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ORIGINAL ARTICLE

The Use of Smartphones as a Digital Security Blanket: The Influence of Phone Use and Availability on Psychological and Physiological Responses to Social Exclusion

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ABSTRACT

Objective: Mobile phones are increasingly becoming a part of the social environment, and when individuals feels excluded during a socially stressful situation, they often retreat to the comfort of their phone to ameliorate the negativity. This study tests whether smartphone presence does, in fact, alter psychological and physiological responses to social stress.

Methods: Participants ($N = 148$, 84% female, mean age = 20.4) were subjected to a peer, social-exclusion stressor. Before exclusion, participants were randomized to one of the following three conditions: (1) phone-present with use encouraged, (2) phone-present with use restricted, or (3) no phone access. Saliva samples and self-report data were collected throughout the study to assess salivary alpha amylase (sAA), cortisol, and feelings of exclusion.

Results: Participants in both phone-present conditions reported lower feelings of exclusion compared with individuals who had no access to their phone ($F(2,143) = 5.49$, $p = .005$). Multilevel modeling of sAA responses revealed that the individuals in the restricted-phone condition had a significantly different quadratic trajectory after the stressor compared with the phone use ($\Upsilon = -0.12$, $z = -2.15$, $p = .032$), and no-phone conditions ($\Upsilon = -0.14$, $z = -2.64$, $p = .008$). Specifically, those in the restricted-phone condition showed a decrease in sAA after exclusion, those in the no-phone condition showed a gradual increase, and phone users exhibited little change. Cortisol responses to the stressor did not vary by condition.

Conclusions: Taken together, these results suggest that the mere presence of a phone (and not necessarily phone use) can buffer against the negative experience and effects of social exclusion.

Key words: alpha amylase, digital security blanket, smartphones, social exclusion, stress buffering.

INTRODUCTION

No other recent technological breakthrough has transformed the nature of social interactions as profoundly as the smartphone. Smartphones are undoubtedly altering many psychosocial processes, but researchers are only beginning to examine them and disentangle their positive and/or negative impacts on well-being. Most research has concentrated on the negative ramifications of technological engagement such as poorer psychological (1,2) and physical health (3,4) and worse health behaviors (5,6). However, it is imperative that we consider the potentially positive impact of these devices on our lives. For example, phones can augment and maintain social capital (7) and aid in healthcare (8). We hypothesize that a smartphones' ability to symbolically tie a person to others and/or allow actual connection with others outside of the immediate surrounding may have at least one specific benefit: reducing the negative psychological and physiological consequences of social exclusion.

Humans are an interpersonal species with an innate desire to belong and be accepted by their peers (9), and when excluded by others, negative psychological, physiological, and health consequences often follow (10). The acute stress induced by social exclusion can result in downstream health implications (11). Previous evidence shows that individuals often retreat to the comfort of their smartphones when faced with socially stressful or awkward encounters (12,13), and this may inadvertently be done in an effort to reduce stress. In light of the empirical evidence illuminating a wide variety of effective stress buffers (14–17), it is plausible that smartphones may also be used to protect against the harmful effects of social exclusion. When an individual engages with a mobile phone, they sometimes drift into a state of "absent presence" where the physical body is present in the here and now, but cognitive awareness is somewhere else (18). This phenomenon may be quite subtle; simply having a smartphone

SAA = salivary alpha amylase, **YIPS** = Yale Interpersonal Stressor

SDC Supplemental Content

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present has been shown to interfere with the dynamics of a social interaction because of its symbolic representation as a communication tool (3,19). Phones serve as symbol of a person's larger social network and can create a micro-fragmented context in which an individual's consciousness is split between external social connections and in-person interactions. This temporary escape has usually been considered a negative by-product of technology use, but that same diverted focus might be beneficial in other contexts such as social exclusion. Specifically, shifting attention away from negative environmental stressors and toward symbolic connections offered by phones may mitigate the negativity stemming from social stress and provide a source of felt security.

In these instances, a smartphone may symbolically operate as a "digital security blanket" that reduces the stress of exclusion. These effects may be analogous to how a young child uses a security blanket to improve resilience in intimidating environments (13). Alternatively, a smartphone may enable avoidance coping by distracting an individual from the exclusion experience and offering alternative activities, which may provide potent short-term benefits (20). Smartphone use in these circumstances may operate as a negative reinforcer (21) and ameliorate the negative feelings of exclusion. This behavior may partially explain why phone use is so pervasive in social situations and why people seem to be so often engaged in the virtual world at their fingertips.

