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Anxiety related distractibility deficits: too much smartphone use is not such a smart call

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ABSTRACT
Smartphones can increase productivity and ease accessing information, however the possible negative implications for high smartphone use or problematic smartphone use (PSU) are not fully understood. The current study examined anxiety-linked memory and attention deficits to determine whether PSU moderates these relationships. Cross-sectional data from 506 young adults aged 18–29 years (68% female) were analysed in separate regression models to investigate whether PSU (Mobile Phone Problem Use scale) moderated the relationship between state and trait anxiety (State-Cognitive and Trait-Cognitive subscales of State Trait Inventory for Cognitive and Somatic Anxiety) and everyday memory and attentional failures (the False Triggering, Forgetfulness and Distractibility subscales of the Cognitive Failures Questionnaire). Our results showed that PSU moderated the combined influence of state and trait anxiety for distractibility, such that those who reported higher PSU and higher trait anxiety reported greater errors of distractibility during higher, but not lower state anxiety. However, our predictions for false triggering and forgetfulness were not supported; the only significant finding was a trend for higher trait anxiety to be related to increased failures of false triggering and forgetfulness. Real-world implications of findings are discussed.

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Anxiety; smartphone use; attention; memory; cognitive failures; young people

1. Introduction

Problematic smartphone use (PSU) is characterised by excessive use of a mobile phone or smartphone device that interferes with daily living (Clayton, Leshner, and Almond 2015). Approximately one in five young people display symptoms of PSU (Oviedo-Trespalacios et al. 2019) making it one of the fastest growing areas of technology research in the last decade and a matter of public health concern (Kuss and Griffiths 2011; Van Velthoven, Powell, and Powell 2018). A plethora of research has shown that PSU is negatively associated with academic achievement (Judd 2014; Karpinski et al. 2013), attention (Byun et al. 2013; Panagiotidi and Overton 2020), memory (He et al. 2020), social engagement (Vahedi and Saiphoo 2018), anxiety (Clayton, Leshner, and Almond 2015; Kuss and Griffiths 2011; Vahedi and Saiphoo 2018) and depression (Kuss and Griffiths 2011; Vahedi and Saiphoo 2018). However, few studies have examined the interplay between such factors. For example, while technology research suggests that PSU is associated with higher anxiety (Clayton, Leshner, and Almond 2015; Kuss and Griffiths 2011; Vahedi and Saiphoo 2018), and poorer cognition (El-Sayed Desouky and Abu-Zaid 2020; Hadlington 2015), studies in applied cognitive psychology have shown that elevated anxiety is related to poorer memory and attention, using both self-reported (Hadlington 2015; Mahoney, Dalby, and King 1998) and behavioural measures of cognition (Edwards, Edwards, and Lyvers 2015, 2016, 2017). Therefore, interactions between these factors seem plausible and warrant investigation. The present study focussed on untangling the relationships between PSU, anxiety and attention and memory.

1.1. Smartphone use and anxiety

The relationship between smartphone use and anxiety is well-established (Clayton, Leshner, and Almond 2015; Hawi and Samaha 2017; Kuss and Griffiths 2011; Vahedi and Saiphoo 2018). Broadly, anxiety is marked by fear, worry and nervousness and can be separated into non-clinical distinctions such as trait anxiety (a

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personality or disposition of being fearful more generally) and state anxiety (fear or worry arising from a particular situation), and clinical symptoms such as social anxiety (fear of being judged by others) and separation anxiety (afraid of being away from someone or something) (Nitschke et al. 2001). Several studies have found that greater PSU was related to higher trait anxiety (Vahedi and Saiphoo 2018), elevated state anxiety (Hong et al. 2019) and higher social anxiety (Elhai, Tiamiyu, and Weeks 2018; Richardson, Hussain, and Griffiths 2018; Van Deursen et al. 2015). Furthermore, Cheever et al. (2014) reported that moderate to high smartphone users experienced greater state anxiety when separated from their phones suggesting a form of smartphone separation anxiety, compared to less frequent users. What is not known is whether higher PSU and anxiety have an interactive relationship with cognitive deficits.

1.2. Smartphone use, memory and attention

Hadlington (2015) investigated the relationship between PSU and cognitive errors or failures of memory, attention and/or distractibility occurring as part of daily life. Hadlington found that higher PSU (indexed by scores on Mobile Phone Problem Use Scale; MPPUS) (Bianchi and Phillips 2005) was related to higher scores on the self-report Cognitive Failures Questionnaire (CFQ) (Broadbent et al. 1982). Similar results were reported in other studies (Xanidis and Brignell 2016; Hong et al. 2020). Together these findings (Hadlington 2015; Hong et al. 2020; Xanidis and Brignell 2016) provide preliminary support for the notion that high PSU is associated with lapses in memory and distractibility occurring during daily activities requiring limited yet sustained cognitive resources. However, these studies used the global CFQ score rather than separating memory and attention errors (Hadlington 2015; Hong et al. 2020; Xanidis and Brignell 2016). Rast et al. (2009) argued that the CFQ assesses multiple dimensions of cognitive failures: false triggering (interrupted processing of cognitive and motor actions); forgetfulness (letting go from one's mind something known or planned); and distractibility (being absentminded or easily disturbed in one's focused attention). Particularly, forgetfulness aligns with everyday memory errors, whereas distractibility and to a lesser extent false triggering marks a loss of attentional resources (Rast et al. 2009). Thus we propose extending the work of Hadlington and others, yet analysing the attention and memory component scores of the CFQ, will provide greater understanding of the link between PSU and these separable cognitive processes.

