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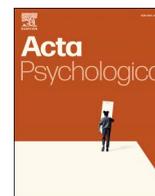
Loneliness unlocked: Associations with smartphone use and personality

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A B S T R A C T

Communication and relationships have been dramatically altered among emerging adults thanks to the rapid adoption of the smartphone in just over a decade. Studying the effects of evolving personal technology helps researchers understand both the detriments of widespread adoption and the benefits that accompany the technology. One such area of concern is the relationship of technology with loneliness. Emerging adulthood is described as the period of transition from adolescence to adulthood, taking place from age 18–25. This period is characterized by change, exploration, but also a vulnerability to psychological distress. Young adults are not only at greater risk of loneliness compared to other developmental stages, but report greater distress about being lonely (Rokach, 2000). Previous research has found support for the hypothesis that use of social communication on the Internet has a bidirectional relationship with loneliness (Nowland et al., 2018); use of the Internet can support relationships and decrease loneliness, but if used as a compensation for social skill deficits, the Internet can also displace quality time spent in relationships, and thereby increase loneliness. This study examines loneliness and its relationship with smartphone use, while also accounting for individual differences in facets of neuroticism, communication apprehension, emotional support, and nomophobia for emerging adults. Participants ($N = 302$; $M_{AGE} = 18.85$) completed self-report measures of loneliness and the individual differences variables. They also reported average daily smartphone data of screen time, pickups, and application (app) use, which was measured by their personal devices. Correlations indicated loneliness was positively associated with screen time, social media app use, neuroticism, social recognition, communication anxiety, and nomophobia. Loneliness was negatively associated with smartphone pickups, communication application use, need for affiliation, and emotional support. A regression analysis revealed that neuroticism, need for affiliation, social recognition, emotional support, and smartphone pickups were significant predictors of loneliness, when taking into account all the individual difference and smartphone use variables. Neuroticism and loneliness have a strong relationship, but a hierarchical regression showed that over and above neuroticism and its facets, smartphone screen time and pickups predict loneliness. Overall, the results for this sample of emerging adults supported the hypotheses by Nowland et al. (2018) about social use of the Internet, but applied to smartphone use. More time spent on one's smartphone and on social media apps is related to increased loneliness, and is discussed in context of identity development. More frequent use (pickups) and use of communication apps is related to decreased loneliness and is discussed with respect to development of relationship intimacy. These results suggest that loneliness in young adults is related to different types of smartphone use, even when accounting for stable characteristics such as personality. Finally, neuroticism remains a significant variable in understanding loneliness, and further examination of lower-order facets help define a more nuanced profile in individual differences.

1. Introduction

In the early 2000s, smartphone technology entered mainstream life. By 2021, an estimated 85% of the American population owned a smartphone, and 96% of those between the ages of 18 and 30 (Pew Research Center, 2021). This has dramatically changed the landscape of communication and relationships, as well as entertainment and information access. The rapid changes in technology make it difficult for research to keep up with measuring the relationship with individual functioning. One such area of concern is the relationship of technology to loneliness. The present study seeks to understand how loneliness relates to smartphone use in emerging adults, while also examining predictor variables of personality, anxiety, and social support. Technology use has previously been difficult to estimate, often relying on

participants' historical estimations or estimations in diary studies. The study expands the literature on smartphone use and loneliness by using data such as screen time and application (app) use time that are available to users and provide a more precise estimation of smartphone use. Loneliness has been shown to be strongly tied to neurotic personality, and many studies neglect to take personality into account when examining loneliness with other factors. The present study includes a measure of the trait of neuroticism, as well as facets, which may advance a richer understanding of loneliness.

1.1. Loneliness

Loneliness has been described as the "subjective experience of social isolation" (Golden et al., 2009, p. 694), involving an evaluation of whether one feels socially and emotionally supported or is content with their social life. Not surprisingly, emotional support and loneliness have been found to be correlated in young adults, even when the emotional support is evaluated by a friend instead of by self-report (Larose et al., 2002).

The present study examines emerging adults, a group who are at risk for loneliness. Emerging adulthood is a developmental period around the ages of 18–25 where individuals manage the transition from adolescence to adulthood. This stage is characterized by identity exploration, instability, self-focus, and possibilities (Reifman et al., 2007). Emerging adulthood is a time of significant change, where people are often leaving public school, moving away from family, starting new employment, or experiencing friends move away. Tanner and Arnett (2011) propose that emerging adulthood is a "critical period" where individuals are expressing resilience, but also at risk for psychiatric disorders. While loneliness is an experience across the lifespan, Rokach (2000) found that compared to other ages, adults in their 20s experience significantly more distress from loneliness than other age groups. Loneliness has been associated with poor subjective health status (Peltzer & Pengpid, 2017) and has been found to predict increased depression, anxiety, and risk of eating disorder in undergraduate students (Richardson et al., 2017). A qualitative study by Vasileiou et al. (2019) identified that the most common methods of coping with loneliness in its sample of university students were distraction, seeking support, and social isolation. The authors noted that digital technologies were heavily featured in their interviews, from using digital communication for their social support, to games and passing the time online for distraction and escape. Loneliness is a problem in young adults and technology appears to have become a key component of its management.

1.2. Internet and smartphone use

Internet use has been shown to be associated with loneliness. In a review of the literature, Nowland et al. (2018) outlined findings that supported two hypotheses with respect to loneliness and Internet use. One is the "stimulation hypothesis", which is that more online social interactions would result in more social support (and thereby less loneliness) because it adds something to relationships, like more information and more time together overall. Indeed, Nowland et al. (2018) found that more total time online is positively associated with loneliness, but that when time online is spent in social communication, the association is negative, suggesting that online relationships are enhancing when they are supported by offline interactions. There is evidence of genetic and biological factors in how one uses online social environments (such as social media) that suggests the online world can become an extension of the offline world; that is, genetic markers that are present in social "in-person" behaviour also similarly influence social online behaviour (e.g. Carollo et al., 2021). Indeed, using one's phone for communication has been found to be a heritable behaviour (Miller et al., 2012; York, 2017).

The other hypothesis examined by Nowland et al. (2018) in relation

to social Internet use and loneliness was the "displacement hypothesis", which is that more online social interactions would result in less social support (and greater loneliness). Nowland et al. (2018) also found evidence supporting this prediction, particularly with respect to problematic Internet use and when social relationships are predominantly online and compensate for social skill deficits. Given the results, Nowland et al. (2018) propose that the theoretical model between loneliness and Internet use is bidirectional and dynamic.

With smartphones now commonplace, much of the Internet research focuses on the use and impacts of portable devices. Studies focus on how much individuals use their smartphone (frequency), how long they use their smartphone (duration), and for what reason they use their smartphone (purpose).