Most research on smartphones and well-being has focused exclusively on self-report and behavioral data. In addition to these methods, physiological data are useful to elucidate the biological pathways potentially linking smartphone use and various health outcomes. One study examining physiological stress responses to experimental social exclusion found that participants who were rejected by their peers exhibited significantly higher levels of salivary cortisol as compared with nonexcluded individuals (22). While provocative, previous research has indicated that this measure of hypothalamic-adrenal-pituitary activation may not be the most appropriate proxy for this type of stress. Cortisol fluctuations are particularly sensitive to social evaluative threat (23), but peer rejection paradigms may not elicit the same sort of adrenocortical responses.

In line with this theorizing, one social exclusion paradigm, the Yale Interpersonal Stressor (YIPS) (24), has yielded inconsistent results regarding cortisol reactivity (25), but more promising results with regard to the less frequently studied salivary alpha-amylase (sAA). This enzyme is a rapid and reliable marker of autonomic nervous system activity that increases during a variety of stressors (26), and it has been tied to numerous health outcomes related to autonomic nervous system dysregulation (27,28) such as immune suppression (28) and prevalence of mental disorders (29). In one YIPS study, socially excluded participants exhibited larger increases in sAA compared with nonexcluded individuals, but there were no significant group differences in cortisol (30). Similarly, sAA was more acutely responsive than salivary cortisol when youths were faced with peer rejection stress (31). Although cortisol is often considered the criterion standard in salivary bioscience stress research, inconsistent cortisol results after social exclusion manipulations suggest that it may be prudent to explore other stress- and health-relevant biomarkers such as sAA.

The Present Study

In this current study, we expand the literature on the positive aspects of mobile phones by investigating whether smartphones may serve a psychological- and physiological-buffering function in an interpersonally stressful situation. To do so, we explored whether individuals who could use their phones during an experience of social exclusion differed from those who did not have access to their phones during exclusion. We also included a condition in which participants had their phones but were restricted from using them. This enabled us to determine whether using smartphones was responsible for the potential benefits or whether the mere symbolic presence of a smartphone imparts stress-buffering effects.

We hypothesized that individuals who were allowed to use their smartphones would report feeling less excluded and would exhibit attenuated physiological stress responses (cortisol and sAA) after social exclusion compared with individuals who could not use or did not have access to a smartphone. We further hypothesized because of the symbolic value of the smartphone that those who had their phone but were restricted from using it would also feel less excluded and exhibit an attenuated physiological stress response compared with individuals who did not have access to their smartphones. We measured both cortisol and sAA with the hopes of providing convergent evidence and/or disentangling the specific mechanisms through which a smartphone might alter stress responses. Because sAA is particularly responsive to peer social exclusion (e.g., 30), and the literature on cortisol is mixed (e.g., 25), we hypothesized that sAA would be more likely to change in response to social exclusion. This study fills important gaps in the field by examining health-relevant, physiological stress responses associated with smartphone use.

METHODS

Participants

The study was approved by the University of California, Irvine (UCI), Institutional Review Board, and participants were recruited via the UCI, undergraduate psychology subject pool. A total of 148 participants completed the study. Two participants were excluded from the analyses for taking hormonal contraceptives or asthma medication, two participants were excluded because they inadvertently became aware of the deception and study goals during the experiment, and three were excluded for not completing the entire study. The final sample consisted of 141 participants, and demographic characteristics of these participants can be found in Table 1. Data collection took place from August 2015 to May 2016.

Procedures

Participants underwent an approximately 90-minute laboratory session after they were screened for eligibility and consented to participate. A cover story was developed to hide the true purpose of the study. Participants were told that researchers were exploring the connection between physical dimensions of their smartphone and personality characteristics. Phones of all participants were confiscated at the beginning of the study under this pretext, which allowed the experimenter to later manipulate the phone conditions without arousing suspicion. The participant was joined by two trained confederates (one male and one female) who were ostensibly also participants in the study.

