APPLIED PSYCHOLOGY | RESEARCH ARTICLE

The effect of smartphones on anxiety: An attachment issue or fear of missing out?

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Abstract: The overuse of smartphones has been linked to anxiety in university students, with two proposed explanations—attachment and fear of missing out (FoMO). The present study examined the contributions of phone separation (i.e., attachment) and phone ringing (i.e., FoMO), on anxiety levels. One hundred and twenty-eight university students were randomly assigned to two experimental conditions—attachment (separated or not separated from their phone) and FoMO (received or did not receive a phone call they were unable to answer). To induce anxiety, participants wrote a paragraph about a personal flaw and were told they would be interviewed about this paragraph; however, the interview did not occur. Participants’ state anxiety levels were measured at the end of the experiment. Results revealed a significant interaction between attachment and FoMO on anxiety levels. Specifically, among those who did not have access to their phones, those who heard an incoming call had significantly higher mean anxiety levels than did those who did not receive a call. Ultimately, results suggest that both FoMO and attachment play a role in creating anxiety among smartphone users. These results provide an important contribution to the literature on smartphone use with this

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PUBLIC INTEREST STATEMENT

Smartphones are increasingly popular, particularly among university students. Research has shown that the overuse of smartphones is linked to anxiety in university students, with two proposed explanations—attachment and fear of missing out (FoMO). This study examined the independent contributions of phone separation (i.e., attachment to the phone), and phone ringing (i.e., FoMO), on anxiety levels. Participants were separated from their smartphones to determine whether separation from the attachment object increased anxiety, and received an incoming call they could not answer to determine whether the inability to answer the incoming call led to FoMO, thus increasing anxiety. It was found that both FoMO and attachment played a role in creating anxiety independently, and, notably, their combined interaction created the most anxiety in university students. These findings suggest implementing smartphone applications and therapeutic interventions to bring awareness to students’ problematic smartphone checking behaviors, potentially reducing this anxiety.

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study being the first to simultaneously manipulate both attachment and FoMO in smartphone users.

**Subjects:** Information & Communication Technology; ICT; Attachment; Anxiety & Mood Disorders

**Keywords:** smartphone use; mobile devices; anxiety; attachment; fear of missing out

1. Introduction and review of literature

In the last decade, smartphones have taken over the mobile phone market. Of the 7.9 billion mobile phone subscriptions currently active worldwide, 5.5 billion are smartphone subscriptions (Ericsson, 2014). As of 2019, 81% of the Americans owned a smartphone, a 13% increase since 2015. These numbers are higher among young people; 96% of those aged 18–29 own a smartphone (Pew Research Center, 2019). Moreover, those who own smartphones use them often. University students spend an average of 4.7 hours a day using this device and check it at least 28 times a day (Atas & Celik, 2019; Informate Mobile Intelligence, 2015). The prevalence of smartphone use, particularly among university students, points to the need for investigating the factors associated with smartphone use. This is especially necessary because the frequency of smartphone use has been linked to negative mental health outcomes in university students, such as depression (Demirci et al., 2015; Elhai et al., 2018; Panova & Lleras, 2016), smartphone addiction (Dalbudak et al., 2013; Darcin et al., 2016; García-Oliva & Piqueras, 2016; King et al., 2013), and anxiety (Cheever et al., 2014; Clayton et al., 2015; Demirci et al., 2015; Elhai et al., 2017; Panova & Lleras, 2016).

There is some debate in the literature as to the direction of the relation between increased smartphone use and negative mental health outcomes—that is, it is unclear whether individuals with mental illness use their smartphones more to cope with or to distract from their symptoms, or if overuse of smartphones leads to an increase in these symptoms. Some researchers argue that smartphone overuse leads to these symptoms, and especially anxiety symptoms (Cheever et al., 2014; Clayton et al., 2015). Examining this possibility and the mechanisms through which this anxiety occurs are the focus of the current paper.

