scree plots for the two model types were not able to show a clear "elbow" indicating the optimal number of classes for that model type. Hence, at this stage, all the 2- and 3-class models seemed to be viable candidate models for identifying different types of solitude experiences (4 candidate models in total).

Step 4: Compare model residuals and classification indices

Model residuals and classification indices were examined for all models generated and are summarized in *Supplementary Materials B, Table 1*.

i. Residuals for the indicator means, variances, covariances, univariate skewness, and univariate kurtosis are indicators of absolute model fit. As shown in the table, introducing an indicator-specific random intercept resulted in very large residuals for the means and variances/covariances, and particularly so for the 2-class model. This model specification (the inclusion of an indicator random intercept) seems to be a poor fit to the data.
ii. Model entropy is an overall summary of latent class assignment error. Values range from 0 to 1, and values near 0 may indicate model misfit (Masyn, 2013). Entropy for all four candidate models is acceptable, and is highest for model type 1, 2-class model.
iii. Average posterior class probability (AvePP) was computed for each class. Values above 0.7 indicate good class separation and classification accuracy (Nagin, 2005). All candidate model classes were well above this threshold, and AvePP values were highest for model type 1, 2-class model.
iv. Odds of correct classification (OCC) was computed for each class based on modal class

assignments. Values above 5 indicate good class separation and assignment accuracy (Nagin, 2005), and again, all candidate model classes were well above threshold.

Step 5: Examine class homogeneity and class separation indices

Class homogeneity and class separation indices are provided in *Table 1* of the main manuscript for the final selected model (model type 1, 2-class).

Smaller within-class variances and covariances, as compared to overall sample values, indicate greater class homogeneity. As shown in *Table 1*, all class 1 and class 2 indicator variances are smaller than their respective overall sample variances, and this is especially true for the negative affect and high cognitive effort thought dimensions. Overall, Class 2 ("positive" solitude) is more homogeneous than Class 1 ("negative" solitude).

Class separation was assessed by calculating the standardized mean distances between classes; this is a class indicator-specific adaptation of Cohen's *d*. Values greater than 2 indicate less than 20% overlap in class distributions, i.e. high separation between classes on that particular indicator. Values less than 0.85 indicate greater than 50% overlap in class distributions, i.e. low class separation on that indicator. *Table 1* values indicate a particularly high degree of separation between solitude Class 1 and Class 2 on the high arousal negative affect dimension, and good class separation on the low arousal negative affect, high cognitive effort thought, and low arousal positive affect dimensions. Class separation is poor on the high arousal positive affect and low cognitive effort thought dimensions.

Step 6: Examine class contents to select a final model

For each of the top candidate models (identified based on model fit, residuals, and classification indices) the final step in model selection is to examine the class contents, taking into consideration parsimony and theoretical meaningfulness: "to what extent do these classes

reflect qualitatively distinct types of solitude experiences?" Based on their high residuals, models with indicator-specific random effects were removed from the pool of candidate models (Step 4 above). The remaining top-candidate models were the 2-class model and 3-class models for model type 1 (no indicator-specific random effects). In general, parsimony considerations would suggest we pick the model with the lower number of classes, i.e., the 2-class model (Masyn, 2013). Moreover, inspection of class contents and class separation indices suggested that in the 3-class model, two of the solitude classes were in fact very similar to one another, indicating they were capturing redundant information. The existence of these two redundant classes also made little theoretical sense because one class was characterized by higher means on all six affect/thought dimensions than the other class. Therefore, we selected the 2-class model as our final model. *Table 1* in the manuscript provides this final model's class-specific means and standard deviations for the 6 affect/thought dimensions, and *Figure 2* plots the means for the two classes. Further elaboration on the solitude classes' theoretical meaning is provided in the main manuscript.