1.3. The current study

Young people aged 18–29 years represent the most vulnerable to smartphone-related problems, as evidenced by their proneness to smartphone separation anxiety (Hartanto and Yang 2016; Toh et al. 2021) and smartphone addiction (Csibi et al. 2021). Given that the highest rates of smartphone use have been reported in 18-19-year-olds (91%), followed by 20–24 years (85%) and then 25–30 years (81%) (Poll 2015), we followed others (Hartanto and Yang 2016; Oviedo-Trespalacios et al. 2019; Toh et al. 2021) who recommended that under 30s provide the most sensitive test of smartphone-related behaviours. In the present study, we examined the interplay between anxiety, PSU and everyday cognitive failures of memory (forgetfulness) and attention (false triggering and distractibility) in a sample of young people aged 18–29 years.

We used separate moderated regression models to determine whether PSU (measured using MPPUS [Bianchi and Phillips 2005]) moderated the relationship between state and trait anxiety (indexed by State-Trait Inventory for Cognitive and Somatic Anxiety; STICSA [Ree et al. 2008]), and lapses in memory and attention (assessed using the three separate subscales from the CFQ [Broadbent et al. 1982]: namely False Triggering, Forgetfulness, Distractibility [Rast et al. 2009]). Our hypothesises were derived from the empirical literature in PSU and the theoretical premise that state and trait anxiety are associated with memory and attention deficits (see Attentional Control Theory; Eysenck et al. 2007). While the development and maintenance of smartphone addiction is outside the scope of the current work, implications for the promising Interaction of Person-Affect-Cognition-Execution (I-PACE) model (Brand et al. 2016, 2019) will be discussed.

Specifically, we hypothesised that:

H_1: Higher PSU will be related to higher trait and state anxiety.

H_2: Higher PSU will be related to more everyday failures of memory and attention.

H_3: Higher state and trait anxiety will be related to greater errors of memory and attention, and that these associations will be more pronounced for those who report higher PSU.

2. Methods

2.1. Participants and procedure

Our project was approved by The University of Queensland Human Research Ethics Committee (#2020003023). Recruitment advertisements were posted on the university's virtual learning environment (Blackboard) and social media (Facebook, Twitter). Six hundred and ninety-eight respondents provided informed consent and commenced the online questionnaire hosted using Qualtrics. Of those, 192 cases (28%) were excluded because they did not meet the age criteria, or they did not complete one of more of the measurements of interest. Further inspection of the data revealed no missing values. The final sample comprised 506 English speaking participants aged 18–29 years (M_{age} = 22.52 years, SD_{age} = 3.26; 68% female). Data cleaning identified no univariate outliers (z-scores > 3.50) and no multivariate outliers (Mahalanobis' Distance; $p < .001$) (Tabachnick and Fidell 2007). The data set met the assumptions of linearity and homoscedasticity ($N = 506$). The online questionnaire comprised some demographic questions (e.g. age, sex, education, social media use), STICSA, MPPUS and CFQ and took approximately 15-minutes to complete. Demographic characteristics of the study participants are shown in Table 1.

2.2. Measures

2.2.1. State-trait inventory for cognitive and somatic anxiety

The STICSA (Ree et al. 2008) assesses cognitive and somatic, state and trait anxiety, however given our interest in the link between anxiety and cognition, only items related to thought-provoking or cognitive anxiety were used e.g. *I feel agonised over my problems* and *I keep busy to avoid uncomfortable thoughts.* Participants responded to 11 statements about how they feel *right now, at this very moment* (state anxiety) and *in general* (trait anxiety) using a 4-point Likert scale (1 = *not at all* – 4 = *very much so*). No items need reverse scoring, and higher scores represent higher anxiety. Internal consistency estimates have been acceptable (Trait-Cognitive α = .87 & State-Cognitive α = .88) (Grös et al. 2007) and in our sample (α = .91, α = .90, respectively).

Table 1. Demographic characteristics of the sample (N = 506).

	%
Sex	
Male	29.2
Female	68.4
Other	2.0
Prefer not to say	0.4
Education	
Less than high school	0.4
High school graduate or equivalent	27.9
Some university – no degree	19.2
Trade/technical/vocational	4.0
Associate degree or Diploma	6.3
Bachelor's degree	35.4
Master's degree	6.5
Doctorate degree	0.4

2.2.2. Cognitive failures questionnaire

The CFQ (Broadbent et al. 1982) measures everyday failures in memory and attention. Following Rast et al. (2009) the 25-item CFQ was used to index False Triggering (e.g. *Do you bump into people?*), Forgetfulness (e.g. *Do you forget where you put something like a newspaper or a book?*) and Distractibility (e.g. *Do you daydream when you are listening to something?*). Participants rate the frequency of errors in daily activities on a 5-point Likert scale (0 = *never* – 4 = *very often*). No items require reserve scoring and higher composite scores on each domain represent higher number of errors. The CFQ has shown adequate psychometric properties in other work (Wallace, Kass, and Stanny 2002), and acceptable internal consistency estimates for False Triggering, Forgetfulness, and Distractibility, α = .82, .81, and .80, respectively were obtained for the present sample.