Two theories exist for the association of anxiety with smartphone overuse in university students. One explanation, based on attachment theory, posits that people form an attachment to their smartphones. Attachment theory proposes that infants form an enduring emotional bond with their caregiver and try to maintain proximity to their caregiver. When they are separated from or not within close proximity of their caregiver, they experience distress (Giddens & Bowlby, 1970). Theory and research suggest that individuals may develop similar attachments to their possessions as well (Weller et al., 2013). Possessions have been demonstrated to serve as easy attachment targets, as they contain controllable and predictable qualities (Keefer et al., 2014; Winnicott, 1971). Further, possessions are often of emotional value to their owner. Research has shown, for example, that university students tend to ensure they are close to their smartphones and feel distressed when they are separated from them (Cheever et al., 2014; Fullwood et al., 2017; Konok et al., 2016; Trub & Barbot, 2016). Both responses are characteristics of attachment theory—motivation to be with the attachment figure/object and anxiety when it is absent.

It also is possible, however, that the attachment to the phone is not akin to the attachment as theorists define it with respect to humans. Perhaps people feel a desire to stay near their smartphone, not because it is an emotionally valued possession, because they view it as a way to facilitate communication to sustain interpersonal connections. In addressing this, Konok et al. (2016) found significant differences between the two main components of their Attachment to Phone Questionnaire: the need to be near the phone (Proximity Seeking) and the need to be in contact with others via the phone (Need for Contact). This suggests a difference between attachment to the phone as an object and attachment to the phone for communication and relationships. Participants in the study endorsed higher mean levels of Proximity Seeking compared to Need for Contact. In an
additional study, when university students were prompted to turn their smartphones off but to keep them within reach, their mean levels of anxiety were significantly lower than their mean levels of anxiety for those separated from their phone entirely (Cheever et al., 2014). These results suggest that university students may be attached to their phones as objects, not as communication devices.

A second explanation for the association of anxiety with smartphone overuse is the fear of missing out (FoMO). FoMO is related to the concept of Need for Contact described above but elaborates on the emotions surrounding that need. FoMO is defined as having two central components: the discomfort associated with the awareness of others engaging in activities in which the individual is not involved, and the desire to stay in touch with one's social circle (Baker et al., 2016; Elhai et al., 2020). The first component involves the cognitions and emotions that individuals experience, such as worrying thoughts. The second component involves the behavior individuals engage in to relieve these cognitions, such as frequent smartphone checking on social networking sites (Elhai et al., 2020). This theory suggests that smartphone check-ins enable individuals to re-engage with their circles in some form. These check-ins alleviate individuals’ worries that they are missing out on a rewarding experience—that is, smartphone checking behavior is reinforced by worry and anxiety reduction.

According to Mower’s two-factor theory of avoidance learning based on operant and classical conditioning, a maladaptive behavior, such as overly frequent smartphone checking, is an operant that is controlled by its consequences (Persons, 2008). An operant serves a function, such as escaping aversive emotional states, like anxiety associated with FoMO. When a behavior results in the removal of a negative emotional state, such as anxiety, this is known as negative reinforcement. Smartphone check-ins are the operant serving the function of anxiety reduction associated with FoMO.

Research supports the theory of FoMO as a driver of smartphone use. For example, those who experience higher levels of FoMO tend to check their smartphones more often than those lower in FoMO (Elhai et al., 2016; Przybylski et al., 2013; Rosen et al., 2013)—that is, the smartphone facilitates communication through text messaging, calling, social media, and other applications that allow those to be relieved of their FoMO. Clayton et al. (2015) found that when university students could not answer their ringing iPhone, their anxiety levels tended to increase, potentially due to FoMO because they knew someone was trying to reach them but were unable to answer. Answering the ringing phone would have served the function of alleviating the FoMO-related anxiety and thus would have negatively reinforced the phone answering. Because university students frequently use their smartphones, the removal of this behavior resulted in increased anxiety which they could not alleviate.

2. The current study
The goal of the present study was to expand the existing research on smartphone use and its impacts by comparing the competing theories of attachment to an object and FoMO. Prior studies have found that university students separated from their smartphones experienced increased anxiety, on average, compared to those not separated, potentially due to attachment-related distress conceptualized through attachment theory. Other studies, however, have found that participants who could hear their phone ringing but could not answer experienced higher mean anxiety compared to those unable to hear the ring, potentially due to their inability to engage in the checking behavior that is usually reinforced by their alleviated anxiety due to the experience of FoMO. Although some studies have considered the smartphone as an attachment object and other studies as a FoMO inducer, to our knowledge, these two views have never been studied together in a single experiment to determine to what degree each contributes to anxiety. In addition, no existing study has explored the combined impact of smartphone separation and FoMO on anxiety levels, specifically during a stressful situation. Considering past research, we had two hypotheses:
H1: After the waiting period, participants separated from their phones will have higher anxiety, on average, than those not separated.