After participants completed a series of questionnaires and acclimated to the laboratory environment (approximately 25 minutes), the experimenter returned to the laboratory room and collected a baseline saliva sample. Before the start of the exclusion manipulation, participants were randomly assigned to one of three conditions using a random number generator. In the *phone-use condition*, participants' phones were returned to them immediately before the social exclusion manipulation and they were

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TABLE 1. Sociodemographic Characteristics by Experimental Condition

	Phone-Use (n = 47), M (SD)	Phone Restricted (n = 50), M (SD)	No-Phone (n = 44), M (SD)	F/χ^2	p
Sex (% female)	89.36[a]	74.00	89.09[a]	20.32	<.001
Ethnicity (% Asian)	44.68	52.00[b]	38.66	8.50	.01
Age	20.40 (2.01)	20.28 (2.67)	20.55 (2.77)	0.71	.49
Social support	39.98 (5.00)	39.94 (5.98)	39.95 (6.30)	0.00	.99
Depressive symptoms	18.96 (4.92)[a]	17.73 (3.76)	19.81 (6.43)[a]	9.06	<.001
Rejection sensitivity	8.77 (3.71)	9.45 (4.06)	8.61 (4.07)	2.95	.06
Hours on phone[c]	5.73 (2.98)	5.91 (3.71)	6.14 (3.69)	0.74	.48

[a] Significantly differs from restricted-phone group.

[b] Significantly differs from no-phone group.

[c] The average number of hours on phone per day.

encouraged to use their phones as they *"normally would*." In the *restricted-phone condition*, the participants' phones were returned to them immediately before the social exclusion manipulation, but they were told to "*please not use it during the study.*" Finally, in the *no-phone condition*, the participants' phones were not returned until the completion of the study. This condition was used as the control.

The experimenter then initiated the social exclusion stressor by leaving the room under the pretext of taking the saliva samples upstairs to a different laboratory for testing. The participant was left at a small table in a room with two confederates while they waited for the next portion of the study. For the next eight minutes, the confederates socially excluded the participant based on a modified version of the YIPS (24). The two confederates followed a conversation script about a fictional personal connection and employed verbal (e.g., "that's not interesting") and nonverbal techniques (e.g., physically turning away) to exclude the participant from the social interaction. This unobtrusive manipulation was intended to simulate real-life exclusion conditions.

After the exclusion period, the experimenter returned to the room and immediately collected another saliva sample from participants and collected additional self-report data. During the remainder of the study, participants submitted three additional saliva samples collected at 10-minute intervals after exclusion. After the completion of the study, the experimenter and the confederates undertook an extensive debriefing with the participant to ensure that the participant experienced no long-term psychological distress from the experienced exclusion.

Measures

Demographics and Covariates

Demographic information and potential covariates, including age, sex, and ethnicity along with measures of daily phone use, rejection sensitivity (32), social support (33), and depression (34) were collected via self-report.

Felt Exclusion

Participants reported feelings of exclusion, rejection, and isolation immediately before and after exclusion. Participants were asked to indicate the extent to which each item reflected how they felt "at the moment" from 1 (not at all accurate) to 5 (extremely accurate). The items "rejected," "excluded," and "isolated" were averaged into a single item of felt exclusion ($\alpha = 0.91$).

Physiological Responses

Salivary cortisol and sAA were collected during the study to assess physiological responses to exclusion. Researchers collected five saliva samples at various time points throughout the study (pre-exclusion, postexclusion, and 3 intervals of 10 minutes after the exclusion) using Salivette collection devices (Sarstdedt, Newton, NC). The postexclusion time point is displayed as time 0 in tables and figures. Experimental sessions were conducted in the afternoon (between 1:00–6:00 pm) to control for the diurnal rhythm of sAA and cortisol. Salivettes were stored at −20°C until batch analysis at the end of data collection at the Laboratory of Biological Health Psychology (Brandeis University, Waltham, MA). Before assaying, saliva was centrifuged at 2000 g for 5 minutes. The sAA measurement was completed using an enzyme kinetic method (27). Saliva was diluted at 1:625 with ultrapure water, and diluted saliva was incubated with substrate reagent (alpha-amylase EPS Sys; Roche Diagnostics, Indianapolis, IN) at 37°C for 3 minutes before a first absorbance reading was taken at 405 nm with a Tecan Sunrise ELISA reader (Tecan, Morrisville, NC). A second reading was taken after 5 minutes incubation at 37°C and increase in absorbance was transformed to sAA concentration (unit per milliliter) using "Calibrator f.a.s." solution (Roche Diagnostics) as a standard. Cortisol was measured using a commercially available chemiluminescence immunoassay with detectable range of 0.3 to 86.4 nmol/l (CLIA; product# RE62119, IBL-International, Hamburg, Germany). Inter- and intra-assay coefficients of variation for both assays were less than 10%.