2.2.3. Mobile phone problem use scale

The 27-item MPPUS (Bianchi and Phillips 2005) assess PSU (e.g. My friends don't like it when my smartphone is switched off and There are times when I would rather use the smartphone than deal with other more pressing issues). Respondents rate how often, in general, statements related to their smartphone usage, on a 10-point Likert scale (0 = not true at all – 10 = extremely true). Scores are summed and higher scores represent higher PSU. The MPPUS has high internal consistency (α = .93) (Bianchi and Phillips 2005) and was supported in the current study (α = .90).

2.3. Data analytic plan

To address H_1 and H_2 we used bivariate correlations to determine whether higher PSU was associated with higher anxiety (H_1) and higher scores on the CFQ subscales representing failures of memory and attention (H_2). To test the hypothesis that PSU moderates the relationship between state and trait anxiety and cognitive failures (H_3), we created a series of regression models where variables were added in stages. For each test, the main effects (state anxiety, trait anxiety and PSU) were added at Step 1, the two-way interaction terms were entered at Step 2 (state anxiety x trait anxiety, trait anxiety x PSU, state anxiety x PSU), and the three-way interaction term (state anxiety x trait anxiety x PSU) was included at Step 3. Multiplicative interaction terms were formed using mean-centred scores on any continuous predictors. Separate analyses were performed for the criterion variables: false triggering, forgetfulness, and distractibility. We conducted all analyses using SPSS version 27 and the PROCESS macro v4.0 (Hayes 2017) using model #3. Interactions were detected with 5000 bootstrap resamples whereby the bias-corrected bootstrapped 95% confidence intervals were interpreted as significant at the $p < .05$ level if they did not cross zero (Tabachnick and Fidell 2007). PROCESS in SPSS decomposes the interactions and performs tests of simple slopes at high and low values on the social anxiety and self-esteem scales (calculated at ± 1 SD from the mean score on each).

3. Results

As the data were derived from self-report measures and the variables had potential to be related, we tested the common method bias using Harman's single factor test. The percentage of shared variance was 22.44%, confirming that the findings reflect the true relationship between the variables. Preliminary analyses were also run with age and sex as covariates. Given that the substantive pattern of results did not change across DVs (i.e. false triggering, forgetfulness, distractibility) the data were reported collapsed across these factors.

Means, standard deviations, zero-order and inter-correlations between predictors and criterions are shown in Table 2. As can be seen, PSU was positively and significantly correlated with state and trait anxiety (H_1) and false triggering, forgetfulness, and distractibility (H_2). To address H_3, we conducted separate moderated regression tests and the unstandardised coefficients, *t*-tests, *p* values, and 95% confidence intervals for all variables are shown in Table 3. The notation $R^2\Delta$ and $F\Delta$ are used to describe R^2 Change and *F* Change, respectively.

The model for false triggering was not significant, with an adjusted R^2 value of .22; $p = .485$. There was, however, a significant main effect of trait anxiety such that higher trait anxiety was associated with higher false triggering, $b = 0.24$, t $(498) = 4.23$, $p < .001$. All other *p*-values > .206.

The model for forgetfulness was also not significant, with an adjusted R^2 value of .26; $p = .652$. Trait anxiety was nonetheless a significant positive predictor of forgetfulness, $b = 0.28$, t $(498) = 5.01$, $p < .001$. All other *p*-values > .106.

The model for distractibility accounted for 39% of the variance, $R = .62$, $R^2\Delta = .01$, $F\Delta$ $(1, 498) = 5.73$, $p < .001$, and the full model was significant, F $(7, 350) = 43.90$, $MSE = 27.70$, $p = .017$. The main effects for PSU, and the two-way interactions were non-significant, *ps* > .245. The main effects of state and trait anxiety were significant, with higher state and trait anxiety associated with higher distractibility, $b = 0.14$, t $(498) = 2.67$, $p = .008$, and $b = 0.39$, t $(350) = 6.01$, $p < .001$, respectively. However, as predicted these main effects were further qualified by a significant three-way state anxiety x trait anxiety x PSU interaction, $b = 0.00$, t $(498) = 2.40$, $p = .017$. The pattern of the interaction is shown in Figure 1. The left panel shows that for those reporting lower PSU, the state anxiety x trait anxiety interaction was not significant, $F < 1$. Tests of simple effects revealed that higher anxiety was associated with higher distractibility at both lower, $b = 0.34$, 95% CI [0.18–0.50], $t(498) = 4.21$, $p < .001$ and higher state anxiety, $b = 0.29$, 95% CI [0.12–0.45], $t(498) = 3.40$, $p = .001$. The right panel shows for those reporting higher PSU, the interaction between state anxiety and trait anxiety was significant, F $(1, 498) = 4.28$, $p = .039$. The interaction reflected the fact that those who reported higher PSU, higher trait anxiety was associated with higher distractibility at higher state anxiety, $b = 0.25$, 95% CI [0.10–0.39], $t(498) = 3.24$, $p = .001$, but distractibility was unrelated to trait anxiety for those lower in state anxiety, $b = 0.11$, 95% CI [−0.10–0.27], $t = 1.29$, $p = .199$.

