Loneliness Unlocked: Associations with Smartphone Use and Personality

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A thesis submitted in partial fulfillment of the requirements for the Master of Science degree in Psychology
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Abstract

Communication and relationships have been dramatically altered because of the rapid adoption of the smartphone in just over a decade. The present study examined loneliness, facets of neuroticism, communication apprehension, emotional support, and nomophobia with individual differences in smartphone use. In addition, the research also looked at differences in loneliness and smartphone use as a result of the novel coronavirus disease 2019 (COVID-19) pandemic. Participants (302 women and 290 men) completed a survey of the variables and reported smartphone data over two years. The sample was also divided into pre-COVID-19 (N = 226) and during-COVID-19 (N = 251). Correlations indicated loneliness was positively associated with screen time, social media app use, communication anxiety, neuroticism, social recognition, and nomophobia. Loneliness was negatively associated with smartphone pickups, communication app use, need for affiliation, and emotional support. A regression analysis revealed that personality, emotional support, and smartphone pickups were significant predictors of loneliness. Comparing pre-pandemic and pandemic states, there was an increase in smartphone duration, and a decrease in the association between social media app use and loneliness during the pandemic. These results suggest that lonely individuals use their smartphones differently, the pandemic has affected smartphone use, and that personality is a stable, but nuanced force in the understanding of loneliness.

Keywords

Loneliness, smartphone, personality, Big Five, neuroticism, COVID-19, anxiety, emotional support, nomophobia, smartphone addiction
Summary for Lay Audience

Communication and relationships have dramatically altered because of the rapid adoption of the smartphone in just over a decade. This study looks at loneliness, specifically how loneliness is associated with smartphone use as well as other personal characteristics. One characteristic includes a personality type that tends to worry or have mood swings (called neuroticism). This study also looked at how much support people feel they have from friends and family. We were also able to compare loneliness and smartphone use before the COVID-19 pandemic and during. Participants (302 women and 290 men) completed an online survey. Each person reported data about their smartphone use, which included the amount of time spent using their smartphone, how often they check their smartphone, and what applications (apps) they use most often.

Results of the study showed that lonelier participants were more likely to spend more time using their smartphone, use social media apps, be anxious about talking to people, tend to worry, want to be liked by peers, and feel anxious about being apart from their smartphone. Participants who were less lonely were more likely to pick up their smartphone often, use apps such as texting or messaging, want to have close relationships, and feel supported by their friends and family. Taking into account all of these factors, lonelier individuals pick up their smartphone less often, score higher on the personality trait of neuroticism, and feel less supported by friends and family. Smartphone use increased during COVID-19, but loneliness did not. These results suggest that lonely individuals do use their smartphones differently, and that personality is a stable, but nuanced force in the understanding of loneliness.
Acknowledgments

First and foremost, I would like to thank my primary supervisor, Dr. Julie Aitken Schermer for welcoming me to Western supporting a project that hit the ground running in my first year. From incredibly timely email replies to early involvement in projects to always making time for meetings, I could not have felt more valued and supported. Your confidence in my ideas, as well as brilliant suggestions and helpful critiques have been essential in carrying this project to completion. I look forward to the years ahead being able to work with and learn from you.

Thank you to my other supervisor, Dr. Donald Saklofske, for welcoming me into your lab of accomplished and exemplary people. I have appreciated your insights, humour, and support in navigating my return to graduate work.

Many thanks to friends, new and old, Angela Rajfur, Monique Chatterton, Christopher Kowalski, Laura Johnson, and Hiten Dave. Cassidy Trahair for her help with coding and app explanations. Thank you all for not just being familiar faces and voices, but also inspirational professionals, researchers, and teachers.

Lastly, a huge thank you to my husband, Caleb MacDonald. I could not have done this without you to share the intense work/childcare balance in the months of lockdown. You are unfailing in your encouragement of my ambitions and always steady during times of stress and doubt.
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Loneliness Unlocked: Associations with Smartphone Use and Personality

In the early 2000s, smartphone technology entered mainstream life. Initially adopted as a business tool with which people could use the same portable device to email and make telephone calls, within a span of less than 15 years, smartphones have reached ubiquity in the general public, and were described by DeGusta (2012) as the fastest adopted technology in history. DeGusta’s article was published in 2012 and since then the use of smartphones has increased exponentially with an estimated 81% of the American population owning a smartphone in early 2019, and 96% of those between the ages of 18 and 30 (Pew Research Center, 2019). This increased use of smartphones 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 relationship with societal and individual functioning; however, without accurate data collection and evaluation, any changes in society, mental health, and relationships are subject to guesswork. Assumptions about how technology changes society often fall to the two extremes of exaggerated fear-mongering or complete apathy. 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. The present study focuses on individual differences in smartphone use and the association with aspects of loneliness. A secondary focus is to reveal and expand upon the role of personality and how personality is associated with both loneliness and smartphone use. 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. Finally, changes in loneliness and smartphone use in the era of the COVID-19 pandemic are evaluated.

**Loneliness**

To be lonely is to feel distress and dissatisfaction with one’s current social relationships (Perlman & Peplau, 1981). Loneliness has also been described as the “subjective experience of social isolation” (Golden et al., 2009, p. 694). Social isolation is usually evaluated in an objective measure by factors such as whether one lives alone, frequency of contact with others, or participation in social activities (e.g. Shankar et al., 2017). Loneliness, being subjective, requires 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 negatively correlated, even when the emotional support is evaluated by a friend instead of by self-report (Larose et al., 2002).

Research seeks to understand both the origins and consequences of loneliness. Feelings of loneliness are not considered to be inherently bad, but rather functional in that feeling isolated can make one more attuned to emotional expression in others (Lucas et al., 2010) and can be motivating to seek social interactions and develop relationships (Cacioppo et al., 2014; Luhmann et al., 2015). This is the case when loneliness is a state of emotion; however, problems arise when loneliness becomes chronic or is manifested as a trait (McHugh Power et al., 2019). While loneliness is impacted by one’s environment and circumstances (such as the availability of emotional support), loneliness is also a trait that is genetically influenced (Asendorpf & Van Aken, 2003) with a heritable component (Schermer & Martin, 2019; Distel et al., 2010), confirming that
some of the variance between individuals may have an enduring genetic attribute. For the chronically lonely, research over the past few decades reveals the persistent theme of associated negative physical health (Cacioppo et al., 2002; Peltzer & Pengpid, 2017; Shankar et al., 2017) and poor mental health outcomes (Conde-Sala et al., 2019; Joiner & Rudd, 1996; Maes et al., 2019). Loneliness that endures, produces the most harmful effects.