Statistical Analysis

Analyses of covariance statistical procedures were used to test variation across conditions in felt exclusion while controlling for baseline values. Multilevel modeling was used to evaluate trajectories of sAA and cortisol throughout the study. Previous research has demonstrated that sAA may increase immediately after, but not during stressors (28); hence, our analyses focused on post-YIPS sAA responses. Because the values of sAA and cortisol were positively skewed, they were natural log transformed to approximate a normal distribution (Table 2). Based on recommendations in the longitudinal data analysis literature (35), we created a series of statistical models to systematically evaluate whether there were differences in the sAA and cortisol trajectories of individuals due to condition. Robust standard errors of the residuals were included in the models of sAA to account for a slight skewness in the distribution of standardized residuals.

First, the amount of outcome variation that exists at each level was examined using an unconditional means model with no predictors entered. Then, an unconditional growth model was evaluated to assess whether within-person variation was systemically associated with time (maximum likelihood estimations indicated that quadratic time was the most appropriate to include for sAA, and linear time was most appropriate for cortisol). Time (or time × time for sAA) was included as fixed and random effects in all models. All continuous variables were centered at their grand mean. Demographic information and potential covariates were inserted into the subsequent models as fixed effects and tested using maximum likelihood estimations but were removed because they were not significantly

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TABLE 2. Effects of Phone Manipulation on Salivary Biomarkers After the Yale Interpersonal Stressor

	Experimental Condition								
	Phone-Use (n = 47)			Phone Restricted (n = 50)			No-Phone (n = 44)		
	M	SE	CI	M	SE	CI	M	SE	CI
sAA, u/ml									
0 min after YIPS	3.13	.18	2.79 to 3.48	3.11	.17	2.78 to 3.44	3.15	.20	2.77 to 3.54
10 min after YIPS	3.11	.17	2.78 to 3.43	2.85	.17	2.54 to 3.19	3.22	.17	2.89 to 3.55
20 min after YIPS	3.11	.16	2.80 to 3.41	2.87	.17	2.55 to 3.20	3.27	.18	2.92 to 3.62
30 min after YIPS	3.14	.16	2.83 to 3.46	3.16	.13	2.90 to 3.42	3.39	.19	2.92 to 3.68
Cortisol, nmol/l									
0 min after YIPS	2.45	.07	2.30 to 2.59	2.50	.07	2.35 to 2.64	2.61	.08	2.46 to 2.75
10 min after YIPS	2.37	.07	2.24 to 2.51	2.41	.07	2.27 to 2.54	2.51	.07	2.38 to 2.66
20 min after YIPS	2.30	.07	2.17 to 2.43	2.32	.07	2.19 to 2.45	2.43	.07	2.30 to 2.56
30 min after YIPS	2.23	.07	2.09 to 2.36	2.24	.07	2.10 to 2.24	2.34	.07	2.20 to 2.47

SE = standard error; CI = 95% confidence interval; YIPS = Yale Interpersonal Stressor.
All values were log transformed to approximate a more normal distribution.

associated with the psychological or physiological outcomes, despite some baseline differences between groups on these variables.

RESULTS

Felt Exclusion

Analysis of self-reported exclusion from before (M(SD) = 1.24 (0.55)) and after (M (SD) = 1.59 (0.88)) the YIPS revealed that participants felt significantly more excluded after exposure to the stressor ($t(143) = 5.4$, $p < .001$).

Felt Exclusion Across Conditions

There was significant between-subject variation in self-reported exclusion depending on phone condition ($F(2, 143) = 5.49$, $p = .005$) (Fig. 1). Individuals in the no-phone condition reported the highest levels of exclusion (M (SD) = 1.95 (1.11)), individuals in the restricted-phone condition reported lower levels of exclusion (M (SD) = 1.49 (0.81)), and individuals in the phone-use condition felt the least excluded (M (SD) = 1.39 (0.62)). These findings represented a small to medium effect size ($\eta^2 = 0.06$) and a 12% difference in felt exclusion. Planned contrasts revealed that individuals in the no-phone condition reported significantly different levels of exclusion compared with the phone-use condition ($t(90) = 3.22$, $p = .002$) and the restricted-phone condition ($t(92) = 2.40$, $p = .017$). However, there were no significant differences between the phone-present conditions with regard to felt exclusion ($t(98) = 0.87$, $p = .46$).