Table SMB-1. Identifying a set of distinct types of solitude experiences using latent profile analysis: Class proportions, model fit indices, residuals, and classification indices for candidate models

| Model type | Number of classes | Number of free parameters | Class proportions | Model fit indices | | Largest residuals | | | | | Classification indices | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | AIC | Adjusted BIC | Mixed means | Mixed variances | Mixed co-variances | Mixed univariate skewness | Mixed univariate kurtosis | Entropy | AvePP | OCC |
| **Model Type 1:** Variances/ covariances vary across classes | 1 | 27 | 1 1.00 | 68268.43 | 68344.31 | n/a | n/a | n/a | n/a | n/a | n/a | 1 1.00 | n/a |
| | **2** | **56** | **1 0.57**<br>**2 0.43** | **65251.48** | **65408.85** | **0.00**<br>**0.00**<br>**0.00** | **0.00**<br>**0.00**<br>**0.00** | **0.00**<br>**0.00**<br>**0.00** | **-0.24**<br>**0.23**<br>**0.18** | **0.65**<br>**-0.29**<br>**0.20** | **0.891** | **1 0.98**<br>**2 0.96** | **1 30.04:1**<br>**2 33.79:1** |
| | 3 | 86 | 1 0.20<br>2 0.36<br>3 0.44 | 63528.73 | 63770.41 | 0.00<br>0.00<br>0.00 | 0.00<br>0.00<br>0.00 | 0.00<br>0.00<br>0.00 | 0.28<br>0.26<br>0.24 | -0.67<br>-0.46<br>0.35 | 0.886 | 1 0.94<br>2 0.96<br>3 0.95 | 1 62.74:1<br>2 42.72:1<br>3 22.90:1 |
| | 4 | 117 | *Model not identified* | | | | | | | | | | |
| **Model Type 2:** Variances/ covariances vary across classes, *indicator-specific random intercept* | 1 | 32 | 1 1.00 | 65094.12 | 65184.05 | n/a | n/a | n/a | n/a | n/a | n/a | 1 1.00 | n/a |
| | 2 | 62 | 1 0.60<br>2 0.40 | 62762.37 | 62936.60 | -3.60<br>-3.38<br>-2.46 | -413.60<br>-404.80<br>-184.30 | -409.70<br>-276.10<br>274.50 | 0.54<br>0.42<br>0.31 | -0.57<br>-0.47<br>-0.39 | 0.845 | 1 0.97<br>2 0.95 | 1 19.44:1<br>2 25.11:1 |
| | 3 | 93 | 1 0.39<br>2 0.19<br>3 0.43 | 61384.73 | 61646.08 | -2.96<br>-1.93<br>-0.47 | -70.90<br>-15.40<br>-5.80 | -34.90<br>31.70<br>30.20 | 0.24<br>0.23<br>0.15 | -0.59<br>0.33<br>-0.28 | 0.854 | 1 0.96<br>2 0.92<br>3 0.92 | 1 34.23:1<br>2 52.49:1<br>3 15.67:1 |
| | 4 | 125 | *Model not identified* | | | | | | | | | | |

*Note:* AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; Adjusted BIC accounts for sample size. Lower AIC and Adjusted BIC values indicate better model fit when comparing models of the same type with different numbers of classes. Entropy is a measure of posterior classification uncertainty; values near 0 may indicate poor class separation. AvePP = average posterior class probability and OCC = odds of correction classification; higher values indicate better class separation and classification accuracy. The bolded model was selected as the final model, based on model fit indices, residuals, classification indices, parsimony, and class contents

*Figure SMB-1:* Person-level distribution of solitude experience classes (*N* = 150 individuals)