As the literature has illuminated consequences of loneliness, research has also delved further into the characteristics of lonely people. Loneliness is strongly associated with negativity; people who are lonely generally leave a poor first impression, have an unfavourable evaluation of themselves, and have a pessimistic worldview (Jones et al., 1981). Individuals who are shy, socially anxious, have low-self-esteem, and high public self-consciousness are more likely to be lonely (Jones et al., 1981). There are also demographic factors that have been associated with loneliness. With respect to gender, results are varied. In a meta-analysis, Borys and Perlman (1985) reported that most individual studies did not report a statistically significant difference, but when combined in a meta-analysis, results revealed that men were lonelier than women. In the same report, the researchers concluded that the terminology used within measures was important. In the UCLA Loneliness Scale (Russell, 1996), which does not use the word “lonely”, men are more likely to endorse the items; however, women were more likely to endorse an item asking if they are “lonely”. In a more recent survey of American college students, Clark et al. (2015) found that men were lonelier than women. Still, other studies have found that women score higher on loneliness scales than men (Hawkley & Kocherginsky, 2018; Shankar et al., 2017; Victor & Yang, 2012). Therefore, the research
is not conclusive, suggesting that the relationship between gender and loneliness is complex.

With respect to the question of age and loneliness, research has generally found a U-shaped relationship; that is, greater loneliness in adults under age 25 and over age 65 (Joiner & Rudd, 1996; MacDonald et al., 2020; Pinquart & Sörensen, 2001; Victor & Yang, 2012). For older adults, it follows logically that as spouses and good friends pass away, one would feel increasingly lonely. Age-related cognitive and physical decline also have a negative impact on social relationships (Shankar et al., 2017). Young adulthood is a time of significant change, where people are often leaving secondary-level school, moving away from their family, starting new employment, or experiencing friends move away. 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. A qualitative study by Vasileiou et al. (2019) described that the most common methods of coping with loneliness were distraction, seeking support, and social isolation. The authors noted that digital technologies were heavily featured in their interviews with participants, from using digital communication for 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.

**Internet Use**

Portable and convenient Internet use is one of the main appeals of smartphone technology but is also a reason for problematic use. In 2001, Davis introduced a cognitive-behavioral model termed, “Pathological Internet Use”, which is also commonly
termed “Problematic Internet Use” and colloquially as “Internet Addiction”. This pattern has been accepted in the research and applies also to “Problematic Smartphone Use”, or “Smartphone Addiction”. Davis (2001) describes two types of problematic Internet use, specific and generalized. Specific refers to addiction to particular content on the Internet that has equivalent problematic dependence offline, such as sexual material or gambling services. Generalized is of greater interest to the current study and refers to a “multidimensional overuse of the Internet” (Davis, 2001, p. 188). Generalized problematic internet use has been associated with low self-esteem, depression, and loneliness, particularly with using the Internet for communication and social services, as opposed to using the internet for information or leisure (Casale & Fioravanti, 2011).

Social Internet use been shown to be associated with loneliness. In a review of the literature, Nowland et al. (2018) describe the results of studies investigating internet use with a specific focus on online social interactions. The authors outlined findings that supported two hypotheses. One is the “stimulation hypothesis”, which suggests that using the Internet for social interaction can help relationships develop by providing information about people to support in-person conversation, as well as to increase total amounts of social interaction (Kraut et al., 2002). The stimulation hypothesis 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. The other hypothesis examined by Nowland et al.
(2018) in relation to social Internet use and loneliness was the “displacement hypothesis”, which posits that face-to-face interactions are replaced by online relationships, thereby increasing loneliness (Kraut et al., 1998). The displacement hypothesis 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.

**Smartphone Use**

With smartphones now commonplace, much of the research focuses on the use and impact of portable devices. Perhaps because smartphone use has caused a visibly noticeable shift in society, such that if anyone is somewhere waiting or alone, they are quite likely to be using their mobile telephone. Physically, this shift has resulted in ramifications ranging from distracted driving accidents to impaired hand function (e.g. İnal et al., 2015) to the humorously titled “text neck”. In addition to these physical problems, the sudden and significant change has raised concerns about possible psychological and sociological impacts; and indeed, correlations between smartphone use and anxiety and depression have been identified (Harwood et al., 2014). Investigating smartphone addiction, Kim (2017) found that lonely people use smartphones for communication the same rate as non-lonely individuals, but are more likely to develop addiction as a result. Given that currently, most individuals use a smartphone, studies
focus on how much (frequency) individuals use their smartphone, how long they use their smartphone (duration), and for what reason they use their smartphone (purpose).

**Frequency**

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). It is important to measure the frequency of smartphone use (known as “checking behaviours”), as the duration of use might not be very long, but preoccupation with it is still high (Harwood et al., 2014). This previous research suggests that lonely individuals will check their smartphone more frequently, as a sign of problematic use.

**Duration**

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 (which they defined as self-esteem, life satisfaction, and happiness) among adolescents in 2012. That was the year, as the authors noted and as stated above, that the majority of Americans owned a smartphone. Although their study examined changes in the economy at the time, the results pointed towards electronic communication as the only activity that increased at the same time that psychological well-being decreased. Loneliness had increased from 2010 to 2012, with a medium effect size, but one that was unusually large compared to other documented increases in loneliness. 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 the 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.

**Purpose**

Andrews et al. (2015) found that problematic smartphone use was not related to checking behaviours or duration, but suggested that it was how smartphones were used, rather than simply their heavy usage. Describing the purpose of smartphone use has been done in a few separate ways. Studies have typically divided smartphone 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. Van Deursen et al. (2015) found that both social and process use contribute positively to habitual smartphone use. 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.

**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. The author’s findings appeared to support the concept that extraverts are less lonely simply because they have larger social networks. 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, other ways of evaluating and understanding personality exist. One such method was developed by Douglas Jackson, who created the Personality Research Form (PRF; Jackson, 1989). Jackson’s evaluation of personality is based on the Variables of Personality that were originally described by Henry Murray, resulting in a test which identifies 22 scales of personality (Jackson, 1989). Several factor analyses have demonstrated that these traits load to the Big Five factor model (e.g. Harris et al., 2005), which suggests that it can be interpreted not as a competing, independent model, but that information from the PRF can 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 need for 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).

**Affiliation**

Individuals who are high in need for 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 believed 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 frequently described as introverted (Saklofske & Yackulic, 1989). These results suggest that loneliness will negatively correlate with need for affiliation.

**Harmavoidance**

Individuals with a high need for harmavoidance 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.

**Social Recognition**

Individuals who seek social recognition are often concerned with their reputation and are socially sensitive. Those who score low on need for 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 young adults. Following, it would then be expected that those higher in need for social recognition would also score higher in loneliness.

**Succorance**

Need for 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 need for 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 need for succorance and loneliness.