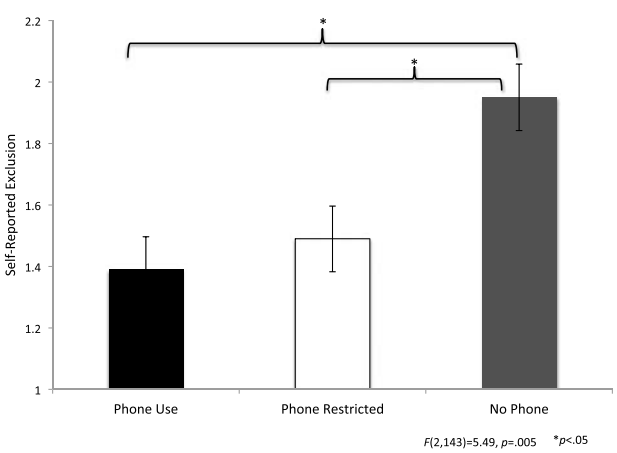

FIGURE 1. Felt exclusion after the Yale Interpersonal Stressor. Error bars depict standard error values.

Salivary Alpha Amylase by Conditions

The unconditional means model determined that 76.6% of the variation in sAA was due to between-person differences, and 23.4% of the variation in sAA was due to within-person differences. The interaction between condition and quadratic time was significant ($\chi^2 = 7.69$, $p = .021$), which signified that the quadratic rate of change in sAA throughout the study significantly varied by condition. When examining specific differences between the groups, the trajectory of sAA responses over the course of the study for individuals in the phone-use condition was significantly different than the trajectory of sAA for individuals in the restricted-phone condition ($\Upsilon = -0.12$, $z = -2.15$ $p = .032$) (Table 3). Those in the phone-use condition had a relatively flat trajectory, whereas those in the restricted-phone condition showed a sharp decrease in sAA responses followed by an eventual increase at the end of recovery (Fig. 2). Furthermore, the trajectory of responses over the course of the study for the restricted-phone use condition was also significantly different than the trajectory for individuals in the no-phone condition ($\Upsilon = -0.14$, $z = -2.64$, $p = .008$). There was not a significant difference between the trajectories of responses for the phone-use and no-phone conditions ($\Upsilon = -0.02$, $z = -0.45$, $p = .65$).

Salivary Cortisol Levels Over Time Across Conditions

Cortisol decreased after the stressor, but the linear rate of decrease did not vary by phone condition ($\chi^2 = 1.19$, $p = .55$, nor was there a main effect of condition on cortisol response, $\chi^2 = 3.10$, $p = .21$. See Figure S2, Supplemental Digital Content 1, http://links.lww.com/PSYMED/A444).

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TABLE 3. The Effects of Phone Manipulation on Salivary Alpha Amylase

Fixed Effects	Coefficients (SE)	95% CI
Intercept	3.64 (0.27)**	3.10 to 4.18
Time	−0.66 (0.22)*	−1.10 to −0.23
Time by time	0.14 (0.04)**	0.06 to 0.22
Condition[a]		
Phone-use	−0.45 (0.37)	−1.18 to 0.29
No-phone	−0.56 (0.42)	−1.39 to 0.26
Condition[a] by time		
Phone-use by time	0.59 (0.29)*	0.03 to 1.15
No-phone by time	0.75 (0.31)*	0.15 to 1.35
Condition[a] by time by time		
Phone-use by time by time	−0.12 (0.56)*	−0.23 to −0.01
No-phone by time by time	−0.14 (0.05)*	−0.25 to −0.04
Random effects parameters	**Estimate**	
Random intercept: person	1.98 (0.96)	0.77 to 5.11
Random slope: time	0.55 (0.49)	0.10 to 3.15
Random slope: time by time	0.01 (0.02)	0.001 to 0.15
Covariance: person, time	−0.62 (0.64)	−1.87 to 0.64
Covariance: person, time by time	0.08 (0.11)	−0.13 to 0.28
Covariance: time, time by time	−0.08 (0.09)	−0.26 to 0.09
Residual variance	0.22 (0.04)	0.15 to 0.33

Based on 141 participants with 555 time points of saliva collection.