Table 2. Means, standard deviations, zero-order and inter-correlations of state anxiety, trait anxiety, problematic smartphone use, false triggering, forgetfulness and distractibility.

	M	*SD*	State anxiety	Trait anxiety	Problematic smartphone use
State anxiety	26.15	8.64			
Trait anxiety	27.42	8.44	.85***		
Problematic smartphone use	100.22	39.44	.39***	.38***	
False triggering	11.49	6.29	.42***	.45***	.26***
Forgetfulness	15.53	5.92	.43***	.49***	.25***
Distractibility	15.97	6.07	.58***	.59***	.32***

Note: $p < .001$***

4. Discussion

We hypothesised that higher PSU would be related to higher anxiety (H_1) and greater number of errors of memory and attention (H_2) and these predictions were fully supported. We also hypothesised that higher state and trait anxiety would be associated with greater failures of memory (forgetfulness) and attention (false triggering and distractibility), and that these associations would be more pronounced for those who report higher PSU (H_3). This prediction received mixed support. Specifically, our analyses revealed that elevated trait anxiety was related to higher errors in false triggering and greater lapses in forgetfulness, but the additions of state anxiety and PSU, nor their combined influences did not explain additional variance. Our hypothesis for distractibility was partially upheld. Our data revealed that for those who reported lower PSU, higher trait anxiety was associated with greater distractibility

Table 3. Unstandardised coefficients, and 95% confidence intervals for false triggering, forgetfulness, and distractibility.

	Unstandardised coefficients				95% confidence intervals	
	b	SE	*t*	*p*	Lower bound	Upper bound
False triggering						
Constant	11.28	0.33	34.07	<.001	10.63	11.93
State Anxiety (SA)	0.05	0.06	0.92	.357	−0.06	0.17
Trait Anxiety (TA)	0.24	0.06	4.23	<.001	0.13	0.35
Smartphone Use (PSU)	0.01	0.01	1.27	.206	−0.01	0.03
SA x TA	0.01	0.01	1.25	.211	−0.00	0.02
TA x PSU	0.00	0.00	0.18	.860	−0.00	0.00
SA x PSU	−0.00	0.00	0.83	.409	−0.00	0.00
SA x TA x PSU	0.00	0.00	0.70	.485	0.00	0.00
Forgetfulness						
Constant	15.38	0.30	50.73	<.001	14.78	15.97
State Anxiety (SA)	0.12	0.06	0.30	.768	−0.10	0.13
Trait Anxiety (TA)	0.28	0.10	5.01	<.001	0.17	0.39
Smartphone Use (PSU)	0.01	0.01	1.20	.233	−0.01	0.03
SA x TA	0.01	0.00	1.62	.106	−0.00	0.01
TA x PSU	−0.00	0.00	1.13	.261	−0.00	0.00
SA x PSU	−0.00	0.00	0.09	.932	−0.00	0.00
SA x TA x PSU	0.00	0.00	0.45	.652	0.00	0.00
Distractibility						
Constant	15.95	0.27	58.97	<.001	15.42	16.48
State Anxiety (SA)	0.14	0.05	2.66	.008	0.04	0.24
Trait Anxiety (TA)	0.25	0.05	5.05	<.001	0.15	0.34
Smartphone Use (PSU)	0.01	0.01	0.78	.435	−0.01	0.02
SA x TA	0.00	0.00	0.68	.498	−0.01	0.01
TA x PSU	−0.00	0.00	1.26	.208	−0.00	0.00
SA x PSU	0.00	0.00	0.35	.727	−0.00	0.00
SA x TA x PSU	0.00	0.00	2.40	.017	0.00	0.00

irrespective of state anxiety. Whereas, for those who reported higher PSU, higher trait anxiety was associated with greater distractibility, but this relationship was restricted to those who reported higher state anxiety. It is possible, therefore that for those higher in PSU, being in a calmer state or situation (lower state anxiety) protected against distractibility deficits usually evident in those higher in trait anxiety, whereas for those higher in trait anxiety and PSU, being in a stressful state (higher state anxiety) exacerbated distractibility. This explanation is consistent with the notion that constant rewarding received from one's smartphone may diminish the motivation to exercise the necessary effort to remain on task (Aru and Rozgonjuk 2022).