1.2.1. Frequency of smartphone use

Oulasvirta et al. (2012) reported that when comparing laptop and smartphone use, smartphones were used more frequently, for shorter duration, and use was spread more evenly throughout the day. The authors identified that smartphone use often becomes habitual, which has contributed to its pervasiveness and ubiquity. Increased habitual use is directly related to maladaptive and problematic use of smartphones (Van Deursen et al., 2015). Higher habitual use and more frequent use has been found to be correlated with depression and anxiety (Harwood et al., 2014; Lowe-Calverley & Pontes, 2020), which suggests that lonely individuals will check their smartphone more frequently.

1.2.2. Duration of smartphone use

Using a national survey of American youth in grades 8, 10, and 12, Twenge et al. (2018) investigated a sharp decline in psychological well-being, including loneliness, among adolescents in 2012. Twenge et al. (2018) also reported decreased time for in-person social interaction at the same time as increases in loneliness and digital media use, results that are consistent with Nowland et al.'s (2018) displacement hypothesis at the cohort level. The displacement hypothesis is that time online replaces time spent in-person, which will increase loneliness. At the individual level, the authors' findings were reversed; individuals who spend more time with friends also spend more time accessing social media, supporting a complementarity hypothesis, similar to the stimulation hypothesis (Nowland et al., 2018). The complementarity hypothesis states that more time socializing online enhances social relationships, thereby reducing loneliness. Other research has found that when it comes to smartphone use, total duration is not as strongly associated with mental wellbeing as involvement or dependence (Harwood et al., 2014). The research is not conclusive, but leans toward a minimal association between daily duration of use and loneliness.

1.2.3. Purpose of smartphone use

In addition to duration and frequency of use, how individuals use their smartphone may reveal useful patterns. Describing the purpose of smartphone use has been done in a few separate ways. Studies have typically divided use into two categories: social versus process use (Elhai et al., 2017; Van Deursen et al., 2015). Social use includes texting, social networking sites, and telephone calls. Process use refers to reading news and accessing entertainment. When it comes to psychological variables associated with smartphone use, anxiety and depression are most strongly correlated with non-social smartphone use (Elhai et al., 2017). This suggests that non-social use of smartphones will be positively correlated with loneliness compared to social use. However, Cho (2015) found that communication and social media use of smartphones functioned differently when examining social isolation and relationship building, suggesting that a higher-order category of social use may not fully capture differences in loneliness. This may explain previous null findings between loneliness and social use of smartphones and will be explored in the present study by separately examining communication use and social media use, as well as examining facets of non-social use in three separate categories. By measuring smartphone use in a variety of

ways, we can better understand how different habits and profiles relate to loneliness.

1.3. Personality

Loneliness and personality research yields consistent findings among the Big Five personality factors. Loneliness positively correlates with neuroticism, characterized by anxiety and high emotionality, and loneliness negatively correlates with extraversion, characterized by sociability and seeking out relationships (Saklofske & Yackulic, 1989). Stokes (1985) found that both neuroticism and extraversion were correlates and predictors of loneliness, but that neuroticism in particular accounted for a larger proportion of the variance in loneliness, even when accounting for size of social network. Stokes (1985) posited that individuals with a neurotic personality may be more likely to worry and focus on what is negative, thereby seeing themselves as more alone and requiring more support than they have.

While the Big Five and its assessments are some of the most widely used in personality theory, the current study contributes to the personality and loneliness literature by examining lower-order facets of neuroticism. The Personality Research Form (PRF; Jackson, 1989) identifies 22 scales of personality which load to the Big Five factor model (e.g. Harris et al., 2005), suggesting that it help to describe personality in a more detailed and nuanced manner. Harris et al. (2005) evaluated PRF scales using factor analysis, finding that scales measuring affiliation, harmavoidance, social recognition, and succorance loaded positively onto a dependence personality factor (factor loadings 0.42 to 0.80), which resembled a neuroticism factor. Descriptions of the four PRF scales below are adapted from the PRF manual (Jackson, 1989).

1.3.1. Affiliation

Individuals who are high in affiliation are people who enjoy being with others and make efforts to form and maintain relationships, whereas those who are low are more likely to keep others at a distance and not seek out friendships. While loneliness is theorized to come from a dissatisfaction with one's social life, often lonely individuals do not show affiliative behaviours such as seeking out friendships and are often described as introverted (Saklofske & Yackulic, 1989). These results suggest that loneliness will negatively correlate with affiliation.

1.3.2. Harmavoidance

High harmavoidant individuals typically seek safety, may be apprehensive, and are unadventurous. Low harmavoidant individuals can be described as daring, rash, or courageous. Loneliness correlates with anxiety (Solano & Koester, 1989) and has been found to negatively correlate with social risk-taking (Moore & Schultz, 1983). These results suggest that loneliness will correlate positively with harmavoidance.

1.3.3. Social recognition

Individuals who seek social recognition are often concerned with their reputation and are socially sensitive. Those who score low on social recognition often do not conform to social norms in either behaviour or appearance. Jackson (2007) found that self-presentation (acting in ways as to gain social recognition) corresponds with loneliness in adolescents and emerging adults. Following, it would then be expected that those higher in social recognition would also score higher in loneliness.

1.3.4. Succorance

Succorance describes the need to seek support, sympathy, and reassurance of others. Those who score low are described as self-sufficient and generally have more confidence in their own judgment. In attachment theory, individuals with anxious attachment often show features of succorance, and often score highly on measures of loneliness (Mikulincer & Shaver, 2014). The description of succorance and findings with anxious attachment would suggest a positive correlation between succorance and loneliness.

1.3.5. Personality and smartphone use

The Big Five personality traits also relate to smartphone use. Beierle et al. (2020) found that higher levels of extraversion and neuroticism were positively associated with increased checking of one's smartphone. They also found that conscientiousness was negatively associated with overall screen time. Using very detailed smartphone data from a tracking app, Stachl et al. (2020) reported that use of phones for social communication was predictive of features of neuroticism, primarily self-consciousness.