Given that university students are consistently with their smartphones (Atas & Celik, 2019), and based on prior studies conducted to assess attachment to smartphones, it is likely that university students have formed an attachment to their smartphones. University students who were not in close proximity to their smartphones tended to experience heightened anxiety compared to those not separated (Cheever et al., 2014; Konok et al., 2016). Therefore, we predicted that participants who are separated from their phones would experience higher mean levels of anxiety than those able to keep their phones, regardless of whether they received a call they cannot answer, because of attachment theory (Giddens & Bowlby, 1970). Participants in the current study were asked to wait without their smartphones and may be more likely to experience greater anxiety when they do not have their attachment object with them.

H2: Participants who receive a phone call and either see or hear their phone ringing, but cannot answer, will have higher mean levels of anxiety than those who do not.

In addition to smartphones potentially serving the function of an attachment object, smartphones also allow individuals to both engage with their social circles and alleviate feelings of FoMO that lead to distress, such as anxiety (Elhai et al., 2020). When individuals are unable to check-in with others on their smartphones, they may be unable to alleviate this FoMO-related anxiety. Checking in with the smartphone is necessary for avoidance learning and short-term alleviation of negative outcomes to occur based on Mowrer’s two-factor theory (Persons, 2008). One study found that participants who heard their ringing iPhones but could not answer tended to experience an increased heart rate and reported feelings of anxiety, potentially due to components of FoMO (Clayton et al., 2015).

Therefore, we predicted that participants who were aware someone was contacting them and could not answer would be more likely to experience heightened anxiety due to FoMO, regardless of whether they had physical access to their phones. These participants would either see someone calling them or hear their phone ringing, indicating someone is calling them, but neither group was able to answer. The incoming call brought participants’ attention to their phones, which might trigger the cognitive component of FoMO in which they would experience worrying thoughts (Elhai et al., 2020). Because they were unable to respond to this incoming notification, the behavioral component of FoMO, their anxiety might increase (Persons, 2008).

3. Method

3.1. Participants

An a priori power analysis using G*Power (Faul et al., 2007) indicated that 128 participants were needed to achieve a power level of .80 based on an expected medium effect size of $f = .25$ and an alpha of .05. We recruited 143 students from the Psychology Department participant pool. Prior to data collection, we determined that we would exclude participants who did not have their phone with them (0 participants), reported that they were unaware of the incoming call either because they did not hear it or because their phone was turned off (10 participants), or reported suspicions that the incoming call was from the researcher (3 participants). Two additional participants were dropped because they did homework during the waiting period, therefore giving them a distraction, coincidentally resulting in exactly 128 participants.

Most participants were first-year students (39%) or sophomores (45%). Most identified as White (52%) and as women (73%). Refer to Table 1 for further participant demographics. Participants received class credit for their participation. Participants gave informed consent.
before the study and were debriefed after the study in accordance with the Institutional Review Board approval.

3.2. Measures

3.2.1. Spielberger state-trait anxiety inventory (STAI)
The Spielberger State-Trait Anxiety Inventory, Form Y (STAI-Y; Spielberger et al., 1970) was used to measure participant anxiety during the experiment. Only the State subscale was used, as we measured situational anxiety. The STAI-Y state is composed of 20 questions rated on a scale from 1 to 4, with higher scores indicating higher state anxiety. This measure has good internal consistency with $\alpha = .83-.94$ in the previous research (Gaudry et al., 1975) and $\alpha = .90$ in the current study.

3.2.2. Demographics form
Participants reported their gender, ethnicity, and year in school. Participants also reported their phone numbers which were necessary to complete the experiment for those in the phone call conditions. The phone numbers were not retained, and therefore were not associated with participant data.

3.3. Procedure
Participants took part in the experiment individually. Upon arrival, participants signed informed consent forms and completed the demographics questionnaire. Participants were randomly assigned to one of each of the two levels of the two independent variables, resulting in four groups—Absent Silent, Present Silent, Present Ringing, and Absent Ringing. Refer to Table 2 for a description of each of the four conditions. Randomization was conducted using randomizer.org, in which one set of numbers ranging from 1 to 4, representing each condition type, was randomly generated. Participants were assigned to a condition based on which number came next in the set.