[a] In this model, the phone-restricted condition served as the comparison group.

* $p < .05$.

** $p < .001$.

Adherence to Experimental Conditions

To understand whether the most critical factor was simply the presence of a phone or the *use* of a phone, we recoded the conditions based on adherence to directions (i.e., if they actually used their phone), which was assessed via visual observations by researchers. Regardless of originally assigned condition, we grouped all individuals who did use their phone into one group labeled "phone used"; this included one participant from the restricted-phone group who failed to adhere to experimental instructions. We also grouped all individuals who had their phone-present but did not use it into the "phone not used" group; this included five individuals from the original phone-use condition. The no-phone condition group remained the same. We tested these three new conditions as predictors of felt exclusion, sAA, and cortisol, and we found the same pattern of results. Felt exclusion significantly varied across the conditions ($F(2,143) = 5.40$, $p = .006$). In addition, sAA trajectories significantly differed by condition over time ($\chi^2 = 7.37$, $p = .025$), but cortisol did not ($\chi^2 = .68$, $p = .71$).

DISCUSSION

Our results indicate that smartphone availability and use influence psychological and physiological responses to social exclusion. Individuals in possession of smartphones felt significantly less excluded compared with individuals who did not have their smartphones. However, the phone-present groups did not significantly differ from each other. This finding implies that using a phone, in comparison with being in possession of a phone, may provide no additional reduction in felt exclusion.

Individuals who had their phones but were not allowed to use them had significantly different trajectories of sAA compared with individuals who had their phones and could use them and individuals who did not have their phones. Those with no phone showed increasing sAA throughout the course of the study, those who used their phone had relatively flat trajectories, and participants who had their phones but were restricted from use exhibited a sharp decline and eventual increase of sAA activity after the stressor. This decline of sAA during recovery suggests that the mere presence of a smartphone dampened sympathetic nervous system responses after the social exclusion stressor. It is important to note that this decreasing effect was short-lived. Nonetheless, this implies that the presence of a smartphone temporarily imparts stress-buffering benefits. The psychological solace provided by a phone aided in tempering physiological stress reactivity, specifically with regard to the autonomic nervous system. An exploratory analysis of whether felt exclusion was responsible for the changes in sAA revealed that there was no significant mediation.

Overall, these results suggest that the *presence* of a smartphone buffers feelings of exclusion and sAA responses during interpersonally stressful situations. Our analyses did not allow us to conclusively uncover the mechanisms by which these processes operate, but it may be that the comfort and security offered by the presence of a phone is the primary reason for its stress-buffering capabilities. When used, the innumerable functions of a smartphone can provide resources to help overcome the demands of dealing with a stressor and therefore temporarily increase resilience to stressful stimuli through their ability to provide an avoidance coping strategy (13).

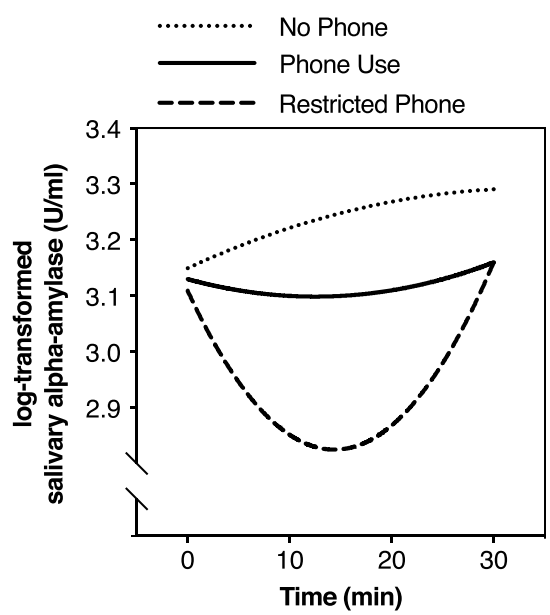

FIGURE 2. Salivary alpha-amylase response to the Yale Interpersonal Stressor differed by condition over time. A figure with error bars included is available online (see Figure S1, Supplemental Digital Content 1, http://links.lww.com/PSYMED/A444).