1.4. Anxiety

Given the association of loneliness and neuroticism, it is unsurprising that anxiety is common in lonely individuals. Anxiety encompasses a wide range of fears, but two that appear to have connection with both loneliness and smartphone use are communication apprehension and nomophobia. Communication apprehension is fear and avoidance of real or anticipated communication with another (McCroskey & Beatty, 1984). As communication apprehension has been linked with loneliness (e.g. Solano & Koester, 1989; Zakahi & Duran, 1982), and has been negatively associated with emotional maturity, adventurousness, confidence, and self-control (McCroskey et al., 1976), it is expected that a positive correlation between communication apprehension and loneliness would be replicable. The literature about smartphone use and communication apprehension is sparser. Neo and Skoric (2009) identified links between individuals who had communication apprehension and a preference for using computer-based instant messaging (somewhat of a precursor to text messaging). Socially anxious individuals are more likely to feel comfortable using technology for communication (e. g. texting, social media websites; Elhai et al., 2017; Pierce, 2009). While the research is consistent that individuals with social and communication-related anxiety prefer online communication, objective smartphone use patterns are less clear. Exploring the link of communication apprehension and smartphone use further explains circumstances that are predictive of loneliness.

Nomophobia is another area of anxiety that emerges when investigating the relationship of loneliness and smartphone use. Nomophobia (from the phrase **no-mo**bile-**phobia**) is fear associated with being separated from one's mobile telephone or being unable to access its services (Yildirim & Correia, 2015). Other researchers have found associations between nomophobia and loneliness (e.g. Gezgin et al., 2018; Kara et al., 2021), so it is important to take into account the impact of nomophobia when evaluating loneliness and its relationship to patterns of smartphone use.

1.5. Present study

Broadly, the purpose of this study was to investigate emerging adults' smartphone use and the association with loneliness. A secondary focus is to reveal and expand upon the role that personality plays in loneliness and smartphone use. Finally, communication apprehension and fear of being without one's smartphone (nomophobia) are examined as additional exploratory variables in the relationship between loneliness and smartphone use.

From these purposes, we developed four hypotheses. First, stemming from the question, do lonely individuals use their smartphone in ways that are different from non-lonely individuals? The evidence points in different directions, with some studies suggesting social internet use positively correlates with loneliness and others suggesting information/ leisure use is more likely to be associated with loneliness. However, more of the recent and robust research suggests the latter, which is consistent with the displacement hypothesis, that smartphone use for leisure and information is displacing time spent in face-to-face social interaction. On the other hand, if smartphone use is for social interaction instead, this would support the complementarity hypothesis, that more time spent using smartphones socially can help to augment, or at least

sustain relationships and social networks.

Hypothesis 1. Individuals scoring higher on loneliness will use their smartphones differently. Lonely individuals will exhibit a higher frequency of checking and will make more use of non-social smartphone functions, such that there will be positive correlations between these behaviours and self-report loneliness. Total time of smartphone usage will not significantly correlate with self-report loneliness.

The next research question asks, what are the specific personality facets of lonely individuals? Neuroticism, as is well known, correlates with loneliness, and the present study will confirm this. Also examined are the PRF scales described above that are suggested to be linked to neuroticism to further explore the personality of lonely individuals.

Hypothesis 2. Self-report loneliness scores will positively correlate with neuroticism, harmavoidance, social recognition, and succorance, and will negatively correlate with affiliation.

This research also seeks to address the relationship between loneliness, communication apprehension, and smartphone usage. Communication apprehension is known to correlate with loneliness and anxious individuals are more likely to use technology to avoid face-to-face interaction.

Hypothesis 3. There will be a positive correlation between communication apprehension scores and loneliness ratings, as well as between communication apprehension with duration and frequency of smartphone use.

In addition, this study aims to evaluate the relationship between feelings of loneliness and perceptions of their emotional support from friends and family.

Hypothesis 4. There will be a negative correlation between loneliness and emotional support.

Finally, this study will explore the question of what factors are the strongest predictors of loneliness. Specifically, an evaluation of which of the variables, smartphone use, personality, communication apprehension, nomophobia, and non-support, are the strongest predictors of loneliness are examined in the present study.

2. Method

2.1. Participants

The participants were 302 (143 men, 158 women, and 1 preferred not to disclose) undergraduate students recruited from a first-year management and organizational studies program at a large Canadian University through the undergraduate research credit system between February 10 and April 15, 2020. The sample had a mean of age of 18.85 years ($SD = 1.04$). Participants were recruited for the study if they used Huawei or iPhone smartphones and had at least one week of screen data. The sample was comprised of undergraduate students, so while the age ranged from 18 to 24, the median age was 19 and not normally distributed (positively skewed and highly leptokurtic). Participants also identified their living situation by choosing from options that best described with whom they were living: "Alone" ($N = 22$), "With roommates (shared common spaces)" ($N = 226$), "With a spouse/long term partner" ($N = 5$), "With parents/relatives/caregivers" ($N = 46$) or "Other (please specify)" ($N = 3$). Participants who rated "other" generally described a combination of living with roommates and with family.

It is impossible to ignore the historical threat to validity of the COVID-19 pandemic. Most of the sample (75%, $N = 226$), was collected prior to March 13, 2020, when the university announced that the semester would be finished online.

2.2. Procedure

Participants accessed an online survey through Qualtrics. Ethics approval was granted by the Ethics Board. Prior to analysis, this study and its hypotheses were pre-registered on the Open Science Framework (https://osf.io/zb9j6?view_only=a6ef03844a704d6495ebfbbda6c8cabc). The online survey contained demographic questions about participants' age, gender, living situation, as well as the measures and smartphone data described below.

Initially, 507 surveys were completed, as was anticipated in the pre-registration of the study. The large sample size was to anticipate incomplete surveys, withdrawal from the study, and exclusion based on data cleaning, with enough participants remaining to have stable correlations and effect sizes. Schönbrodt and Perugini (2013) propose that 250 participants are needed for stable moderate correlations with a narrow corridor of stability, while Lakens and Evers (2014) argue that a wider corridor of stability is acceptable, such that a minimum of 250 participants is required for identifying small effect sizes. Following, we planned for having a sample size which was *at least* 250 individuals. For this study, the final sample size is 302 individuals.

Due to the challenges in having participants locate and report screen time, we included a stringent data cleaning process. Participants were asked to report the total usage, as well as the average so that the number of days of data could be calculated (total divided by average). According to Wilcockson et al. (2018), five days of screen time data is sufficient to represent a reliable average. For pickups, two days of data is sufficient (Wilcockson et al., 2018). Following, entries were kept if the calculated number of days fell between five and eight (to account for rounding; $N = 116$ did not pass) for screen time and between two and eight for pickups ($N = 35$ did not pass). If the information was entered incorrectly, it is highly unlikely that the days calculated would fall between two and eight, so this was also viewed as a check for accurate data entry by participants. Within the remaining entries, there were fourteen participants with outliers in their average pickups (less than five per day and more than 400), so these cases were removed. One additional participant's data was removed due to unlikely response pattern (i.e. marking 'true' for almost all items across several scales). The resulting sample was $N = 343$. From these participants, we eliminated 41 who completed the study in a second recruitment effort, but the data was considered to be confounded by differences in educational program and school year timing (i.e. recruited after the academic term was complete). The final sample consisted of 302 individuals.