Given that our focus was on examining whether the anxiety-cognition link was moderated by PSU we have limited our discussion to findings from empirical work that also viewed anxiety and/or PSU as predictors of attention and memory (i.e. as dependent or criterion variables). Our results were conceptually similar to studies reporting that elevated anxiety was related to poorer memory (Edwards, Edwards, and Lyvers 2016)

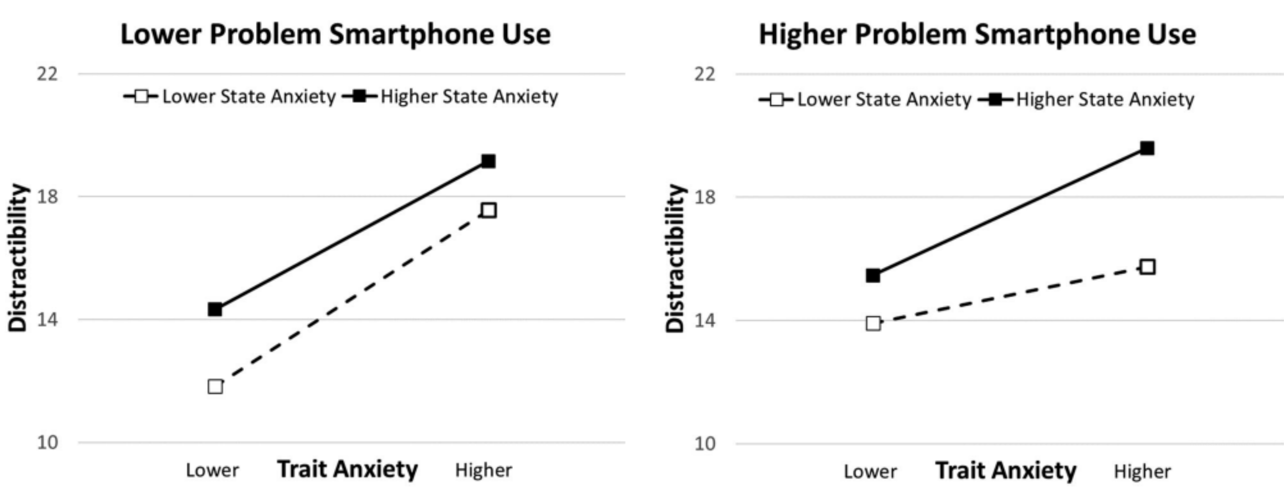

Figure 1. Relationship between state anxiety, trait anxiety, problematic smartphone use, and distractibility. Simple slopes were calculated at ± 1 SD from the mean score on each of high and low values on the predictor variables.

and poorer attention (Edwards, Edwards, and Lyvers 2015; 2017), albeit these examples used behavioural rather than self-report tests of cognitive performance. Our CFQ data conceptually agreed with Hadlington (2015), Xanidis and Brignell (2016) and Hong et al. (2020) who reported higher PSU was related to more cognitive failures. Nonetheless, their studies demonstrated a direct correlation between PSU and cognitive failures, whereas our design was able to untangle the contributions of state and trait anxiety and PSU for everyday errors of memory (forgetfulness) and attention (false triggering and distractibility). Specifically, our data supports the notion that for younger adults elevated trait anxiety is related to memory errors (forgetfulness), whereas both state and trait anxiety combine to associate with attention failures (distractibility). Most importantly, we showed that for those lower in PSU, PSU did not moderate the anxiety-cognition link as expected, but for those higher in PSU, lower state anxiety appears to buffer the negative impacts of trait anxiety on distractibility, but not false triggering or forgetfulness.

Our findings are somewhat consistent with the predictions of attentional control theory (Eysenck et al. 2007) which suggests that anxious individuals might lack the cognitive control necessary to focus their attention on the demands of the task at hand and succumb to task-irrelevant distractions. From this perspective it seems plausible that an overload of smartphone stimuli presents as a task-irrelevant distraction that intensifies the influence of anxiety on distractibility. Another plausible description of the resulting pattern of data could be explained by extended self theory (Belk 2014) and extended mind theory (Clark and Chalmers 1998). Belk (2013) proposed that the smartphone becomes another extension of self, thus in accord with the concept of extension of the mind (Wallace, Kass, and Stanny 2002) the smartphone provides an agent of cognitive extension into daily life. From this viewpoint, the poorer distractibility scores we reported for those higher in PSU might be explained by individuals offloading cognitive and memory tasks to their phones. Although this idea is beyond the scope of the current study, logical next steps would be to explore the purpose of the smartphone use in those high users to reject or confirm this suggestion. The I-PACE model (Brand et al. 2016, 2019) has shown considerable success in explaining how and when addictive behaviours manifest and has previously been discussed in PSU literature (Elhai, Tiamiyu, and Weeks 2018). The I-PACE model shares a number of similarities with attentional control theory (Ree et al. 2008) by proposing that affective and cognitive responses interrelate in complex ways to predict problematic behaviours. Our findings for distractibility concur with I-PACE in that inhibitory control seems to play a pivotal role in the link between anxiety and PSU. Although beyond the scope of the present study, future work is needed to determine the affective and cognitive factors underlying the development and maintenance of PSU. Undoubtedly, the I-PACE model will provide an important pathway for framing these investigations.