**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. Solano and Koester (1989) addressed the question of whether loneliness is a result of low social skills or high communication apprehension. They found evidence that each were independent predictors of loneliness, but also appeared to have an additive effect. Individuals with higher social anxiety are more likely to feel comfortable using technology for social communication (e.g. texting, social media websites; Pierce, 2009, Elhai et al., 2017), and as a result, are more likely to demonstrate compulsive and problematic smartphone use (Lee et al., 2014; Elhai et al., 2017). Despite their preference for using texting or email, individuals with high social anxiety exhibit
comparable physiological arousal from electronic communications as from face-to-face interactions (Shalom et al., 2015). The present study focuses particularly on individual’s communication apprehension; that is, fear and avoidance of real or anticipated communication with another (McCroskey & Beatty, 1984). As communication apprehension has been linked with loneliness (e.g. Zakahi & Duran, 1982), and has been negatively associated with emotional maturity, adventurousness, confidence, and self-control (McCroskey et al., 1976), it would be expected that a positive correlation between communication apprehension and loneliness would be replicable. The literature about smartphone use and communication apprehension is quite sparse. 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). 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-mobile-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., 2019), so it is important to take into account the impact of nomophobia when evaluating loneliness and its relationship to patterns of smartphone use.
COVID-19

In March 2020, the spread of the COVID-19 virus was declared a pandemic by the World Health Organization. In Ontario, Canada, this declaration prompted changes in social interactions such as social distancing, isolation, lockdowns, and mask-wearing. Loneliness is almost inevitable in such circumstances, and most studies conducted near the beginning of the pandemic identified that loneliness increased during initial lockdowns compared to before (Bu et al., 2020; Lee et al., 2020). Younger adults and females were identified as being particularly at risk (Lisitsa et al., 2020; Losada-Baltar et al., 2021). One study did not find any significant increase in loneliness in the first two months of the pandemic and noted that there was in fact an increase in perceived support (Luchetti et al., 2020). With respect to smartphone use, studies have found that overall duration of use was higher during the first COVID-19 lockdown than the month prior to any restrictions (Ohme et al., 2020; Sañudo et al., 2020). An in-depth look into smartphone use changes between February and March 2020 revealed that frequency (number of pickups) remained stable, but more time was spent on news apps, communication apps, and social media (Ohme et al., 2020).

Smartphone use has been demonstrated to be a moderator for feelings of social connection due to social distancing restrictions; greater reported smartphone use lessens the negative impact of social distancing on feelings of social connectedness (David & Roberts, 2021). The way that people use technology may be important in understanding how smartphones can relate to social connection as Lisitsa et al. (2020) found that during COVID-19, greater social media use mediated the relationship between young adults and higher loneliness scores. Most of the published studies have examined smartphone use
and loneliness within the first month of the pandemic, but little is yet known about changes in behaviour and mental health in later waves.

**Present Study**

The present study addresses six main research questions. First, 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 theory, 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 theory as well, that more time spent using smartphones socially can help to augment, or at least sustain relationships and social networks. This hypothesis is tested by asking participants to record their most frequently used applications. Data regarding weekly total smartphone screen time and amount of “pickups” is also collected in order to gain a broader sense of any differences in frequency and duration of use.

_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 is known to correlate 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. Social anxiety is known to correlate with loneliness and individuals with communication apprehension 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.

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 social support, are the strongest predictors of loneliness are examined in the present study.

Finally, given the timing of the study, we are able to examine the impact of changes due to COVID-19 on loneliness and smartphone use. Studies in the COVID-19 era suggest longer duration of smartphone use, as well as increased use of news, social media, and communication apps. Most studies have also found that loneliness increased. In addition, smartphone use has been found to mitigate the negative impacts of social distancing measures (David & Roberts, 2021).

*Hypothesis 5a:* In comparing the pre-COVID-19 sample to the during-COVID-19 sample, participants will report greater loneliness, longer duration of smartphone use, and increased use of communication, social media, and information apps.

*Hypothesis 5b:* Smartphone use in the sample during COVID-19 will be associated with lower loneliness than smartphone use duration in the pre-COVID-19 sample.

*Hypothesis 5c:* Social media app use in the sample during COVID-19 will be associated with lower loneliness than social media app use in the pre-COVID-19 sample.

**Method**

**Participants**

The first group of participants were 302 (158 women, 143 men, and 1 preferred not to disclose) undergraduate students recruited from a first-year management and organizational studies course at Western University through the SONA research credit
system between February 10 and April 15, 2020. A second group of undergraduate students was recruited through the university mass email system between April 29 and May 15, 2020. This sample included 41 (32 women and 9 men). A third group of participants was recruited between November 4, 2020 and December 9, 2020. This sample included 251 (112 women, 138 men, 1 preferred not to disclose). Initially, 912 surveys were completed in total. Entries were retained if the participant reached the end of the survey, spent more than five minutes completing the survey, and met criteria described further in the Data Preparation section. The resulting complete sample was 594 (302 women and 290 men, 2 preferred not to disclose) with a mean of age of 18.74 \( (SD_{AGE} = 1.89) \). The sample was comprised of undergraduate students, so while the age ranged from 17 to 53, the median age was 18 and not normally distributed (positively skewed and highly leptokurtic). Participants choose from options that best describe their living situation: “Alone” \( (N = 51) \), “With roommates (shared common spaces)” \( (N = 372) \), “With a spouse/long term partner” \( (N = 14) \), “With parents/relatives/caregivers” \( (N = 147) \) or “Other (please specify)” \( (N = 10) \). Participants who rated “other” generally described a combination of living with roommates and with family.

**Procedure**

Through SONA, participants accessed an online survey through Qualtrics. They were first shown a letter of introduction to read (Appendix A). Consent was given by clicking ‘continue’. Upon completion of the survey, participants were shown a debriefing letter (Appendix B). Ethics approval was granted by the Non-Medical Research Ethics Board of the University of Western Ontario (Appendix C). Prior to analysis, this study and its hypotheses were pre-registered on the Open Science Framework.
The online survey contained demographic questions about participants’ age, gender, living situation, and the measures described below.

**Measures**

*University of California Los Angeles (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 .86 to .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 = .94).

*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. These items can be further divided into six facets of neuroticism: anxiety, angry hostility, depression, self-consciousness, impulsiveness, and vulnerability. 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 .90 (Costa & McCrae, 1992), which was consistent with the present study results (α = .89 for the total scale, and .77, .70, .77, .59, .59, and .76 for the facets, anxiety, angry hostility, depression, self-consciousness, impulsiveness, and vulnerability, respectively).
**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 .88 for Affiliation, .91 for Harmavoidance, .91 for Social Recognition, and .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: .76 for Affiliation, .79 for Harmavoidance, .67 for Social Recognition, and .76 for Succorance.