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However, the buffering effects are even stronger when the phone is merely present, which suggests that avoidance through distraction is not the only mechanism at play. The simple presence of the phone may provide an emblematic safe haven that helps an individual feel less stressed when faced with exclusion. Thus, having a smartphone at your side may be akin to a digital security blanket that buffers stress and provides comfort in uncomfortable circumstances, much like a child's security blanket (33). This stress-buffering effect may also be due to the association of smartphones with perceived social support, which is a proven, potent stress-buffer (14). Even when not using a phone to communicate with family or friends, the phone itself represents a symbolic medium by which we can contact our social networks (3). The representational image of our phone may boost feelings of perceived social support through its symbolic importance as a communication tool, and therefore, it may provide a reminder of the resources available to cope with the stressor at hand. A child does not engage in activities or have specific uses for a security blanket, rather it is the simple act of having it in their possession that leads to the reduction of stress. Similarly, we found that individuals do not need to use their phones to harness the stress-buffering capabilities of their digital security blankets but only need to have them at their side to reap the symbolic benefits.

Our discussion up to this point has mainly focused on why phones in general alter feelings of exclusion and sAA levels. However, the question remains about why individuals who *used* their phones displayed higher levels of sAA than individuals who merely had their phones with them. It was hypothesized that phone users would derive more stress-buffering benefits than individuals who had restricted access, but this was not the case. Individuals in both conditions had lower sAA responses in comparison with those with no phone.[1] However, those in the restricted group experienced more potent buffering effects. Why does using your phone have different effects than just having your phone? To address this question, it is important to consider the body of literature about technology use and negative psychophysiological outcomes.

One possible reason why individuals in the phone-use condition had higher levels of sAA than individuals in the restricted-phone condition may be that actually *using* a phone can increase stress. The act of sending and receiving text messages can increase heart rate, respiration, and skin conductance (36). These findings imply that using your phone (and specifically texting) increases physiological stress reactivity. Based on follow-up questions about phone activities of the participants in our study, most individuals who used their phones reported texting a friend or family member (n = 24). Although we do not know the content of the text messages, it can be assumed that in some instances, the conversation was stressful in nature (e.g., tasks to accomplish, conflicts to resolve) or at least not as positive as the participant desired. Thus, it is possible that the act of messaging induced stress or at least negated the extent of the stress-buffering effects seen with mere phone presence. The next most popular activity for phone users during our study was browsing through, but not posting on, social media (n = 21). The type of social media activity may also inform why phone users did not see the same benefits as individuals in the phone-restricted group. None of the individuals who used social media (Facebook or Instagram) actively posted any material; instead they simply browsed the sites. This passive social media use, in contrast to active use, has been shown to predict declines in numerous well-being outcomes (37). In this way, the passive use of social media by individuals in the phone-use condition may have contributed to the lack of positive influences from the phone. Those actions of texting and browsing social media may have served to exacerbate the negativity felt in their real-world environment of social exclusion.

Another possibility is that the individuals who used their phones felt that they were violating social norms by interacting with their phones in the direct presence of two acquaintances that were engaged in a nearby conversation. The participants who took part in the YIPS were at a small table only three feet in diameter. For those individuals who used their phones, they were blatantly ignoring the conversation partners in their immediate vicinity and may have felt guilty or stressed by these seemingly inappropriate actions. Social psychology research has demonstrated that individuals usually feel compelled to comply with social norms and violating these norms can lead to distress (38). This effect may have been particularly salient in our population because our participants were mainly women, and previous research on mobile phone etiquette has suggested that women advocate for more restricted mobile phone use in most social situations than men (39). In the context of our study, it is possible that participants who used their phones felt mildly distressed by inappropriately using their phones and therefore had higher levels of sAA in comparison with individuals who simply had their phones in their presence. Future studies should probe this possibility by asking participants more targeted questions to this end.