Participants were separated from their phones in the two Absent groups to determine if being separated from the attachment object would increase mean anxiety levels. The researcher locked the phones in a lockbox within the experiment room. The lockbox remained in the room with the participants, but out of sight and reach. Participants received a phone call in the two Ringing groups to determine if the incoming call would cause participants to experience FoMO, leading to

### Table 1. Participant Demographics

| Variable          | n   | Percentage (%) |
|-------------------|-----|----------------|
| Gender            |     |                |
| Female            | 93  | 72.7           |
| Male              | 35  | 27.3           |
| Academic Standing |     |                |
| First-year        | 50  | 39.1           |
| Sophomore         | 57  | 44.5           |
| Junior            | 12  | 9.4            |
| Senior            | 9   | 7.0            |
| Ethnicity         |     |                |
| Caucasian         | 67  | 52.3           |
| African American  | 15  | 11.7           |
| Hispanic/Latino   | 17  | 13.3           |
| Asian             | 17  | 13.3           |
| Multiple or other | 12  | 9.4            |
Table 2. Description of Conditions

|                        | Phone (On participants’ desk vs. locked box)                                                                 | Waiting Period (Phone ringing vs. not ringing)                                                                 |
|------------------------|----------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| Present Ringing        | - Phone left on and placed on participant’s desk (present) to ensure that participant would receive and see the  | - Received phone call (ringing) within two minutes of the ten-minute waiting period                            |
|                        | incoming call.                                                                                                  | - Participant saw the incoming call on their phone sitting on the desk, but could not answer because of the    |
|                        | - Participant instructed not to use phone until completion of the experiment to ensure they were not communicating | instructions given                                                                                                |
|                        | with others.                                                                                                    |                                                                                                              |
| Absent Ringing         | - Phone left on and given to researcher who discreetly disabled silent mode on phone; phone locked in a box      | - Received phone call (ringing) within two minutes of the ten-minute waiting period                            |
|                        | (absent) in the experiment room.                                                                                | - Participant heard the phone call because the researcher disabled silence mode, but could not                 |
|                        | - Done to ensure participant would hear later incoming call but not have possession of their phone.              | answer because it was locked in the box.                                                                        |
| Present Silent         | - Participant asked to turn phone to airplane mode to ensure their inability to communicate with others.         | - No phone call (silent)                                                                                       |
|                        | - Phone placed on participant’s desk (present) to keep conditions similar to Present Ringing group                |                                                                                                              |
| Absent Silent          | - Participant asked to turn phone to airplane mode; phone locked in a box (absent) in the experiment room.      | - No phone call (silent)                                                                                       |
|                        | - Done to remove the attachment object from the participant and to keep conditions similar to Present Silent     |                                                                                                              |
|                        | group.                                                                                                           |                                                                                                              |

higher mean anxiety levels. To ensure participants in the Absent Ringing group would hear the incoming call, the researcher disabled silent mode on the device in one of the two ways. For iPhones, the silent mode was disabled by flipping the on/off switch located on the left side of the iPhone. For Androids, the silent mode was disabled by holding down the power button and pressing the “disable silent mode” option. This was done discreetly with the intention of the participant not noticing. Disabling silent mode was successful for all participants in this condition.

Using a paradigm developed by Panova and Lleras (2016) that has been demonstrated to induce anxiety, the researcher instructed participants to write a paragraph about a perceived personal flaw during a five-minute period. Participants were told that two psychology graduate students would read this paragraph and interview the participant in the paragraph as part of the graduate students’ training; however, no interview took place. This exercise was only meant to determine participants’ anxiety levels across groups after waiting in anticipation for ten minutes. Writing about a personal flaw, as demonstrated in prior research (see Panova & Lleras, 2016), was included to introduce a situation that would lead to anxiety in general to determine whether participants in the various conditions would have varying levels of anxiety due to the differences in smartphone presence and smartphone incoming calls.

After asking the participant to write the paragraph, the researcher set a timer for five minutes and left the room. After five minutes, the researcher retrieved the paragraph from the participant and informed the participant that the graduate students needed ten minutes to assess the
paragraph before interviewing the participant. The researcher instructed participants to wait while their paragraph was assessed.