2.3. Measures

2.3.1. UCLA Loneliness Scale (Version 3; Russell, 1996)

The UCLA Loneliness Scale is one of the most widely used self-report measures of loneliness (Russell, 1996), consisting of 20 items, each responded to using a 4-point Likert scale of "0 = Never", "1 = Rarely", "2 = Sometimes", and "3 = Often". Vassar and Crosby (2008) found generalized reliability estimates of 0.86 to 0.95 across 13 studies for the UCLA Loneliness Scale. The scale has been shown to have good construct and convergent validity (Russell, 1996). The present study resulted in high internal consistency (α = 0.95).

2.3.2. Neuroticism scale from the NEO Personality Inventory Revised (NEO-PI-R; Costa & McCrae, 1992)

The NEO-PI-R is a self-report inventory of personality. The present study used the items for the neuroticism factor scale. Items are statements that are evaluated on a 5-point scale of how much the statement applies to the rater from "0 = Strongly Disagree" to "4 = Strongly Agree". Internal consistency reliability for the neuroticism scale is reported to be 0.90 (Costa & McCrae, 1992), which was consistent with the present study results (α = 0.88).

2.3.3. Personality Research Form (PRF; Jackson, 1989), select subscales

The Affiliation, Harmavoidance, Social Recognition, and Succorance scales from the PRF were selected for this study. Each scale contains 16 statements, which participants rate as "True" or "False". From the PRF manual (Jackson, 1989), internal consistency reliabilities for the scales of interest are 0.88 for Affiliation, 0.91 for Harmavoidance, 0.91 for Social Recognition, and 0.91 for Succorance. Internal consistency as measured by the Kuder-Richardson 20 (KR-20; recommended for assessing internal reliability of dichotomous scales) in the present study were noticeably lower but acceptable: 0.75 for Affiliation, 0.78 for Harmavoidance, 0.65 for Social Recognition, and 0.76 for Succorance.

2.3.4. Personal Report of Communication Apprehension scale (PRCA-24; McCroskey, 1982)

The PRCA-24 is a 24-item self-report measure of anxiety in different types of communication. The scale is divided into four types of communicative situations including participating in group discussions, speaking in meetings, engaging in conversations, and giving a speech. Participants rate whether each statement applies to them on a 5-point scale from "0 = Strongly Disagree" to "4 = Strongly Agree". Ratings can be evaluated in the four specific situations, or can be compiled as a total score. Internal consistency overall has been estimated to be 0.97 (McCroskey et al., 1985). The present study was consistent with the previous findings for the overall score ($\alpha = 0.94$).

2.3.5. Personality Assessment Inventory, Non-Support Scale (PAI Non-Support; Morey, 1991)

The PAI Non-Support is an 8-item subscale of the PAI, which evaluates the amount of perceived family and friend support. This scale was included in this study as a method of corroborating participants' assessment of their loneliness with the UCLA Loneliness Scale (Russell, 1996). Items are rated as "true" or "false". The KR-20 = 0.59 for the PAI Non-Support scale, suggesting low but adequate internal consistency value (Taber, 2018). Total scores were reverse coded for clarity so that higher scores on the PAI Non-Support suggest lower perceived support from family and friends.

2.3.6. Smartphone use

To determine smartphone use, three different types of information, taken from built-in applications (apps) on Apple iPhone devices and Huawei Android devices, was collected. These devices were chosen specifically because they collect weekly totals of the information, which will give a broader picture of typical use than a daily snapshot. Participants were instructed with text and photos on how to access the appropriate information. Participants entered weekly total and daily average "screen time" (measured in hours and minutes, calculated to minutes for analysis). Participants were also asked to enter the number of "pick-ups" (iPhone) or "unlocks" (Huawei), as an estimate of how frequently individuals used and checked their smartphones (note, the term "pickups" is used by the iPhone, but it does not register a count unless the user unlocks the smartphone).

The third type of information participants entered was their five most used apps. These apps were then coded into being in one of five categories. In the App Store or Google Play, where apps are first downloaded, each app has a category; however, these categories are decided by the developer and there are no set criteria. Furthermore, the categories in one store are not the same as the other. Using either one of these services for coding resulted in more than 10 different categories, with no consistent definitions. Using previous studies as guides (e.g. Cho, 2015; Elhai et al., 2017; Kim et al., 2015), as well as reviewing the apps recorded in the present sample, we used five categories: social media, communication, entertainment, productivity, information, for which we created a coding system (see Supplemental material).

The descriptions for the categories were sent to an independent rater. The other rater and the first author separately coded the five apps for thirty-six participants (approximately 10% of the total), with a high level of consensus (Cohen's Kappa = 0.99). Some apps could fall into different categories depending on which function is being used (for example, Instagram has a social media function, as well as a communication function with direct messaging). The guideline used by raters was to favour the app's primary function. Once the apps were coded, they were arranged into counts of each category. For example, if a participant recorded their five most used apps as: Facebook, Messages, Instagram, Netflix, YouTube; the data would be: Social Media = 2, Communication = 1, Entertainment = 2, Productivity = 0, Information = 0. In addition to recording the apps they used, participants were also asked to rank order 14 possible smartphone uses in order of importance to them.

2.3.7. Nomophobia Questionnaire (NMP-Q; Yildirim & Correia, 2015)

Nomophobia (from the phrase **no-mo**bile-**phobia**) is fear associated with being separated from one's mobile telephone. The NMP-Q is a 20-item self-report questionnaire developed to measure severity of nomophobia with items such as, "Running out of battery in my smartphone would scare me" or, "If I did not have my smartphone with me, I would be nervous because I would be disconnected from my online identity". Participants indicate the degree of their agreement on a 7-point Likert scale from "1 = Strongly Disagree" to "7 = Strongly Agree". Yildirim and Correia (2015) found the internal consistency to be high ($\alpha = 0.95$), which was the case in the present study ($\alpha = 0.93$).

3. Results

The data was analysed using R version 6.3.1 (R Core Team, 2020). See Table 1 for descriptive statistics and intercorrelations. Holm-Bonferroni corrections were applied for multiple correlation analysis, except for hypothesized correlations (loneliness and all study variables, as well as the PRCA-24 and screen time and PRCA-24 and pickups). Each scale was assessed for possible violations of distribution. The PAI Non-Support scale was positively skewed (i.e. more students reported good emotional support; skewness = 1.27). The other scale distributions appeared generally normal and had kurtosis values less than ±2 and skew values not greater than ±1.