**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 .97 (McCroskey et al., 1985). The present study was consistent with the previous findings for the overall score ($\alpha = .94$). For the four situational sections, reliability was estimated to be .87 (group discussions), .86 (conversation), .89 (meetings), .87 (speeches).
**Personality Assessment Inventory, Non-Support Scale (PAI Non-Support; Morey, 1991)**

The PAI Non-Support is an 8-item subscale of the PAI which seeks to evaluate the amount of family and friend support that an individual perceives. 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 = .58, suggesting that the scale had a 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.

**Smartphone Use**

Smartphone use was evaluated using three different types of information taken from built-in applications (“apps”) on Apple iPhone devices and Huawei Android devices. These two types of device 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 weekly 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 the 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. The literature does not have consensus about how many categories are needed, with a range from two categories (process and social, as described in Elhai et al., 2017), to twenty-nine (Zhao et al., 2016). With average smartphone use being 6-7 hours per day, and there being over 150 unique applications used in this study, using two categories was too simplistic. In contrast, 29 categories may be too specific to provide applicable results and is perhaps more meaningful with a much larger sample size. In their study about smartphone use and personality, Kim et al. (2015) used five categories: E-commerce, entertainment, literacy, information, and relational. I used this study as a guideline; however, in reviewing the apps recorded from the present sample, it was clear that the categories of e-commerce and literacy were not prevalent uses. Literacy applications were coded as entertainment, and the e-commerce category was expanded to include other apps related to productivity (e.g. timers, fitness apps, maps). I divided the relational category into social media and communication to see whether these two types of uses affected loneliness differently. This resulted in five categories (social media, communication, entertainment, productivity, information), for which I created a coding system.
The descriptions for the categories were sent to an independent rater (see Appendix D for descriptions). The other rater and I separately coded the five apps for thirty-six participants (approximately 10% of the total), with a high level of consensus (Cohen’s Kappa = .99). 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.

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

Nomophobia (from the phrase no-mobile-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 (α = .95), which was the case in the present study (α = .92).

Data Preparation

Data were eliminated on a listwise basis for a number of conditions. Two attention checks were included in the survey (e.g. “Check three boxes”); cases where these were not answered correctly were excluded (N = 73). An additional check was that
participants entered their age at the beginning and at the end of the survey. One participant had entered ‘1’ for one entry and ‘19’ for another, so this was presumed to be an error and their age was entered as 19. Another participant entered their age as ‘10’ for one, and did not fill out the second age question, so it was also presumed to be an error and their age was considered ‘NA’. Other anomalies included entering what appeared to be a year for one (e.g. ‘2001’) and the age in the other. The remainder with inconsistencies were one year different, so these were presumed to be errors in typing or in calculation. For each one, I checked the responses for patterns or significant amounts of missing data, but found no other reason to eliminate the cases from the analysis.

Participants also entered both the average screen time and total screen time for a one-week period from their personal smartphone. Several steps are involved for individuals to access this information correctly. To assess for possible reporting errors, I divided the total screen time minutes by the average. According to Wilcockson et al. (2018), five days of screen time data is sufficient to represent a reliable average. Following, we kept cases that fell between five and eight days (eliminated N = 188). Examining the data for average pickups, there were some unusual outliers on both ends. We kept cases that had more than five pickups and less than 400 (eliminated N = 25). We also divided the total by the average as a precaution; retaining participants who had between two and eight days of data Wilcockson et al. (2018) found that pickups were reliable with two days of data (eliminated N = 62). After these checks, one additional participant was eliminated due to an unlikely response pattern (i.e. marking ‘true’ for almost all items).
Results

The data was analyzed using R version 4.0.2 (R Core Team, 2020). See Table 1 for descriptive statistics and inter correlations. 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 = 1.25). The other scale distributions appeared generally normal with kurtosis values less than ±2 and skew values not greater than ±1.

Loneliness and Demographic Variables

The correlation between age and loneliness scores was not significant \( (r = .06) \) and the loneliness scores between male and female participants were approaching significance, with slightly higher loneliness in females \( (t_{\text{welch}} (572.46) = 1.86, p = .063) \). A one-way ANOVA was used in order to discern the effect of living arrangements on loneliness scores. The group reporting “other” was not included due to its small size \( (n = 10) \) 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, \( F(3, 578) = 1.27, p = .28 \). Results of the ANOVA indicated that loneliness scores did not vary significantly between groups, \( F(3,578) = 1.67, p = .172 \).

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
Table 1

Descriptive Statistics and Inter Correlations Between Demographic and Scale Study Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Age</td>
<td>594</td>
<td>18.74</td>
<td>2.05</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Gendera</td>
<td>592</td>
<td></td>
<td></td>
<td>.05</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Screen time</td>
<td>593</td>
<td>369.03</td>
<td>146.68</td>
<td>-.04</td>
<td>.06</td>
<td>1.00</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Pickups</td>
<td>594</td>
<td>121.15</td>
<td>63.19</td>
<td>-.11</td>
<td>.03</td>
<td>.15*</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>5. Loneliness</td>
<td>592</td>
<td>22.71</td>
<td>12.01</td>
<td>.06</td>
<td>.08</td>
<td>.13**</td>
<td>-.14**</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. PAI Non-Support Scale</td>
<td>594</td>
<td>1.45</td>
<td>1.48</td>
<td>.10</td>
<td>-.04</td>
<td>.14*</td>
<td>-.09</td>
<td>.50**</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. PRCA-24</td>
<td>593</td>
<td>44.13</td>
<td>16.43</td>
<td>.05</td>
<td>.29**</td>
<td>.15*</td>
<td>-.03</td>
<td>.37**</td>
<td>.24**</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. PRF Affiliation</td>
<td>592</td>
<td>9.64</td>
<td>3.47</td>
<td>-.15*</td>
<td>-.07</td>
<td>-.09</td>
<td>.24**</td>
<td>-.51**</td>
<td>-.49**</td>
<td>-.42**</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. PRF Harm avoidance</td>
<td>594</td>
<td>9.10</td>
<td>3.81</td>
<td>.01</td>
<td>.14*</td>
<td>.10</td>
<td>-.08</td>
<td>.11*</td>
<td>.00</td>
<td>.28**</td>
<td>-.13</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. PRF Social Recognition</td>
<td>591</td>
<td>8.77</td>
<td>3.08</td>
<td>-.05</td>
<td>.02</td>
<td>.05</td>
<td>.06</td>
<td>.16**</td>
<td>-.01</td>
<td>.14*</td>
<td>.06</td>
<td>.14*</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. PRF Succorance</td>
<td>594</td>
<td>7.95</td>
<td>3.49</td>
<td>.01</td>
<td>.24**</td>
<td>.05</td>
<td>.00</td>
<td>-.01</td>
<td>-.13</td>
<td>.16**</td>
<td>.09</td>
<td>.27**</td>
<td>.31**</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. NEO Neuroticism</td>
<td>541</td>
<td>96.27</td>
<td>19.49</td>
<td>.00</td>
<td>.29**</td>
<td>.14*</td>
<td>.05</td>
<td>.52**</td>
<td>.30**</td>
<td>.51**</td>
<td>-.36**</td>
<td>.24**</td>
<td>.31**</td>
<td>.28**</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>13. NMP-Q</td>
<td>577</td>
<td>89.72</td>
<td>20.32</td>
<td>.01</td>
<td>.19**</td>
<td>.17**</td>
<td>.11</td>
<td>.13**</td>
<td>.07</td>
<td>.20**</td>
<td>-.03</td>
<td>.26**</td>
<td>.24**</td>
<td>.26**</td>
<td>.34**</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Note. Sample sizes varied due to missing data; 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
Table 2