While our large sample size was a strength, limitations of self-report measures are well known. We utilised valid and reliable psychometric assessments for our variables of interest, that is, we used the same measures as previous research capturing state and trait anxiety (Edwards, Edwards, and Lyvers 2015, 2016, 2017), cognitive failures (Hadlington 2015; Xanidis and Brignell 2016; Hong et al. 2020) and PSU (Vahedi and Saiphoo 2018; Hadlington 2015). Nonetheless, research has shown that self-report and objective measurements of PSU are often inconsistent (Rozgonjuk et al. 2018, 2021). It is therefore possible that while self-reported PSU might correlate with anxiety and cognitive problems, this might not be the case for actual smartphone use. Despite the granular approach we took delineating the total CFQ score used by others (Hadlington 2015; Hong et al. 2020; Xanidis and Brignell 2016), into the separate subscales for memory (forgetfulness) and attention (false triggering and distractibility), future research using biofeedback and cognitive indices could confirm the robustness of the data reported here. For example, using an experimental or quasi-experimental design and deploying ecological momentary assessment of smartphone use, whereby device behaviours, emotional symptoms and cognitive processes are sampled in real time in the individual's environment could prove useful for extending the current cross-sectional design. Furthermore, while we focussed on young people aged 18–29 years when smartphone use is at its peak, more research is needed to determine whether our findings are generalisable across ages. We hope the present findings encourage such research.

In sum, our results shed light on existing anxiety-linked cognitive deficits and highlight that higher PSU can exacerbate problems of distractibility. As the world becomes more technological, it is unlikely that smartphone use will subside, therefore it is imperative to provide real-world implications for these findings. While new research has shown great promise for the capability of wearable devices to track psychological and cognitive factors in real-time (Gjoreski et al. 2020, 2021) the complexity and challenge of understanding and solving PSU relies on a multiprong approach. As a minimum, we suggest psychoeducation is critical so that young people who are prone to higher PSU (and social media use), are aware of the downstream consequences of their smartphone behaviour for their anxiety levels particularly when in stressful situations that call for maximum cognitive performance. Finally, we suggest that if teachers, academics, and counsellors are purely targeting the anxiety-stress levels, they could be missing an important contributing factor – the additive influence of high smartphone use.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

References

Aru, J., and D. Rozgonjuk. 2022. "The Effect of Smartphone use on Mental Effort, Learning, and Creativity." *Trends in Cognitive Sciences* 26 (10): 821–823.

Belk, R. W. 2013. "Extended Self in a Digital World: Table 1." *Journal of Consumer Research* 40 (3): 477–500. https://doi.org/10.1086/671052.

Belk, R. 2014. "Digital Consumption and the Extended Self." *Journal of Marketing Management* 30 (11-12): 1101–1118. https://doi.org/10.1080/0267257X.2014.939217.

Bianchi, A., and J. G. Phillips. 2005. "Psychological Predictors of Problem Mobile Phone use." *CyberPsychology & Behavior* 8 (1): 39–51. https://doi.org/10.1089/cpb.2005.8.39.

Brand, M., E. Wegmann, R. Stark, A. Müller, K. Wölfling, T. W. Robbins, and M. N. Potenza. 2019. "The Interaction of Person-Affect-Cognition-Execution (I-PACE) Model for Addictive Behaviors: Update, Generalization to Addictive Behaviors Beyond Internet-use Disorders, and Specification of the Process Character of Addictive Behaviors." *Neuroscience & Biobehavioral Reviews* 104: 1–10. https://doi.org/10.1016/j.neubiorev.2019.06.032.

Brand, M., K. S. Young, C. Laier, K. Wölfling, and M. N. Potenza. 2016. "Integrating Psychological and Neurobiological Considerations Regarding the Development and Maintenance of Specific Internet-use Disorders: An Interaction of Person-Affect-Cognition-Execution (I-PACE) Model." *Neuroscience & Biobehavioral Reviews* 71: 252–266. https://doi.org/10.1016/j.neubiorev.2016.08.033.

Broadbent, D. E., P. F. Cooper, P. FitzGerald, and K. R. Parkes. 1982. "The Cognitive Failures Questionnaire (CFQ) and its Correlates." *British Journal of Clinical Psychology* 21 (1): 1–16. https://doi.org/10.1111/j.2044-8260.1982.tb01421.x.

Byun, Y.-H., M. Ha, H.-J. Kwon, et al. 2013. "Mobile Phone Use, Blood Lead Levels, and Attention Deficit Hyperactivity Symptoms in Children: A Longitudinal Study." *PLoS One* 8 (3): e59742. https://doi.org/10.1371/journal.pone.0059742.

Cheever, N. A., L. D. Rosen, L. M. Carrier, and A. Chavez. 2014. "Out of Sight is not out of Mind: The Impact of Restricting Wireless Mobile Device use on Anxiety Levels among low, Moderate and High Users." *Computers in Human Behavior* 37: 290–297. https://doi.org/10.1016/j.chb.2014.05.002.

Clark, A., and D. Chalmers. 1998. "The Extended Mind." *Analysis* 58 (1): 7–19. https://doi.org/10.1093/analys/58.1.7.

Clayton, R. B., G. Leshner, and A. Almond. 2015. "The Extended ISelf: The Impact of IPhone Separation on Cognition, Emotion, and Physiology." *Journal of Computer-Mediated Communication* 20 (2): 119–135. https://doi.org/10.1111/jcc4.12109.

Csibi, S., M. D. Griffiths, Z. Demetrovics, and A. Szabo. 2021. "Analysis of Problematic Smartphone use Across Different age Groups Within the 'Components Model of Addiction'." *International Journal of Mental Health and Addiction* 19 (3): 616–631. https://doi.org/10.1007/s11469-019-00095-0.