Within two minutes of the ten-minute waiting period for the Present Ringing group, the researcher called the participant’s cell phone number. Because we instructed participants not to answer their phone during the experiment, the participant saw an incoming call but was unable to answer. This was done to determine if participants’ inability to answer their phone would increase anxiety symptoms due to FoMO. Within two minutes of the ten-minute waiting period for the Absent Ringing group, the researcher called the participant’s cell phone number. Because the researcher disabled silent mode earlier in the experiment as described above, the participant heard the incoming phone call. Because the phone was locked in a box out of sight, the participant was unable to look at the phone or answer it. This was done to see if being without the phone and the inability to answer the ringing phone would increase anxiety symptoms.

At the end of the waiting period, participants completed the State portion of the STAI-Y to measure anxiety. After completion of the measure, participants were informed that the graduate students would not be able to interview them. Participants completed post-experiment questions to determine if those who received a phone call were aware of the call and/or suspicious about the origin of the call. Those unaware of the call and/or suspicious at the time of the call were excluded from the analysis. Participants responded to the following questions: “Were you aware of your phone ringing during the experiment?” and “If so, did you think it was the experimenter calling you?” The researcher then debriefed the participants and returned their flaw paragraphs to them.

4. Results
A two-way between-groups ANOVA was conducted to examine the effects of attachment (phone presence vs. absence) and FoMO (phone ringing vs. not ringing) on anxiety. But first, we conducted preliminary analyses to determine whether the assumptions of the ANOVA were met. All analyses were conducted using IBM SPSS Statistics, Version 24. First, the data were examined to ensure there were no potential outliers. Given our removal of participants from the study described in the participants section above, the data did not include outliers, as determined by an examination of box plots. Next, a histogram of residuals was produced to assess whether the data were normally distributed; this assumption was satisfied. Finally, Levene’s test of equality of equal variances was conducted to assess for homogeneity of variance and ensure that there were no statistically significantly unequal variances in the dataset; this assumption was satisfied (p > .05). Because the assumptions of the ANOVA were satisfied, primary analyses were then conducted.

Results showed a significant main effect of FoMO on participants’ anxiety scores (F(1,124) = 12.71, p = .001, partial η2 = .09), a medium effect size. On average, participants who received a call (M = 36.75, SD = 9.25) had higher anxiety levels than those who did not receive a call (M = 31.40, SD = 7.59). Specifically, participants in the Present Ringing and Absent Ringing groups had, on average, higher anxiety scores than participants in the Present Silent and Absent Silent groups. These results provide evidence for H1.

There was also a significant main effect of attachment (F(1,124) = 28.99, p < .001, partial η2 = .19), a large effect. On average, participants who were separated from their phone (M = 37.12, SD = 9.40) had higher anxiety levels than those not separated (M = 30.03, SD = 6.14). Specifically, participants in the Absent Silent and Absent Ringing groups had, on average, higher anxiety scores than participants in the Present Silent and Present Ringing groups. These results provide evidence for H2.

There also was a significant interaction between FoMO and attachment (F(1, 124) = 5.50, p = .02, partial η2 = .04), a small effect (see Table 3 for means, standard deviations, and confidence intervals). Simple effect tests revealed significantly different anxiety scores among those separated from their phones (t(65) = -3.79, p < .001, d = .92), a large effect; specifically, among those who did not have their phones, those who received a call had higher mean anxiety levels
(M = 41.39, SD = 9.41) than those who did not receive a call (M = 33.44, SD = 7.80). Simple effect tests revealed there was no such significant difference among those who had their phones (t (59) = -1.03, p > .05, d = .28), a small effect; specifically, among those who had their phones, the mean anxiety levels among those who received a call (M = 31.00, SD = 4.82) did not significantly differ from those who did not receive a call (M = 29.36, SD = 6.90).

5. Discussion

As smartphone use in the United States continues to rise, especially among university students (Atas & Celik, 2019; Informate Mobile Intelligence, 2015), researchers and policymakers must consider the negative impacts these devices can impose. As more and more studies link anxiety to smartphone use (Cheever et al., 2014; Clayton et al., 2015; Demirci et al., 2015; Elhai et al., 2017; Panova & Lleras, 2016), researchers face a challenge to understand the mechanisms through which this anxiety occurs. The anxiety associated with smartphone use has been conceptualized as resulting from smartphone overuse which leads either to an attachment to the device (Konok et al., 2016), or to the cognitive and behavioral components of coping with FoMO (Clayton et al., 2015). Given these two possibilities, the current study manipulated smartphone attachment by separating participants from their phones and manipulated FoMO by calling participants when they were unable to answer. The results suggest that both FoMO and attachment play a role in creating anxiety among university smartphone users. Specifically, among our participants, FoMO seemed to kick in when participants did not have their phones as compared to when they did have their phones (but could not use them).