Our findings show that the presence of a phone influences psychological and physiological reactions to stressors, but what do those patterns ultimately mean for health? As mentioned earlier, social exclusion is associated with many detrimental health outcomes, including greater risk of mortality (e.g., 13,14,38,40), so anything that mitigates social exclusion likely has an indirect positive impact on health. The research on health implications of sAA is still in its infancy, but there are a number of interesting connections with mental and physical health outcomes. High levels of sAA are indicative of autonomic nervous system dysregulation and prevalence of mental disorders (29). Interestingly, individual differences in sAA among children are associated with health, negative affectivity, social relationships, behavior problems, and cardiovascular reactivity. For example, higher levels of sAA have been linked with immune suppression and therefore greater illness susceptibility (41), chronic stress in asthmatic and healthy children (42) and, in experimental stress settings, with respiratory problems, frequency of illness, and fatigue (43). Therefore, the effect of phone presence on sAA responses and feelings of exclusion may have downstream consequences for health.

When considering these health implications, it should be noted that our effect size of felt exclusion and sAA were small to moderate. How should we interpret this? The magnitude of the effect for felt exclusion was similar to the magnitude of the effect of

[1]While not shown in the results section, an exploratory analysis revealed that if both phone-present were combined together, then the sAA trajectory was marginally different than the no-phone group (Υ = .087, p = .062). As shown in Figure 2, this effect was likely driven by the phone-restricted group. Because we believe that the phone present conditions operate through different mechanisms, it is important to examine each condition individually.

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affectivity in the past studies of the YIPS (e.g., 25,30), and while not large, in our study, this effect was accompanied by physiological changes. In addition, the magnitude of our sAA changes was similar to previous studies (e.g., 30). Unfortunately, given the newness of the sAA literature, it is unknown whether the magnitude of variation in sAA trajectories by condition could be health protective in a meaningful way. That being said, studies of differences in other measures of stress reactivity (e.g., blood pressure) have previously connected small to moderate in-lab magnitude of changes to future health (44). Thus, it is plausible to assume that similar sized acute changes in sAA may also be predictive of the sAA-related health outcomes mentioned previously.

There are a variety of limitations that restrict the generalizability of these results. Cortisol did not increase after the manipulation and did not significantly differ between groups, and thus, our conclusions do not encompass the entirety of the stress response. This observed decline in cortisol after the stressor may be due to the passive and subtle nature of the social exclusion manipulation, which may not have induced the type of social evaluative threat that is most strongly tied to cortisol reactivity (23). Rather, we can only infer that phone presence influences autonomic stress responses to peer rejection, but not hypothalamic-adrenal-pituitary reactivity. In future studies, it would be advisable to collect a wider range of physiological biomarkers that would help elucidate the extent to which smartphones serve as buffers to physiological responses to social exclusion. In addition, future studies could test other types of stressors (e.g., social evaluative threat, physical pain) and examine whether the presence of a smartphone influences the responses.

Furthermore, our investigation was limited to studying the specific effects of smartphones with an undergraduate population and therefore cannot provide generalizable information about all mobile phones for all people. It would be advantageous in future studies to capture a wider range of sociodemographic variation. It is also possible that certain features of a smartphone may be responsible for its buffering abilities, and nonsmartphones may not produce the same pattern of findings. However, all of our participants were smartphone owners and our data cannot answer this question.

These findings should not be taken as a green light to encourage individuals to have their phones with them at all times in all situations. Our experiment narrowly focused on one specific social context and only demonstrated the stress-buffering capabilities of phones for one physiological system. The benefits of phone presence were only temporary (as noted in Fig. 2) and therefore should not be interpreted as a long-term solution to social exclusion. Although our findings are statistically significant and are, to our knowledge, the first to shed light on the role of phone presence in social situations, the magnitude of changes in sAA and exclusion may not be indicative of change with clinical significance that would warrant behavior change. The initial aims of this study were to explore why individuals use their phones so often in social situations, and our results about the potential stress-buffering capabilities provide only one answer. The interplay between phones, stress, and social relationships is continually evolving with the changing technological advancements and societal acceptance of their presence in our lives. Individuals should seek to maximize their well-being by using phones but should also be cautious in doing so appropriately.

In sum, our results show that the presence of a smartphone can alter negative psychological and physiological responses associated with social exclusion. Phones are increasingly becoming integrated into our lives, and as the philosopher Marshall McLuhan once foreshadowed, we may be moving toward an age where technological devices serve as "extensions of our central nervous system," pervading all aspects of our lives and surreptitiously influencing the functions of our physical and psychological being (45). Further research must be conducted to unpack the intricacies of these relationships, but this study demonstrates one way in which smartphones are beneficial through their ability to act as digital security blankets and stress buffers.

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