3.1. Loneliness and demographic variables

As reported in Table 1, the correlation between age and loneliness scores was significant, suggesting that older participants were lonelier. There was no significant difference in loneliness scores between male and female participants ($t(298) = -0.46$, Cohen's $d = -0.05$, $p = .649$). A one-way ANOVA was used to discern the effect of living arrangements on loneliness scores. The group reporting "other" was not included due to its small size ($n = 3$) and the similarity to the roommates or family groups. Levene's test showed equal variances in loneliness scores for the remaining living arrangement groups despite differing sizes, $F(3, 294) = 1.31$, $p = .27$. Results of the ANOVA indicated that loneliness scores varied significantly between groups, $F(3,294) = 3.28$, $p = .021$. Post-hoc comparisons (Tukey HSD) identified specifically that individuals who lived alone ($M = 30.46$, $SD = 14.18$) were lonelier those who lived with roommates ($M = 21.93$, $SD = 12.03$, Tukey HSD = 8.52, Hedges' $g = 0.70$, $p = .011$) and those who lived with parents/relatives ($M = 21.94$, $SD = 12.84$, Tukey HSD = 8.52, Hedges' $g = 0.64$, $p = .038$).

3.1.1. Group differences before and after university class cancellation

To assess the impact of the closing of university classes due to the COVID-19 pandemic on the data in the present study, independent sample t-tests were conducted to compare the participants who completed the study prior to cancelled classes on March 13 (Pre-Group, $N = 226$) and those who completed it after (Post-Group, $N = 76$) on the major variables of this study. Levene's test of homogeneity of variance for each of the tests was not significant ($p > .05$) for all comparisons, despite the discrepancy in sample size. Participants in the Post-Group

Table 1
Descriptive statistics and inter correlations between demographic and scale study variables.

Variable	N	M	SD	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Age	302	18.85	1.04	1.00												
2. Gender[a]	302	–	–	0.04	1.00											
3. Screen time	302	361.40	145.36	0.21*	0.05	1.00										
4. Pickups	302	125.45	64.03	−0.13	0.08	0.09	1.00									
5. Loneliness	302	22.57	12.35	0.14*	−0.03	0.18**	−0.13*	1.00								
6. PAI Non-Support Scale	302	1.46	1.51	0.19**	−0.09	0.25**	−0.11	0.55**	1.00							
7. PRCA-24	302	43.38	15.58	0.16	0.27**	0.16**	0.01	0.39**	0.26**	1.00						
8. PRF Affiliation	302	9.44	3.45	−0.17	−0.04	−0.18	0.24**	−0.54**	−0.53**	−0.46**	1.00					
9. PRF Harm avoidance	302	9.28	3.73	0.15	0.07	0.05	−0.08	0.06	0.01	0.23**	−0.13	1.00				
10. PRF Social Recognition	301	8.70	3.02	0.06	−0.05	0.05	0.05	0.18**	0.05	0.16	0.02	0.14	1.00			
11. PRF Succorance	302	7.85	3.51	0.11	0.20*	0.06	0.02	−0.07	−0.13	0.10	0.05	0.23**	0.23**	1.00		
12. NEO Neuroticism	274	96.72	18.49	0.10	0.25**	0.16	0.08	0.53**	0.33**	0.54**	−0.44**	0.19*	0.31**	0.19*	1.00	
13. NMP-Q	294	90.28	20.49	0.15	0.14	0.17	0.09	0.15*	0.12	0.19	−0.09	0.29**	0.19*	0.20*	0.27**	1.00

Note. Sample sizes varied due to missing items; Screen time = average daily smartphone screen time in minutes; Pickups = Average daily number of smartphone pickups; Loneliness = UCLA Loneliness Scale (Russell, 1996); PAI = Personality Assessment Inventory, Non-Support Scale (Morey, 1991); PRCA-24 = Personal Report of Communication Apprehension Scale (McCroskey, 1982); PRF = Personality Research Form (Jackson, 1989); NEO Neuroticism = Neuroticism scale from the NEO Personality Inventory Revised (Costa & McCrae, 1992); NMP-Q = Nomophobia Questionnaire (Yildirim & Correia, 2015).

[a] Male = 0, female = 1.
* *p* < .05.
** *p* < .01; two-tailed.

were not significantly lonelier ($M = 22.93$) than those in the Pre-Group ($M = 22.45$; $t_{(299)} = -0.29$, Cohen's $d = -0.04$, $p = .768$). No significant differences were found for smartphone use duration, average pickups, personality variables, social support, communication anxiety, or nomophobia ($p > .10$). Regarding how participants used their smartphones, participants in the Post-Group used more communication apps ($t_{(300)} = -2.41$, Cohen's $d = -0.32$, $p = .016$) and fewer entertainment apps ($t_{(300)} = 2.64$, Cohen's $d = 0.35$, $p = .009$).

3.2. Loneliness and smartphone use

The current study examined whether individuals who are lonelier interact differently with their smartphones. Correlations were conducted between the UCLA Loneliness Scale (Russell, 1996) and four smartphone metrics (see Table 2). The first two were correlations directly with the average screen time in minutes and the average number of pickups. Small correlations emerged for both, albeit in different directions. Screen time was positively correlated with loneliness scores, so more time spent using the smartphone is related to greater loneliness. Average pickups data was negatively related to loneliness scores, indicating that the more someone unlocks their smartphone, the lower their loneliness scores. Social media and communication apps dominated participants' top apps, with 92% having one or more social media apps, and 95% having one or more communication apps. The app uses were analysed using Pearson correlations with scores on the UCLA Loneliness Scale (Russell, 1996). A small, statistically significant correlation emerged for social media use and loneliness scores, indicating a positive relationship between smartphone use for social media purposes and loneliness scores. Also found was a small, significant negative correlation between communication apps and loneliness scores, suggesting an association between lower loneliness scores and higher communication app use. The relationships between loneliness scores and the other categories of entertainment, information, and productivity were near zero. Participants also ranked smartphone uses based on how important that use was to them. The seven highest rated usages were evaluated using Spearman correlations for each use and the loneliness score.

Texting was the most frequently top ranked smartphone use (55%), followed by browsing social media (22%) and emailing (5%). Emailing had the largest correlation, in the negative direction, with loneliness scores, but did not reach statistical significance. The relationship

Table 2
Descriptive statistics for smartphone measures and correlations with loneliness.