The findings of the current study support the first hypothesis that, after the ten-minute waiting period, on average, participants separated from their phones would have higher anxiety than those not separated. Participants in the Absent Silent and Absent Ringing groups had higher average anxiety levels than those in the Present Silent and Present Ringing groups. These results suggest that the heightened anxiety participants experienced when separated from their phones is due to a possible attachment to their phones, where separation increases anxiety. Participants in the latter two groups were able to keep their emotionally valued possession with them, which likely reduced their anxiety. Because of the frequency with which university students are with their smartphones, there is an associated connection with these devices, likely separate from its ability to connect individuals to one another (Fullwood et al., 2017). In the previous research, when university students were prompted to turn their smartphones off but keep them within reach, their anxiety levels were lower than those separated entirely, suggesting an attachment to the object itself, not its ability to connect to others (Cheever et al., 2014). The results of the current study provide further support for the smartphone as an attachment object, in which participants separated from their smartphones had higher anxiety than those prompted to keep the phone within reach but turned to airplane mode. Had both groups experienced similar anxiety, attachment theory may not have been the mechanism behind this anxiety.

The results of the current study also provide support for the second hypothesis that, on average, participants who received a phone call would have higher anxiety than those who did not receive a phone call. After the ten-minute waiting period, participants in the Absent Ringing and Present Ringing groups had higher average anxiety levels than those in the Present Silent and Absent Silent groups. These results provide support for Mowrer’s two-factor theory of avoidance learning in which the incoming call likely prompted the cognitive component of FoMO—worrying thoughts

|                | 95% CI          |
|----------------|-----------------|
|                | M   | SD  | Lower Bound | Upper Bound |
| Present        |     |     |              |              |
| Absent         |     |     |              |              |
| RingingNot     | 31.00 | 4.82 | 28.02        | 33.98        |
| Ringing        | 29.36 | 6.90 | 26.89        | 31.84        |
| RingingNot     | 41.39 | 9.41 | 38.72        | 44.06        |
| Ringing        | 33.44 | 7.80 | 30.96        | 35.92        |

Table 3. Means, Standard Deviations, and Confidence Intervals for Interaction

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around being out of touch with participants’ social circles. Then, the behavioral component of checking in with others was activated but unable to be carried out due to the instructions of the study. The removal of this checking behavior did not allow for the negative reinforcement to occur, which increased anxiety at that moment (Elhai et al., 2020; Persons, 2008). These results suggest that university students may continue to experience negative cognitions and resulting anxiety symptoms in situations in which FoMO is induced (such as when receiving an incoming notification) because it is negatively reinforced by smartphone checking.

More importantly, although we did not hypothesize a significant interaction between FoMO and attachment, these results suggest that the interaction between the presumed feelings of FoMO and being separated from the attachment object is what drives anxiety in university students. Specifically, when participants did not have access to their phones, they experienced higher mean anxiety levels when they heard the incoming call than when they did not receive a call. Among participants who did have access to their phones, there was no statistically significant difference in anxiety levels between those who did and did not receive an incoming call. Perhaps smartphones become problematic when university students are in the presence of the phone frequently (Atas & Celik, 2019; Informate Mobile Intelligence, 2015) and become attached to the object itself as a result.

Additionally, the smartphone exists as a means of communication and ties to social circles and the inability to connect with that circle raises anxiety, especially when that connection to the circle has been reinforced by anxiety reduction in the past (Persons, 2008). But the latter—FoMO—may be particularly heightened when individuals not only cannot respond to an incoming call and become negatively reinforced, but also do not have their phone in their presence, an additional layer of distress according to attachment theory (Giddens & Bowlby, 1970). It is important to add that anxiety may have been higher because participants in the phone Absent group could not physically retrieve the locked phone to answer the call; even though the students in the phone Present group were told not to answer them, they technically could have, which may have reduced anxiety.