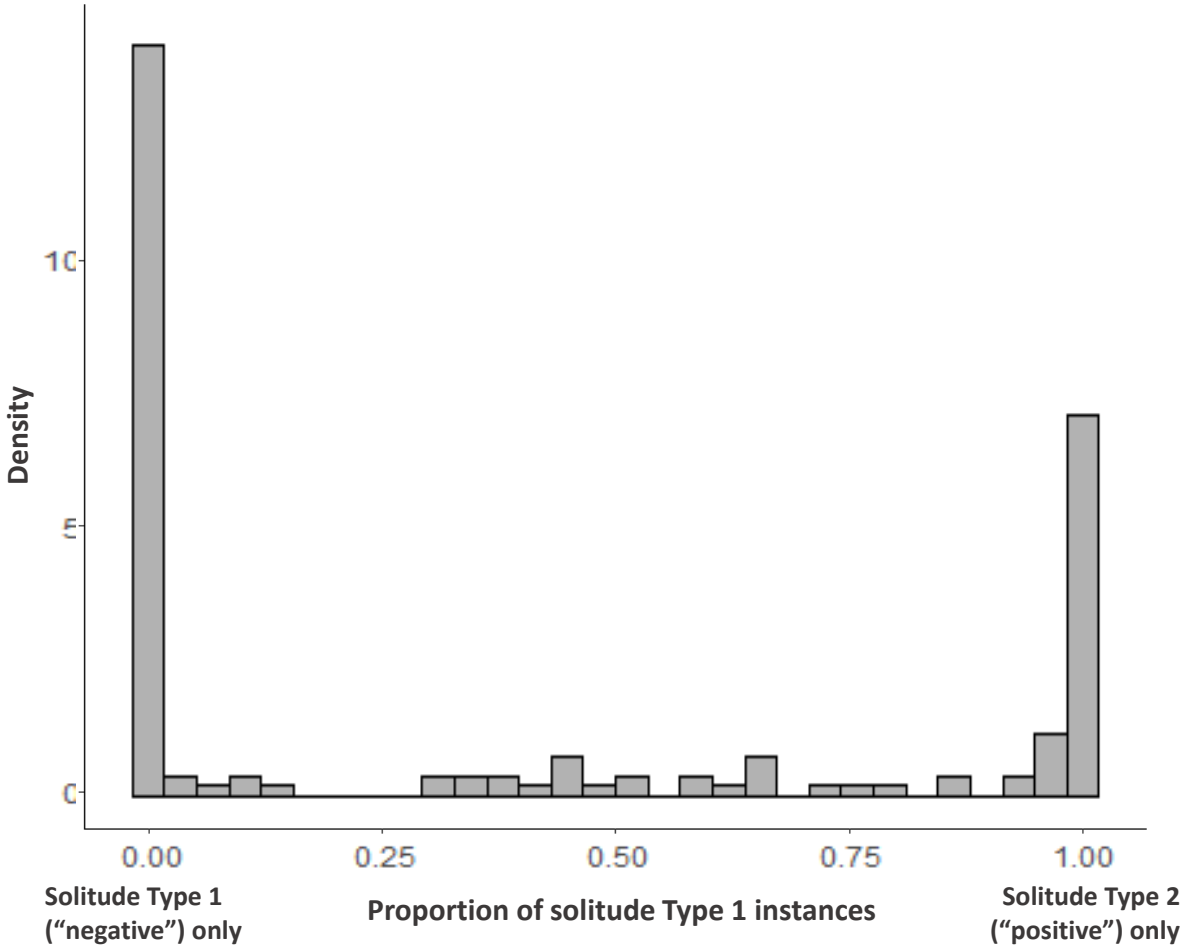


*Figure SMB-1 caption:* Distribution of person-level solitude class membership, i.e. each individual's proportion of solitude episodes categorized as solitude type 1 ("negative solitude experiences") versus type 2 ("positive solitude experiences"). Most individuals experienced either exclusively negative solitude (*N* = 73) or exclusively positive solitude (*N* = 37).

## Supplementary Materials C: Multilevel Latent Class Regression Procedure

Latent Class Regression Model Equations and Variables

In the latent profile analysis procedure (*Supplementary Materials B*), solitude episodes were classified into two types (Class 1: "negative solitude experiences" and Class 2: "positive solitude experiences") based on momentary affect/thought profiles. Our next aim was to predict for whom and under what circumstances solitude would be experienced negatively or positively. To do this, we built on the final 2-solitude-class model by adding a set of Level 1 (situation-level) and Level 2 (person-level) predictors of solitude class membership, using multilevel latent class regression (LCR; Henry & Muthén, 2010; Masyn, 2013). Multilevel LCR allows us to model random effects, i.e. person-level clustering of situation-level solitude class membership, using a logistic model. This is the equivalent of adding covariates to the latent profile analysis model, but is done after establishing the final solitude class structure. Model equations and variable interpretations are provided below. All predictors were grand mean centered.