Variable	M	SD	Loneliness r	p
Average screen time (minutes)	361.40	145.36	0.18	0.002
Average pickups	125.45	64.03	−0.13	0.021
App use				
Social media	1.62	0.83	0.13	0.023
Communication	1.51	0.76	−0.13	0.023
Entertainment	1.17	0.93	−0.04	0.513
Information	0.57	0.61	0.02	0.754
Productivity	0.13	0.24	0.03	0.551
Importance				
Texting	2.08	1.93	0.04	0.524
Emailing	4.90	2.93	−0.10	0.091
Browsing social media (e.g. Instagram, Twitter, Facebook, forums)	3.18	2.23	−0.02	0.763
Posting onto social media	6.74	3.11	−0.07	0.209
Information (weather, maps, news, recipes)	6.53	2.34	0.00	0.995
Taking photos/video	6.46	2.44	0.09	0.141
Video/audio entertainment (e.g. YouTube, Netflix, podcasts)	6.00	3.01	0.03	0.649

Notes: Means for App Use variables are the mean number of that type of app in participants' top five most used apps. Means for the Importance variables are the mean ranking (1–14); N = 302; p values based on two-tailed t-tests.

between how lonely one feels and how important different uses are, is minimal.

3.3. Loneliness and personality

As reported in Table 1, loneliness scores were highly correlated with the NEO neuroticism scale (Costa & McCrae, 1992). Examining facets of personality, a small correlation emerged with social recognition and a high negative correlation with affiliation. The correlations between loneliness scores and harmavoidance and succorance were weak and did not reach statistical significance. The PAI Non-Support scale (Morey, 1991) had a high positive correlation with loneliness ratings.

There was a moderate positive correlation between the total PRCA-24 (McCroskey, 1982) communication apprehension score and loneliness ratings. A small, significant correlation was between screen time (duration) and PRCA-24 total score; however, the correlation between pickups (frequency) and the PRCA-24 total was not significant.

3.4. Predicting loneliness scores

Table 3 contains the result of an exploratory direct entry regression analysis to determine the best predictors of loneliness scores taking into account the smartphone measures, as well as the personality, social non-support, communication anxiety, and nomophobia measures. Demographic variables were included due to differences in Pre-Group and Post-Group sample, living arrangements, and sex. Taking sample size and the number of predictors into account, the adjusted R-squared was 0.47. The overall model was significant ($F(20, 241) = 12.44$, $p < .001$),

Table 3
Regression coefficients of study variables on loneliness.

Variable	b	SE	β	95% CI	sr
(Intercept)	−0.27	14.74	0.00	[−29.04, 29.04]	
Age	0.13	0.57	0.01	[−1.14, 1.16]	0.01
Gender[a]	−1.68	1.23	−0.06	[−2.49, 2.35]	−0.08
Sample[b]	−1.37	1.44	−0.05	[−2.89, 2.79]	−0.06
Living with spouse	−1.31	4.93	−0.01	[−9.72, 9.7]	−0.01
Living with parents	3.61	2.84	0.10	[−5.5, 5.7]	0.05
Living with roommates	1.12	2.46	0.04	[−4.81, 4.88]	0.02
Average screen time	0.00	0.00	0.06	[0.05, 0.06]	0.06
Average pickups	−0.03**	0.01	−0.16	[−0.18, −0.14]	−0.16
Social media app use	−0.17	1.69	−0.01	[−3.34, 3.31]	0.00
Communication app use	0.66	1.78	0.04	[−3.46, 3.54]	0.00
Entertainment app use	−1.38	1.71	−0.10	[−3.46, 3.27]	−0.02
Information app use	−1.17	1.86	−0.06	[−3.71, 3.6]	−0.02
NEO Neuroticism	0.23**	0.04	0.34	[0.26, 0.42]	0.25
PRF Affiliation	−0.60*	0.24	−0.16	[−0.63, 0.3]	−0.11
PRF Harm Avoidance	−0.12	0.17	−0.03	[−0.37, 0.3]	−0.04
PRF Social Recognition	0.56*	0.21	0.13	[−0.29, 0.56]	0.15
PRF Succorance	−0.32	0.18	−0.09	[−0.45, 0.27]	−0.10
PAI Non-Support	2.32**	0.49	0.28	[−0.67, 1.24]	0.22
PRCA-24 total	0.04	0.05	0.06	[−0.04, 0.15]	0.04
NMP-Q total	0.01	0.03	0.02	[−0.04, 0.08]	0.02

Notes: b = Unstandardized regression coefficient; SE = Standard error; β = standardized regression coefficient; CI = Confidence interval; sr = semi-partial correlations; Living arrangements: reference group is living alone; Productivity app use was eliminated due to singularity among app use variables. Loneliness = UCLA Loneliness Scale (Russell, 1996); NEO Neuroticism = Neuroticism scale from the NEO Personality Inventory Revised (Costa & McCrae, 1992); PRF = Personality Research Form (Jackson, 1989); PAI = Personality Assessment Inventory, Non-Support Scale (Morey, 1991); PRCA-24 = Personal Report of Communication Apprehension Scale (McCroskey, 1982); NMP-Q = Nomophobia Questionnaire (Yildirim & Correia, 2015).
[a] Male = 0, female = 1.
[b] Completed survey before March 13 = 0, after and including March 13 = 1.
* $p < .05$.
** $p < .01$.

indicating that loneliness scores can be predicted significantly better than chance when these variables are included.

Among the predictors, the NEO neuroticism scale (Costa & McCrae, 1992) was the strongest predictor of loneliness scores, followed by perceived lack of family and friend support [high scores on the PAI Non-Support (Morey, 1991) scale]. The personality facet of a need for affiliation negatively predicted loneliness scores, while a need for social recognition was a significant positive predictor. Average pickups was the only predictor of loneliness scores to emerge from the smartphone variables, and it is a negative relationship; fewer pickups is predictive of greater loneliness scores. This finding raised a question about whether average pickups was related to a specific use pattern as some apps would likely lend themselves to more frequent use. Correlations between app use and pickups revealed small positive correlations between pickups and social media ($r = 0.11$, $p = .104$) and communication ($r = 0.28$, $p < .001$).

Negative relationships were found between pickups and entertainment ($r = −0.20$, $p = .002$), information ($r = −0.14$, $p = .047$), and productivity ($r = −0.08$, $p = .190$). Holm-Bonferroni corrections were applied to correct for multiple exploratory correlations. The number of pickups is significantly related to the use of communication, entertainment, and information apps, but the relationships remain somewhat small and when they are controlled for, frequently using one's smartphone is still predictive of lower loneliness scores.