*Descriptive Statistics for Smartphone Measures and Correlations with Loneliness*

<table>
<thead>
<tr>
<th>Variable</th>
<th>$M$</th>
<th>$SD$</th>
<th>Loneliness $r$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Screen Time (minutes per day)</td>
<td>369.03</td>
<td>146.68</td>
<td>.13</td>
<td>.002</td>
</tr>
<tr>
<td>Average Pickups (per day)</td>
<td>121.34</td>
<td>63.19</td>
<td>-.14</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>App Use</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Media</td>
<td>1.62</td>
<td>0.75</td>
<td>.08</td>
<td>.047</td>
</tr>
<tr>
<td>Communication</td>
<td>1.46</td>
<td>0.73</td>
<td>-.14</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Entertainment</td>
<td>1.20</td>
<td>0.85</td>
<td>.02</td>
<td>.688</td>
</tr>
<tr>
<td>Information</td>
<td>0.41</td>
<td>0.60</td>
<td>.02</td>
<td>.617</td>
</tr>
<tr>
<td>Productivity</td>
<td>0.38</td>
<td>0.49</td>
<td>.00</td>
<td>.923</td>
</tr>
<tr>
<td>Importance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texting</td>
<td>2.13</td>
<td>1.81</td>
<td>.07</td>
<td>.107</td>
</tr>
<tr>
<td>Emailing</td>
<td>4.94</td>
<td>2.84</td>
<td>-.03</td>
<td>.416</td>
</tr>
<tr>
<td>Browsing social media (e.g. Instagram, Twitter, Facebook, forums)</td>
<td>3.17</td>
<td>2.24</td>
<td>-.04</td>
<td>.306</td>
</tr>
<tr>
<td>Posting onto social media</td>
<td>7.09</td>
<td>3.30</td>
<td>-.06</td>
<td>.151</td>
</tr>
<tr>
<td>Information (weather, maps, news, recipes)</td>
<td>6.42</td>
<td>2.35</td>
<td>.05</td>
<td>.247</td>
</tr>
<tr>
<td>Taking photos/video</td>
<td>6.65</td>
<td>2.56</td>
<td>.04</td>
<td>.355</td>
</tr>
<tr>
<td>Video/audio entertainment (e.g. YouTube, Netflix, podcasts)</td>
<td>5.77</td>
<td>3.09</td>
<td>-.01</td>
<td>.834</td>
</tr>
</tbody>
</table>

*Note.* Means for the Importance variables are the mean ranking (1-14).

$N = 594$

$p$ values based on two-tailed t-tests
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 ($r = .13$). Average pickups data was negatively related to loneliness scores, indicating that the more someone unlocks their smartphone, the less lonely they tend to be ($r = -.14$).

Social media and communication apps dominated participants’ top apps, with $93.77\%$ having one or more social media apps, and $93.27\%$ 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 ($r = .08$, $p = .047$), indicating a positive relationship between smartphone use for social media purposes and loneliness scores. The correlations also showed a small, significant negative correlation between communication apps and loneliness scores ($r = -.14$, $p = <.001$), suggesting an association between lower loneliness scores and more 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 ($51.52\%$), followed by browsing social media ($21.38\%$) and emailing ($4.88\%$). Texting and posting onto social media had the largest correlations with loneliness scores, but neither were approaching statistical
significance \((p > .10)\). In general, the relationship between how lonely one feels and how important different uses are is minimal.

**Loneliness and Personality**

Loneliness scores were moderately correlated with the NEO neuroticism scale \([\text{Costa \\ McCrae, 1992}, r = .52, p < .001]\). Examining facets of personality, a small correlation emerged with social recognition \((r = .16, p < .001)\) and harm avoidance \((r = .11, p < .05)\) and a negative moderate correlation with affiliation \((r = -.51, p < .001)\). The correlations between loneliness scores and succorance were near zero and did not reach statistical significance. The PAI Non-Support scale (Morey, 1991) was moderately and positively correlated with loneliness ratings \((r = .50, p < .001)\).

There was a moderate positive correlation between the total PRCA-24 (McCroskey, 1982) score and loneliness ratings \((r = .42, p < .001)\). A small, significant correlation was between screen time (duration) and PRCA-24 total score \((r = .15, p < \text{.001})\); however, the correlation between pickups (frequency) and the PRCA-24 total was not significant \((r = -.02, p = .565)\).

**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, communication anxiety, and nomophobia measures. Demographic variables were included due to differences in living arrangements, age, and sex. Taking sample size and the number of predictors into account, the adjusted R-squared was 0.45. The overall model was significant \((F(21, 493) = 20.72, p < .001),\)
indicating that loneliness scores can be predicted significantly better than chance when these variables are included.