Edwards, E. J., M. S. Edwards, and M. Lyvers. 2015. "Cognitive Trait Anxiety, Situational Stress, and Mental Effort Predict Shifting Efficiency: Implications for Attentional Control Theory." *Emotion* 15 (3): 350. https://doi.org/10.1037/emo0000051.

Edwards, E. J., M. S. Edwards, and M. Lyvers. 2016. "Individual Differences in Trait Anxiety and Goal-Commitment Predict Updating Efficiency on the Reading Span Task." *Motivation and Emotion* 40 (6): 936–945. https://doi.org/10.1007/s11031-016-9572-8.

Edwards, M. S., E. J. Edwards, and M. Lyvers. 2017. "Cognitive Trait Anxiety, Stress and Effort Interact to Predict Inhibitory Control." *Cognition and Emotion* 31 (4): 671–686. https://doi.org/10.1080/02699931.2016.1152232.

El-Sayed Desouky, D., and H. Abu-Zaid. 2020. "Mobile Phone Use Pattern and Addiction in Relation to Depression and Anxiety." *Eastern Mediterranean Health Journal* 26 (6): 692–699. https://doi.org/10.26719/emhj.20.043.

Elhai, J. D., M. Tiamiyu, and J. Weeks. 2018. "Depression and Social Anxiety in Relation to Problematic Smartphone Use." *Internet Research* 28 (2): 315–332. https://doi.org/10.1108/IntR-01-2017-0019.

Eysenck, M. W., N. Derakshan, R. Santos, and M. G. Calvo. 2007. "Anxiety and Cognitive Performance: Attentional Control Theory." *Emotion* 7 (2): 336–353. https://doi.org/10.1037/1528-3542.7.2.336.

Gjoreski, M., T. Kolenik, T. Knez, M. Luštrek, M. Gams, H. Gjoreski, and V. Pejović. 2020. "Datasets for Cognitive Load Inference Using Wearable Sensors and Psychological Traits." *Applied Sciences* 10 (11): 3843. https://doi.org/10.3390/app10113843.

Gjoreski, M., B. Mahesh, T. Kolenik, J. Uwe-Garbas, D. Seuss, H. Gjoreski, M. Luštrek, M. Gams, and V. Pejović. 2021. "Cognitive Load Monitoring with Wearables–Lessons Learned from a Machine Learning Challenge." *IEEE Access* 9: 103325–36. https://doi.org/10.1109/ACCESS.2021.3093216.

Grös, D. F., M. M. Antony, L. J. Simms, and R. E. McCabe. 2007. "Psychometric Properties of the State-Trait Inventory for Cognitive and Somatic Anxiety (STICSA):