In addition to regression with all the study variables, we conducted a hierarchical regression focussed on predicting loneliness from personality and smartphone use (Table 4). The first step included sex and age variables, the second step added the NEO Neuroticism scale, and PRF facets, and the third step added average screen time and average pickups. The results of the first block were not statistically significant ($p > .05$). Model 2 suggested that the personality variables accounted for 42% of the variance ($F(7, 254) = 26.31$, $p < .001$). In the third block analysis, Model 3 accounted for 44% of the variance of loneliness ($F(9, 252) = 21.95$, $p < .001$), with an R^2 change value of 0.02 ($F(2, 252) = 4.29$, $p = .015$), suggesting that the addition of both smartphone use duration and pickups accounts for 2% of the variance in loneliness, controlling for the personality variables.

4. Discussion

Loneliness is a difficult and formative experience in emerging adults and this study set out to explore and clarify how it relates to personality, anxiety, and smartphone usage. Primarily, this research aimed to examine self-reported loneliness and its link to smartphone use across a

Table 4
Hierarchical regression coefficients of personality, screen time, and pickups variables on loneliness.

Variable	Model 1	Model 2	Model 3
Age	0.12	0.05	0.02
Gender[a]	−0.02	−0.08	−0.08
NEO Neuroticism		0.37**	0.40**
PRF Affiliation		−0.35**	−0.30**
PRF Harm Avoidance		−0.04	−0.06
PRF Social Recognition		0.15**	0.14**
PRF Succorance		−0.13**	−0.13**
Average screen time			0.09
Average pickups			−0.13**
R^2	0.01	0.42**	0.44**
R^2 change		0.41**	0.02*

Notes: Loneliness = UCLA Loneliness Scale (Russell, 1996); NEO Neuroticism = Neuroticism scale from the NEO Personality Inventory Revised (Costa & McCrae, 1992); PRF = Personality Research Form (Jackson, 1989). $N = 297$.
Regression coefficients presented in standardized form.
[a] Male = 0, female = 1.
* $p < .05$.
** $p < .01$.

variety of metrics that denote duration, frequency, and purpose. The results indicated that lonely young adults do interact differently with their smartphones than non-lonely individuals; however, not necessarily in the directions that were expected. Loneliness was not expected to be significantly related to the overall duration of use, given previous literature findings (e.g. Harwood et al., 2014), but indeed it was, with greater loneliness scores correlated with spending more time using a smartphone. While unexpected a priori, this finding is consistent with a study by Kara et al. (2021) who found a significant correlation between smartphone duration and self-report loneliness.

In the present study, self-report loneliness was linked to a lower frequency of smartphone use overall and with less use of communication apps. The initial hypothesis, that lonely people would have a higher pickup rate, was made with the rationale that frequency of smartphone use would be an indication of checking behaviour or reassurance seeking, which has been suggested as a link to problematic smartphone use (Billieux et al., 2015; Van Deursen et al., 2015). However, frequency of use also correlated with using communication apps, therefore counting smartphone pickups is not clearly a metric of anxious telephone checking, but may have alternate meanings, including that the individual has a large social network and frequently reads and responds to communication. Even when controlling for communication app use and neurotic personality traits, smartphone checking frequency was the only smartphone variable to be a significant predictor of loneliness. Rozgonjuk et al. (2018) reported a comparable finding, that increased telephone unlocks was negatively associated with depression and anxiety. Perhaps checking their smartphone is a behavioural response reinforced by the reward of a message waiting. It is possible that lonelier individuals do not pick up their smartphone as frequently because they have learned that there is less emotional support, or interaction, waiting for them.

It was expected that lonelier people would spend more time using non-social apps, as has been the case for mental health constructs (depression, anxiety) in previous studies (e.g. Elhai et al., 2017; Van Deursen et al., 2015), but this was not supported; correlations between loneliness and non-social uses (entertainment, information, productivity) were negligible. Rather, the results highlight the importance of distinguishing between types of social apps. Many studies combine social media and communication as a homogenous "social" category (e.g. Elhai et al., 2017; Van Deursen et al., 2015), but the current results showed a distinction between these two categories when it comes to evaluating correlates of loneliness. Combining social media and communication into a broad "social" category may be creating suppression effects. Loneliness has a positive relationship with social media app use, and a negative relationship with communication app use, therefore, if the app use types are combined, correlations with loneliness may be effectively cancelling each other out.

There is literature that supports the findings that communicative smartphone use has socioemotional benefits (e.g. Cho, 2015; Park et al., 2016). Nowland et al. (2018) found comparable results for Internet users; that using the Internet for social communication was inversely related to loneliness (evidence for a complementarity hypothesis, that online social interaction enhances relationships). Using media for communication is a way that emerging adults develop intimacy in relationships, whether it is forming new relationships or keeping in touch across distance as they experience new separations from friends and family (Coyne et al., 2013). The positive association between social media use and loneliness contributes to the growing social media literature that its use may have detrimental effects. Thomas et al. (2021) also found that social media use correlated positively with loneliness, and that increased social media use was associated with lower identity development in young adults. Emerging adults are characterized by a more fluid self-identity, but healthy adjustment is related to moving toward a commitment to an identity (Nelson & Padilla-Walker, 2013). Future studies would be wise to explore further how users are interacting with social media as many platforms have communicative

functions, which likely contribute to the impact on mental wellbeing. For example, Yang (2016) reported differences in loneliness depending upon how one uses social media. Students who interacted and browsed were found to be less lonely than those who spent more time posting. In addition, social media platforms differ among themselves and may have unique effects on loneliness (Pittman & Reich, 2016). Social media has become a social environment unto itself that, for many young adults, is playing a role in shaping their identity as an adult.

Personality continues to show a substantial role in understanding loneliness. Developmentally, personality is moderately stable in emerging adulthood, with some evidence that neuroticism decreases more in this stage than later adulthood (Roberts et al., 2006). The strongest predictor of loneliness in this study was the neurotic personality trait, but only some of the facets that are associated with neuroticism (and which were all significantly correlated with the overall neuroticism score in this study) were significant predictors (and significant correlates) with loneliness when controlling for anxiety, social support, and smartphone variables. Hypothesis 2, that self-report loneliness would positively correlate with neuroticism, harmavoidance, social recognition, and succorance, and would negatively correlate with affiliation was partially supported with these results. Individuals with a high need for affiliation were indeed less likely to be lonely (and were less neurotic), while those needing social recognition were more likely to be lonely. Those who are lonely often do not show affiliative tendencies. Even though lonely individuals may be dissatisfied with their relationships, they often withdraw from social interactions (McHugh Power et al., 2019) and expect social rejection (Jones et al., 1981). Affiliation is also highly associated with extraversion (Harris et al., 2005), and lonelier people are more often introverted. Despite not seeking out relationships, this study indicates that lonely people do desire social recognition; they want to be well regarded and care about their reputation. Self-presentation (i.e. motivation to gain social approval, similar to social recognition) correlates with loneliness in previous studies and is also associated with general identity confusion and anxiety in emerging adults (Jackson et al., 2002; Michikyan, 2020). Lonely people are more likely to have a low need for relationships, but a high need for social approval.