**Table 3**

*Regression Coefficients of Study Variables on Loneliness*

<table>
<thead>
<tr>
<th>Variable</th>
<th>$b$</th>
<th>$SE$</th>
<th>95% CI</th>
<th>$sr$</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>9.95</td>
<td>9.54</td>
<td>[-8.80, 28.70]</td>
<td>.00</td>
</tr>
<tr>
<td>Age</td>
<td>-0.03</td>
<td>0.20</td>
<td>[-0.42, 0.36]</td>
<td>.00</td>
</tr>
<tr>
<td>Gender$^a$</td>
<td>0.11</td>
<td>0.90</td>
<td>[-1.65, 1.87]</td>
<td>.00</td>
</tr>
<tr>
<td>Living alone</td>
<td>-1.99</td>
<td>1.55</td>
<td>[-5.04, 1.06]</td>
<td>-.04</td>
</tr>
<tr>
<td>Living with parents</td>
<td>0.52</td>
<td>0.98</td>
<td>[1.40, 2.45]</td>
<td>.01</td>
</tr>
<tr>
<td>Living with spouse</td>
<td>0.58</td>
<td>2.64</td>
<td>[-4.61, 5.77]</td>
<td>.02</td>
</tr>
<tr>
<td>Living (Other)</td>
<td>4.12</td>
<td>3.30</td>
<td>[-2.37, 10.62]</td>
<td>.00</td>
</tr>
<tr>
<td>Average screen time</td>
<td>0.00</td>
<td>0.00</td>
<td>[0.00 – 0.01]</td>
<td>.02</td>
</tr>
<tr>
<td>Average pickups</td>
<td>-0.02*</td>
<td>0.01</td>
<td>[-0.03, 0.00]</td>
<td>-.08</td>
</tr>
<tr>
<td>Social media app use</td>
<td>-0.38</td>
<td>1.59</td>
<td>[-3.50, 2.74]</td>
<td>-.01</td>
</tr>
<tr>
<td>Communication app use</td>
<td>-0.76</td>
<td>1.62</td>
<td>[-3.94, 2.42]</td>
<td>.00</td>
</tr>
<tr>
<td>Entertainment app use</td>
<td>-1.19</td>
<td>1.59</td>
<td>[-4.32, 1.94]</td>
<td>-.02</td>
</tr>
<tr>
<td>Information app use</td>
<td>-1.51</td>
<td>1.66</td>
<td>[-4.77, 1.75]</td>
<td>-.03</td>
</tr>
<tr>
<td>Productivity app use</td>
<td>-1.15</td>
<td>1.74</td>
<td>[-4.57, 2.26]</td>
<td>-.02</td>
</tr>
<tr>
<td>NEO Neuroticism</td>
<td>0.21**</td>
<td>0.03</td>
<td>[0.16, 0.27]</td>
<td>.25</td>
</tr>
<tr>
<td>PRF Affiliation</td>
<td>-0.73**</td>
<td>0.15</td>
<td>[-1.04, -0.43]</td>
<td>-.16</td>
</tr>
<tr>
<td>PRF Harm Avoidance</td>
<td>0.05</td>
<td>0.12</td>
<td>[-0.18, 0.28]</td>
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<tr>
<td>PRF Social Recognition</td>
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<td>.10</td>
</tr>
<tr>
<td>PRF Succorance</td>
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<td>[-0.53, -0.01]</td>
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</table>

*Notes: $^a$Male = 0, female = 1; $b$ = Unstandardized regression coefficient; SE = Standard error; 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*
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 \( (r = .12, p = .014) \) and communication \( (r = .26, p < .001) \). Negative relationships were found between pickups and entertainment \( (r = -.19, p < .001) \), information \( (r = -.10, p = .028) \), and productivity \( (r = -.09, p = .028) \). Holm-Bonferroni corrections were applied to correct for multiple exploratory correlations. The number of pickups is related to the use of particular 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.
Loneliness, Smartphone Use, and COVID-19

As stated in the Method section, the data was collected in three samples in order to obtain a larger sample, as well as to examine differences before and during the COVID-19 pandemic. The majority of the first sample (75%) was collected prior to March 13, 2020 when the World Health Organization declared the pandemic and the university announced that the semester would be finished online. The second sample ($N = 41$) was collected after the exam period (April 29 to May 15, 2020) when students had likely left campus and social distancing and quarantine orders were in place. The third sample was collected from November 5 to December 9, 2020. The following analyses compare the sample that was collected from February 19 to March 13, 2020 (Wave 1, $N = 226$) to that which was collected from November 5 to December 9, 2020 (Wave 2, $N = 251$). This allows two distinct groups of one prior to COVID-19 restrictions, and one during COVID-19.

Independent group $t$-tests were conducted to compare the two samples on UCLA Loneliness scale scores and smartphone use, including duration, frequency, information app use, social media app use, communication app use. Smartphone use duration (average screen time) increased significantly from Wave 1 ($M = 358.01, SD = 143.14$) to Wave 2 ($M = 385.78, SD = 144.67, t(474) = -2.10, p = .036, d = -.19$). Use of information apps was evaluated by the Mann-Whitney U test due to non-normality and unequal variances; information app use decreased significantly from Wave 1 ($M = 0.58, SD = 0.64$) to Wave 2 ($M = 0.19, SD = .51; p < .001, r = .36$). Ratings of loneliness and reports of smartphone use frequency, social media app use, and communication app use were not statistically different from Wave 1 to Wave 2. To examine whether there are changes in
the relationship of loneliness and smartphone use between the two samples, the
correlations of loneliness and smartphone duration were compared. Correlation
coefficients for Wave 1 ($r = .14$) and Wave 2 ($r = .11$) were transformed to $z$ scores using
Fisher’s $r$ to $z$ transformation and compared with the following equation (from Warner,
2012):

$$z_1 - z_2 \over \sqrt{1 \over N_1 - 3} + 1 \over \sqrt{1 \over N_2 - 3}$$

The correlations were not statistically different ($z = .33, p = .363$). The same method was
used to compare correlations between loneliness and social media use from Wave 1 ($r =
.12$) and Wave 2 ($r = -.04$), with a significant difference between the two groups ($z =
1.74, p = .041$), suggesting that social media was more highly correlated with loneliness
in the pre-COVID-19 sample than in the sample during COVID-19.

**Discussion**

Loneliness is considered to be a universal human experience 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 variety of metrics that denote duration, frequency, and purpose.
The results indicated that lonely individuals 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,
particularly for access to social media (evidence in support of the displacement
hypothesis, increased use of smartphones replaces satisfying relationships). While unexpected *a priori*, this finding is consistent with a study by Kara et al. (2019) 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 one’s 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. The evidence from this study extends previous literature that there are patterns in loneliness and overall smartphone use.
Smartphone App Use

We 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 because of the correlations, which are in the opposite direction, with loneliness. 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). The positive association between social media use and loneliness contributes to the growing social media literature that its use may have detrimental effects. Hunt et al. (2018) found psychological benefits for participants who limited their time using a social media platform. 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. Those who interact and browse were found to be less lonely than those who spend more time posting.

When examining pre-COVID-19 data comparing to during COVID-19 in the current study, the association of social media with loneliness was significantly lower during the pandemic, consistent with the findings reported by Lisitsa et al. (2020). This result suggests that when in-person interactions are limited, use of social media apps is not related to overall reports of loneliness. There are a number of possible reasons for this. In keeping with the displacement hypothesis, if social media app use is not displacing in-person socializing, it becomes less related to feelings of loneliness. This may also be due to individuals who are not chronically lonely spending more time on social media apps during COVID-19, and thereby reducing the correlation. Another possibility may be a shift in how social media is used. Vasileiou (2019) identified coping mechanisms for loneliness were often distraction and seeking support; it is possible that social media has been used more as a tool for seeking support in the pandemic than a tool for distraction. Further studies may examine individual use patterns, or if there has been a shift in the content of social media platforms.