Level 1: $$logit(P_{ij}) = \beta_{0j} + \beta_{1j} ALONE_{ij} + \beta_{2j} DES\_SOL_{ij}$$

Level 2: $$\beta_{0j} = \gamma_{00} + \gamma_{01} PROP\_SOL_j + \gamma_{02} ALONE\_M_j + \gamma_{03} DES\_SOL\_M_j$$
$$+ \gamma_{04} AGE_j + \gamma_{05} EURO_j + \gamma_{06} UNIV_j + \gamma_{07} RELAT_j$$
$$+ \gamma_{08} NET\_SIZE_j + \gamma_{09} REL\_QUAL_j + \gamma_{010} SOC\_STAT_j$$
$$+ \gamma_{011} SOC\_EFF_j + \gamma_{012} REFL_j + \gamma_{013} SOC\_ANX_j + \gamma_{014} RUMI_j + U_{0j}$$

$$\beta_{1j} = \gamma_{10} \qquad \beta_{2j} = \gamma_{20}$$

– Subscript *i* indicates level 1 units (solitude episodes), and *j* indicates level 2 units (persons)

– $P_{ij}$ is the probability of experiencing positive (Class 2) rather than negative (Class 1) solitude at a given moment. $logit(P_{ij})$ is the log-odds; values greater than 0 indicate greater odds of experiencing positive solitude and values less than 0 indicate greater odds of experiencing

negative solitude.

– $\beta_{0j}$ is the random intercept of the logit outcome (the log-odds of experiencing positive over negative solitude is allowed to vary randomly across people).

– $\gamma_{00}$ is the average log-odds of experiencing positive over negative solitude (when all model predictors are at their grand means).

– $\gamma_{10}$ is the average change in log-odds when currently alone (*ALONE* = 1) versus not alone (*ALONE* = 0), when all other predictors are at their grand means.

– $\gamma_{20}$ is the average change in log-odds when currently desiring solitude (*DES_SOL* = 1 vs. 0), when all other predictors are at their grand means.

– $\gamma_{01}$ through $\gamma_{14}$ are the average changes in log-odds for a one unit change in the respective person-level variable, when all other predictors are at their grand means. The predictors are: proportion of instances of solitude across all momentary assessments (*PROP_SOL*); proportion of solitude instances when participant was alone (*ALONE_M*, person-average of *ALONE*); proportion of solitude instances when participant desired solitude (*DES_SOL_M*, person-average of *DES_SOL*); age in years (*AGE*); being European (*EURO* = 1 vs. 0); having at least some post-secondary education (*UNIV* = 1 vs. 0); being in a relationship (*RELAT* = 1 vs. 0); number of individuals in social network (*NET_SIZE*); social relationship quality on a 5-point scale (*REL_QUAL*); perceived social status on a 10-point scale (*SOC_STAT*); social self-efficacy on a 5-point scale (*SOC_EFF*); self-reflection on a 5-point scale (*REFL*); social anxiety on a 5-point scale (*SOC_ANX*); and self-rumination on a 5-point scale (*RUMI*).

– $U_{0j}$ is the residual influence of Level 2 units (people) after accounting for all model predictors; assumed to be normally distributed. This intercept random effect was fixed to zero for model convergence.

Latent Class Regression Modeling Procedure

In estimating this latent class regression (LCR) model, we used the 3-step approach recommended by Vermunt (2010) to account for uncertainty in solitude class assignment. Modal class assignments are weighted by probabilistic class assignments when determining the influence of the predictors on class membership. The steps are as follows:

1. After picking a final LPA model (see *Supplementary Materials B*), look at the solitude class assignment results. Each solitude episode is assigned to a single class (modal class assignments, with values of either 0 or 1 for each class). The LPA results also give us information about classification uncertainty for each solitude episode (probabilistic class assignments, values ranging from 0 to 1 for each class), including logits for the classification probabilities for the most likely class membership (one logit per class). All this information is part of the *Mplus* LPA output.
2. Create a nominal "most likely class" variable to use in the LCR analysis, based on the modal class assignments. Then, using the logits for the classification probabilities for the most likely latent class memberships, pre-fix the class-specific measurement error rates for this "most likely class" variable to match the misclassification rates from the LPA analysis. This process is analogous to gathering reliability information for a particular measure, and then using this reliability information to specify error variance when using the measure in a subsequent model.
3. Run the LCR model, including the "most likely class" variable from the previous step as a nominal indicator of solitude class membership. Add Level 1 and Level 2 covariates, as appropriate, to test hypotheses regarding situation-level and person-level predictors of solitude class membership.