Comparison to the State-Trait Anxiety Inventory (STAI)." *Psychological Assessment* 19 (4): 369. https://doi.org/10.1037/1040-3590.19.4.369.
Hadlington, L. J. 2015. "Cognitive Failures in Daily Life: Exploring the Link with Internet Addiction and Problematic Mobile Phone use." *Computers in Human Behavior* 51: 75–81. https://doi.org/10.1016/j.chb.2015.04.036.
Hartanto, A., and H. Yang. 2016. "Is the Smartphone a Smart Choice? The Effect of Smartphone Separation on Executive Functions." *Computers in Human Behavior* 64: 329–336. https://doi.org/10.1016/j.chb.2016.07.002.
Hawi, N. S., and M. Samaha. 2017. "The Relations among Social Media Addiction, Self-Esteem, and Life Satisfaction in University Students." *Social Science Computer Review* 35 (5): 576–586. https://doi.org/10.1177/0894439316660340.
Hayes, A. F. 2017. *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach*. New York: Guilford Publications.
He, J-w, Z-h Tu, L. Xiao, T. Su, and Y-x. Tang. 2020. "Effect of Restricting Bedtime Mobile Phone use on Sleep, Arousal, Mood, and Working Memory: A Randomized Pilot Trial." *PloS One* 15 (2): e0228756.
Hong, W., R. D. Liu, Y. Ding, X. Sheng, and R. Zhen. 2020. "Mobile Phone Addiction and Cognitive Failures in Daily Life: The Mediating Roles of Sleep Duration and Quality and the Moderating Role of Trait Self-Regulation." *Addictive Behaviors* 107: 106383. https://doi.org/10.1016/j.addbeh.2020.106383.
Hong, W., R.-D. Liu, T.-P. Oei, R. Zhen, S. Jiang, and X. Sheng. 2019. "The Mediating and Moderating Roles of Social Anxiety and Relatedness Need Satisfaction on the Relationship Between Shyness and Problematic Mobile Phone Use among Adolescents." *Computers in Human Behavior* 93: 301–308. https://doi.org/10.1016/j.chb.2018.12.020.
Judd, T. 2014. "Making Sense of Multitasking: The Role of Facebook." *Computers & Education* 70: 194–202. https://doi.org/10.1016/j.compedu.2013.08.013.
Karpinski, A. C., P. A. Kirschner, I. Ozer, J. A. Mellott, and P. Ochwo. 2013. "An Exploration of Social Networking Site use, Multitasking, and Academic Performance among United States and European University Students." *Computers in Human Behavior* 29 (3): 1182–1192. https://doi.org/10.1016/j.chb.2012.10.011.
Kuss, D. J., and M. D. Griffiths. 2011. "Online Social Networking and Addiction—A Review of the Psychological Literature." *International Journal of Environmental Research and Public Health* 8 (9): 3528–3552. https://doi.org/10.3390/ijerph8093528.
Mahoney, A. M., J. T. Dalby, and M. C. King. 1998. "Cognitive Failures and Stress." *Psychological Reports* 82 (3_suppl): 1432–1434. https://doi.org/10.2466/pr0.1998.82.3c.1432.
Nitschke, J. B., W. Heller, J. C. Imig, R. P. McDonald, and G. A. Miller. 2001. "Distinguishing Dimensions of Anxiety and Depression." *Cognitive Therapy and Research* 25 (1): 1–22. https://doi.org/10.1023/A:1026485530405.
Oviedo-Trespalacios, O., S. Nandavar, J. D. Newton, D. Demant, and J. G. Phillips. 2019. "Problematic Use of Mobile Phones in Australia … Is It Getting Worse?" *Frontiers in Psychiatry* 10: 105. https://doi.org/10.3389/fpsyt.2019.00105.
Panagiotidi, M., and P. Overton. 2020. "Attention Deficit Hyperactivity Symptoms Predict Problematic Mobile Phone Use." *Current Psychology* 41: 2765–2771. https://doi.org/10.1007/s12144-020-00785-2.
Poll, H. 2015. Pearson Student Mobile Device Survey 2014. Accessed November 2015;18.
Rast, P., D. Zimprich, M. Van Boxtel, and J. Jolles. 2009. "Factor Structure and Measurement Invariance of the Cognitive Failures Questionnaire Across the Adult Life Span." *Assessment* 16 (2): 145–158. https://doi.org/10.1177/1073191108324440.
Ree, M. J., D. French, C. MacLeod, and V. Locke. 2008. "Distinguishing Cognitive and Somatic Dimensions of State and Trait Anxiety: Development and Validation of the State-Trait Inventory for Cognitive and Somatic Anxiety (STICSA)." *Behavioural and Cognitive Psychotherapy* 36 (3): 313–332.
Richardson, M., Z. Hussain, and M. D. Griffiths. 2018. "Problematic Smartphone use, Nature Connectedness, and Anxiety." *Journal of Behavioral Addictions* 7 (1): 109–116. https://doi.org/10.1556/2006.7.2018.10.
Rozgonjuk, D., J. D. Elhai, O. Sapci, and C. Montag. 2021. "Discrepancies Between Self-Reports and Behavior: Fear of Missing Out (FoMO), Self-Reported Problematic Smartphone use Severity, and Objectively Measured Smartphone use." *Digital Psychology* 2 (2): 3–10. https://doi.org/10.24989/dp.v2i2.2002.
Rozgonjuk, D., J. C. Levine, B. J. Hall, and J. D. Elhai. 2018. "The Association Between Problematic Smartphone use, Depression and Anxiety Symptom Severity, and Objectively Measured Smartphone use Over one Week." *Computers in Human Behavior* 87: 10–17. https://doi.org/10.1016/j.chb.2018.05.019.
Tabachnick, B. G., and L. S. Fidell. 2007. *Using Multivariate Statistics*. Vol. 5. Boston, MA: Allyn and Bacon.
Toh, W. X., W. Q. Ng, H. Yang, and S. Yang. 2021. "Disentangling the Effects of Smartphone Screen Time, Checking Frequency, and Problematic use on Executive Function: A Structural Equation Modelling Analysis." *Current Psychology* 42: 4225–4242. https://doi.org/10.1007/s12144-021-01759-8.
Vahedi, Z., and A. Saiphoo. 2018. "The Association Between Smartphone use, Stress, and Anxiety: A Meta-Analytic Review." *Stress and Health* 34 (3): 347–358. https://doi.org/10.1002/smi.2805.
Van Deursen, A. J., C. L. Bolle, S. M. Hegner, and P. A. Kommers. 2015. "Modeling Habitual and Addictive Smartphone Behavior." *Computers in Human Behavior* 45: 411–420. https://doi.org/10.1016/j.chb.2014.12.039.
Van Velthoven, M. H., J. Powell, and G. Powell. 2018. "Problematic Smartphone use: Digital Approaches to an Emerging Public Health Problem." *Digital Health* 4: 205520761875916. https://doi.org/10.1177/2055207618759167.
Wallace, J. C., S. J. Kass, and C. J. Stanny. 2002. "The Cognitive Failures Questionnaire Revisited: Dimensions and Correlates." *The Journal of General Psychology* 129 (3): 238–256. https://doi.org/10.1080/00221300209602098.
Xanidis, N., and C. M. Brignell. 2016. "The Association Between the use of Social Network Sites, Sleep Quality and Cognitive Function During the day." *Computers in Human Behavior* 55: 121–126. https://doi.org/10.1016/j.chb.2015.09.004.