This study addresses important gaps in the literature on the effects of smartphone use. First, it investigated the combination of smartphone presence for attachment theory and smartphone ringing for FoMO and the impact these have on anxiety levels. Previous studies have demonstrated that university students experience heightened anxiety when they are separated from their phones (Cheever et al., 2014) and heightened anxiety when they are unable to answer their ringing phone (Clayton et al., 2015). No existing study to our knowledge has induced both attachment anxiety and FoMO simultaneously to determine which is impacting anxiety, if it is both, or if it is a combination. The findings of the current study suggest both attachment to the phone and FoMO create anxiety in university students, but that FoMO-related anxiety occurs primarily in situations in which people do not have access to their phones.

An additional strength of the current study was the incorporation of both iPhone users and Android users. Prior research has examined a population of iPhone users and their anxieties associated with the inability to answer the ringing iPhone, but this study did not include Android users (Clayton et al., 2015). This was due to the ease of disabling silent mode on the iPhone relative to other phones. The current study recruited individuals who owned both types of phones, and the researcher was able to disable silent mode on both types of phones. This inclusion provided us with a more representative sample, as Androids account for 51% of the smartphone subscribers and iPhones account for about 47% (Holst, 2019). There may be demographic or sociocultural differences between these two groups of users, so it is important to include both groups.

6. Limitations and future directions
The findings of the current study should be considered in light of some limitations. First, we used a self-report measure of anxiety, which may have been affected by demand characteristics or
other biases. Directly measuring physiological anxiety symptoms may address this in future studies. Further, using the state portion of the STAI provided us with information regarding the participant's anxiety at that moment, but not their overall anxiety (i.e., trait anxiety). When considering the implications of the study, we cannot make statements regarding trait anxiety, only state anxiety. Future research may include measures of the trait or stable anxiety as well as to conduct longitudinal research with these measures to address this.

Second, regarding participants in the Present Ringing and Absent Ringing groups, we did not control for additional phone calls or text messages received from other sources. Some participants may have received several other calls, potentially making these participants more anxious as compared to participants who only received the researcher's call. We therefore cannot assume consistency across participants in both groups, though we would expect the number of calls to be balanced across the two randomly assigned ringing groups. Future studies can address this by recording and statistically controlling for the number of alerts received and by asking participants at the completion of the experiment what specifically made them feel anxious. This would help tease apart the factors that led to anxiety.

Third, participants in both ringing phone conditions may have been surprised by the sound of the ringing phone and may have not comprehended that it was their own phone. Although it is possible that the participants might have misconstrued the ringing as coming from another source, it seems more likely that they would recognize their own phone's ring. Further, phone calls may not be a representative form of communication for college students. Future research may include text messages in place of the phone call to provide more representative communication modality.

Finally, the way in which FoMO and attachment is defined as independent variables should also be considered. Although the experimental paradigm set up situations of separation for attachment theory and FoMO, we did not measure these variables directly. Despite this limitation, these results suggest that phone separation, if not attachment per se, as well as the inability to answer the phone, if not FoMO per se, leads to anxiety. Future research should consider incorporating measures of FoMO and attachment when studying smartphone use to more confidently ensure the anxiety was a result of FoMO and attachment.

In conclusion, the results of the current study suggest both smartphone-related attachment and smartphone-related FoMO influence anxiety in university students, but that FoMO is particularly relevant when people do not have access to their smartphones. These results add to the existing literature on the relation between smartphone use and anxiety and provide a better understanding of this link. Additionally, these results provide an important contribution to the literature on smartphones in that this study is, to our knowledge, the first to simultaneously manipulate both attachment and FoMO in smartphone users, and, therefore, examine their combined effect.

These findings raise the possibility of providing university students with alternatives to their current smartphone interaction behaviors. It may be beneficial to implement smartphone applications that train individuals to become aware of their usage and promote a reduction in checking behavior. Intervention programs and therapies may focus on addressing the negatively reinforcing checking behaviors and conceptualize them as avoidance. Clinicians working with individuals coping with anxiety related to smartphone use may consider targeting both duration of smartphone presence daily as well as checking behaviors associated with FoMO and anxiety reduction in order to provide more effective coping strategies. Educating the public on the negative impacts of smartphone use might ease the ramifications of using smartphones and spread awareness on this phenomenon.
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Competing interests
The authors declare no competing interests.

Data availability statement
The data that support the findings of this study are available from the corresponding author, KM, upon reasonable request.

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