Levels of risk-taking (harm avoidance) and care-seeking (succorance) were not significantly correlated with or predictive of loneliness. It was expected that loneliness would be positively and significantly related to avoiding risks (harmavoidance), but this was not the case in present study. Theoretically, lonelier people would avoid possible social risks; however, the PRF harmavoidance subscale items present more physically daring situations such as skydiving or tightrope walking. Future studies may consider investigating harmavoidance from an emotional or relational risk perspective. Ratings on the succorance scale of the PRF were not significantly related to loneliness in the present study. This relationship suggests that the degree to which an individual sees themselves as dependent or needing care is not substantially related to whether they feel lonely or not; some individuals who have a higher need for help from others are satisfied with the help they receive, and some are not. Given that, the harmavoidance and succorance scales significantly correlated with overall neuroticism, but not with loneliness, gives support for studying the Big Five, but also for examining patterns at the facet level (e.g. Paunonen & Ashton, 2001). The pattern in these findings suggests loneliness is related to a low need for affiliation, a high need for social recognition, and is not significantly correlated with physical risk-taking and relational dependence.

The third hypothesis addressed communication apprehension and predicted positive relationships with loneliness and with smartphone use. This hypothesis was mostly supported as results showed significant correlations for communication apprehension with loneliness and with duration of smartphone use. Individuals who experience anxiety communicating in various settings are more likely to be lonely and also spend more time using their smartphone. Solano and Koester (1989) also found a significant relationship between loneliness and communication

apprehension, consistent with the present study results. Communication apprehension relating to smartphone use has not previously been studied, but the results suggest parallels to studies demonstrating that those with social anxiety often prefer technology for communication and may demonstrate compulsive smartphone use (Elhai et al., 2017). Exploratory correlations with nomophobia suggested significant association with loneliness as well, a finding that replicates Kara et al. (2021); however neither nomophobia, nor communication apprehension were significant predictors when taking into account the other study factors. Future studies may consider how these types of anxiety are related to some of the strong predictors in this study such as neuroticism and emotional support.

Contrary to expectations, frequent smartphone use was not significantly related to communication apprehension. Consistent with the present study findings, Lee et al. (2014) found that social anxiety was not predictive of texting frequency, and suggested that socially anxious individuals may be reluctant to engage in social interaction overall, despite generally preferring smartphone mediated communication. Shalom et al. (2015) also reported that interacting online does not eliminate anxiety associated with communication and in fact, physiological arousal was comparable to that experienced with face-to-face communication. Given that pickup frequency correlated with messaging apps, it is likely that the lack of finding with frequent use implies no increase in texting compared to non-anxious individuals.

Perceived emotional support is an important part of understanding loneliness. Hypothesis 4 predicted a negative relationship between emotional support and loneliness, which was confirmed with moderate positive correlations between the PAI Non-Support scale (Morey, 1991) and UCLA Loneliness Scale. The results also revealed that reported lack of emotional support is a significant predictor of loneliness. Bernardon et al. (2011) affirm that one's perception of support has a pivotal effect on the experience of loneliness. Loneliness is strongly tied to believing one has friends or family to rely upon when needed.

4.1. Limitations and future directions

Several limitations should be taken into account with the present study. The design is cross-sectional and largely correlational, such that causation cannot be inferred. Loneliness, personality, social support, and anxiety variables were measured by self-report, so there is a possibility of socially desirable responding and bias. The smartphone use data is objective in itself, but it was entered by participants and thus is susceptible to error and socially desirable responding as well. Additionally, most participants are from a specific university program. Thus, the results should be interpreted cautiously when relating to other socioeconomic, or cultural groups. Future studies may consider comparisons with other age groups, taking into account the development of personality, as well as changes in smartphone habits and loneliness over time and across ages.

The present study examined neuroticism as it is reliably correlated with loneliness, along with four personality facets that have shown correlations with neuroticism in previous studies. Future research on additional facets that might relate to loneliness, such as those that correlate with extraversion, might further explain aspects of loneliness that are related to core personality traits.

As these findings encourage the use of facet-level personality assessment to reach a more distinct understanding of psychological concepts, so future research could also investigate facets of loneliness. The UCLA Loneliness Scale (Russell, 1996) is considered unidimensional and may be overlooking some other subtypes of loneliness such as romantic and emotional loneliness (DiTommaso & Spinner, 1993). Bernardon et al. (2011) found that romantic loneliness functioned differently than family and social loneliness in terms of perceived support and attachment. The researchers recommended that at the time of development for emerging adults, this distinction is particularly important.

The present research sought to include measures of smartphone use that were more objective than self-report evaluations that typically have been used in the past. There are still limitations to the data, particularly with how app use is evaluated. Many apps have multiple functions that make categorization imprecise (particularly, use of Internet browsers as categorized as "information", but any of the five functions are accessible by internet browser). The variations in the smartphone data results strongly suggest that "smartphone use" is not a homogenous variable, but that using metrics such as total time, pickups, and types of app use provide different information for patterns of use. Other research is emerging that uses direct evaluation through app installation that provides very detailed metrics beyond screen time and frequency, such as GPS, message content, or proximity to others (e.g. Beierle et al., 2020). This brings interesting opportunities for examining passive behavioural measures of psychological constructs in future research studies.

Finally, while we analysed the difference in study variables before and after the cancellation of classes due to the COVID-19 pandemic to better understand the impact on the data in this study, making conclusions from those findings is beyond the scope of the present research. With the small sample size of the Post-Group, we would not expect these findings to generalize. There is research to suggest that loneliness has been impacted by the pandemic (Bu et al., 2020; Lee et al., 2020), as well as that smartphone use has changed (David & Roberts, 2021).

4.2. Conclusion

Lonelier emerging adults are more likely to use their smartphone longer, but less frequently. They are more likely to use social media and less likely to use communication apps. Loneliness is also associated with anxiety about communicating, which shows similar patterns of smartphone use. Taking all of the study factors into account, loneliness was best predicted by personality factors (i.e. overall neuroticism, negative affiliation, and positive social recognition), emotional support ratings, and smartphone pickup behaviour. These results shed light on the stable personality characteristics of loneliness, as well as changeable environmental characteristics of emotional support and smartphone use.

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Declaration of competing interest

The authors declare no conflicts of interest.

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