**Loneliness and Personality**

Personality continues to show a substantial role in understanding loneliness. 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. Hypothesis 2, that self-report loneliness would positively correlate with neuroticism, harmavoidance, social recognition, and
sucorance, 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. Jackson et al. (2002) found that self-presentation (i.e. motivation to gain social approval, similar to social recognition) significantly correlated with loneliness, and acted as a mediator in the relationship between shyness and loneliness.

Levels of risk-taking (need for harmavoidance) and care-seeking (need for succorance) had much smaller relationships with loneliness. It was expected that loneliness would be positively and significantly related to avoiding risks (harmavoidance), but the magnitude of the correlation was small, and in regression, was not significant. 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 correlated to loneliness in the present study, but were a significant predictor. 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 less so 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 consistently related to physical risk-taking and relational dependence.

**Loneliness and Communication Apprehension**

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 (2019); 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.

**Loneliness and Emotional Support**

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 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.
Loneliness, Smartphone Use, and COVID-19

The current study was uniquely placed to be able to compare loneliness and smartphone use before the COVID-19 pandemic, and eight months after the pandemic was declared. With Hypothesis 5a, we expected that participants would report greater loneliness, longer duration of smartphone use, and increased use of information, communication, and social media apps in Wave 2, during the pandemic. This was only partially supported, by a significant increase in smartphone duration, consistent with findings from research at the outset of pandemic lockdowns (Ohme et al., 2020; Sañudo et al., 2020). Smartphone use overall increased by almost half an hour a day (to an overall average of about six hours and 40 minutes). In contrast to expectation, information app use (which includes news apps) decreased from Wave 1 to Wave 2. News and information apps may have been more important earlier in the pandemic (Ohme et al., 2020), but as the current study occurred 8 months later, smartphone use may have been focussed elsewhere.

Results did not show increased number of social media or communication app use, but since these two types of apps are already very popular, it is possible that there may be increased duration of use in these apps. Future studies that wish to focus on types of use would benefit from measuring time spent in each app. There was no significant difference between average loneliness in February – March 2020 and average loneliness in November – December 2020. While this not consistent with most prior studies on loneliness pre- and post- pandemic declaration, the prior studies were all conducted within the first few months of the pandemic; at the same time as some of the strictest lockdown measures. In November – December 2020 in London, Ontario, it was not
considered a lockdown, with gathering restrictions at 10 people indoors and 25 people outdoors. While in-person university classes were rare and travel was restricted, there were opportunities to be with other people face-to-face. The measure of loneliness used in the present study is generally considered to measure loneliness as a trait, so while feelings of loneliness may have fluctuated during stricter lockdown measures, it appears likely that when measures are more relaxed, reports of loneliness are at a typical level. The two other studies that found significant increases in loneliness had used shorter, three item measures of the UCLA Loneliness Scale (Bu et al., 2020; Lee et al., 2020), which may capture more of a state feeling of isolation (the three items ask about lack of companionship, feeling isolated from others, and feeling left out), as found in a factor analysis of the UCLA Loneliness Scale (Lee & Cagle, 2017). The research by Luchetti et al. (2020), who found no significant change in loneliness, used a longer 11-item measure, which includes item items related to social connections and sense of belonging (Lee & Cagle, 2017). Thus, while the COVID-19 lockdown restrictions are resulting in feelings of isolation, other aspects of loneliness such as social connections and a sense of belonging may be less affected.

Hypotheses 5b and 5c relate to the idea put forth by David and Roberts (2021) that in the time of social distancing and isolation, smartphone technology becomes a primary means of connection with others, and therefore would be less related to loneliness and may even support feelings of positive social support. This prediction was not supported with general smartphone use; the relationship between duration of smartphone use and loneliness was not statistically different from Wave 1 to Wave 2. Hypothesis 5c was supported, as discussed earlier, that an increased use of social media
apps was significantly less associated with loneliness in Wave 2. Prior to the COVID-19 pandemic, use of social media apps was significantly associated with loneliness; however, during COVID-19, the relationship became non-significant and near zero.

**Limitations and Future Directions**

Several limitations should be taken into account with the present study. The original design is cross-sectional and largely correlational, such that causation cannot be inferred. The sample has a very narrow age range, and is composed of university students, the majority of who are from a specific program. Thus, the results should be interpreted cautiously when relating to other age, socio-economic, or cultural groups. Future studies should consider other age groups, taking into account the development of personality, as well as changes in smartphone habits and loneliness over time and across ages. For example, over a period of 1-2 years, Kraut et al. (1998) studied families who were experiencing the Internet in their home for the first time. They found that increased Internet use was associated with declines in social involvement and increases in loneliness and depression. In a follow-up study, Kraut et al. (2002) discovered that most of the negative effects had dissipated. Over time, it is certainly likely that the impact of smartphone technology will change as it becomes a regular method of communication.

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. 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.

**Conclusions**

Lonelier people 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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DOI 10.1007/s11165-016-9602-2

https://doi.org/10.1037/emo0000403
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https://doi.org/10.1016/j.chb.2014.12.039

https://doi.org/10.1016/j.mhp.2018.11.002


Appendix A: Letter of Information and Consent For Online Study

Project Title: Associations between loneliness, personality, and smartphone use in university students

Document Title: Letter of Information and Consent

Principal Investigator: Dr. Julie Schermer, PhD, Department of Psychology

MSc Thesis Student: Kristi MacDonald

General information: You are being asked to participate in a study that examines the relationship between loneliness, personality, and smartphone use.

Invitation to Participate: You are being invited to participate because you are an undergraduate or graduate student at the University of Western Ontario. There are no known risks associated with participation in this study.

Why is this study being done? The purpose of this study is to understand individual differences in emotional well-being, as well as to examine the links between social functioning and use of technology.

Inclusion and Exclusion Criteria: This study requires that participants be regular users of an iPhone or a Huawei smartphone. We are investigating smartphone use and request that participants refer to and report information available in Screen Time on iPhone devices which are running iOS 12 and up. Screen Time is found under “Settings”, and must have been turned on for the past seven days. Users of Huawei phones running Android 9.0 and up may also be eligible. Participants will be asked to refer to and report information available in Digital Balance which is found under “Settings”.

Step-by-step instructions for accessing the information will be provided at the appropriate time in the study.

How long will you be in this study? We anticipate this will take no longer than 30 minutes to complete.

What are the study procedures? If you consent to participate, you will be asked to complete questions in an online questionnaire through Qualtrics®. Specifically: demographic information (how old you are, your gender, your living situation); ratings of your personality and socio-emotional functioning; questions about your smartphone use. Smartphone use questions ask you to refer to and report data from Screen Time (iPhone) or Digital Balance (Android) apps. Your responses to the survey questions will be stored electronically (without identifying information) by the principal investigator.

What are the risks and harms of participating in this study? There are no known or anticipated physical, psychological or social risks associated with this study. You may choose not to answer any questions you deem objectionable.
Should you feel any sort of distress as a result of participating in this research, it is strongly recommended that you consult Western’s Mental Health and Wellness Resource Guide for students: http://studentexperience.uwo.ca/student_experience/wellness_initiatives/mental_health_resource_guide.html

**What are the benefits of participating in this study?** You may not directly benefit from participating in this study, but information gathered may provide benefits to society as a whole which includes providing better understanding loneliness among students and its association with personal technology. This can have the capability to inform development of mental health intervention, planning, and policy.

**Can participants choose to leave the study?** Participating in this study is entirely voluntary and you can choose to discontinue the study while completing the online survey by closing your Internet web browser. Because identifying information will not be collected in the study you may not withdraw your data after completion because it will not be possible to determine which response came from which person.

**How will participants’ information be kept confidential?** All data collected through this study will remain confidential and accessible only to the researchers. Results will only be reported in aggregate form in any published study.

Your survey responses will be collected through a secure online survey platform called Qualtrics. Qualtrics uses encryption technology and restricted access authorizations to protect all data collected. In addition, Western’s Qualtrics server is in Ireland, where privacy standards are maintained under the European Union safe harbour framework. The data will then be exported from Qualtrics and securely stored on Western University's server.

Representatives of The University of Western Ontario Non-Medical Human Research Ethics Board may require access to your study-related records to monitor the conduct of the research. All survey responses will be stored on a password-protected computer.

You do not waive any legal right by consenting to this study.

**Cost and Compensation:** There is no cost to participate in this study. No compensation will be given for participation in this study.

**Whom do participants contact for questions?** If you have questions about this research study, please contact Kristi MacDonald or Dr. Julie Schermer via email. You may also call Dr. Schermer.

If you have any questions about your rights as a research participant or the conduct of this study, you may contact The Office of Human Research Ethics.
Consent:

- Please click ‘continue’ if you consent to proceed with the study.

This letter is for you.
Please print this letter for future reference.
Appendix B: Debriefing Information

“Associations between loneliness, personality, and smartphone use in university students”

Thank you for participating!

The survey contained a number of self-report scales that measured loneliness (University of California, Los Angeles [UCLA] Loneliness Scale; Russell, 1996), social support (Personality Assessment Inventory [PAI]; Morey, 1991), communication anxiety (Personal Report of Communication Apprehension scale (PRCA-24; McCroskey, 1984), and personality related to emotional stability (Revised NEO Personality Inventory [NEO PI-R]; Costa & McCrae, 1992; Personality Research Form [PRF]; Jackson, 1989). The final part of the survey collected different measures of smartphone use. We are primarily interested in the relationship between loneliness and smartphone use, with possible moderating effects of personality and anxiety.

Research suggests that overall internet use is greater for lonely individuals, and that increased use of technology, including smartphones, may replace time that is spent in face-to-face social interaction (e.g. Nowland, Necka, & Cacioppo). The literature has also shown that smartphone use that is social can actually augment social relationships. In brief, we expect that our participants who are lonelier will generally spend more time on their smartphone, and also make more use of non-social purposes such as entertainment or information. We are hoping to learn more about the communication anxiety and personality facets of smartphone users and lonely individuals.

This project is being undertaken as an evaluative component of MSc thesis and the data collected may be part of a publication or public presentations. All materials collected are used for research purposes only and will be held by Ms. MacDonald and Dr. Schermer and subsequently destroyed.

If you have any questions or concerns about your participation in this study, or if you’re simply interested in its outcome, please feel free to contact Kristi MacDonald or Julie
Aitken Schermer. We expect to have our overall results by December 30th, 2020. Individual results will not be calculated or released, just the grouped data. If you have questions about your rights as a research participant, you should contact the Director of the Office of Research Ethics.
Appendix C: Non-Medical Research Ethics Board Approval

Date: 22 January 2020
To: Prof. Julie Schermer
Project ID: 115063

Study Title: Associations between loneliness, personality, and smartphone use in university students
Short Title: Loneliness, personality, and smartphone use
Application Type: NMREB Initial Application
Review Type: Delegated
Full Board Reporting Date: 07/Feb/2020
Date Approval Issued: 22/Jan/2020 10:54
REB Approval Expiry Date: 22/Jan/2021

Dear Prof. Julie Schermer

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed and approved the WREM application form for the above mentioned study, as of the date noted above. NMREB approval for this study remains valid until the expiry date noted above, conditional to timely submission and acceptance of NMREB Continuing Ethics Review.

This research study is to be conducted by the investigator noted above. All other required institutional approvals must also be obtained prior to the conduct of the study.

Documents Approved:

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No deviations from, or changes to the protocol should be initiated without prior written approval from the NMREB, except when necessary to eliminate immediate hazard(s) to study participants or when the change(s) involves only administrative or logistical aspects of the trial.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB. The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

Please do not hesitate to contact us if you have any questions.

Sincerely,

Katelyn Harris, Research Ethics Officer on behalf of Dr. Randal Graham, NMREB Chair

Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations).
### Appendix D: Coding Descriptions for Smartphone Apps

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<td>1</td>
<td>Social Media</td>
<td>Capable of public posting by user  &lt;br&gt; Usually creates an online community &lt;br&gt; Includes forums (public online discussion), dating apps, professional networking &lt;br&gt; Often a public profile &lt;br&gt; Information sharing &lt;br&gt; May include individual communication, but this is not its sole or main function &lt;br&gt; If there is a separate app for communication, that app is coded under communication (e.g. Messenger is communication, Facebook is Social Media)</td>
</tr>
<tr>
<td>2</td>
<td>Communication</td>
<td>Mostly used for private communication &lt;br&gt; Not primarily for public posting &lt;br&gt; Includes texting, emailing</td>
</tr>
<tr>
<td>3</td>
<td>Entertainment</td>
<td>Media players (video, audio incl music, podcasts, photos) &lt;br&gt; Media editing (photo editors) &lt;br&gt; Games &lt;br&gt; Books &lt;br&gt; Sports (watching e.g. Sportsnet)</td>
</tr>
<tr>
<td>4</td>
<td>Productivity</td>
<td>Tools to assist tasks &lt;br&gt; Commerce (shopping, mobile ordering) &lt;br&gt; Finance &lt;br&gt; Health &lt;br&gt; Transportation/maps &lt;br&gt; Academic &lt;br&gt; Timer, calculator</td>
</tr>
<tr>
<td>5</td>
<td>Information</td>
<td>Accessing news or information &lt;br&gt; News &lt;br&gt; Sports news &lt;br&gt; Browsers &lt;br&gt; May include public discussion (i.e. comments), but is not primary purpose &lt;br&gt; Dictionaries</td>
</tr>
</tbody>
</table>
**VITA**

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