The problematic use of smartphones in public

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THE PROBLEMATIC USE OF SMARTPHONES IN PUBLIC: THE DEVELOPMENT AND VALIDATION OF A MEASURE OF SMARTPHONE 'ZOMBIE' BEHAVIOR

Structured Abstract

Purpose

We have witnessed an evolution in the use of smartphones in recent years. We have been aware for some time of the potentially deleterious impact of smartphones on users' lives and their propensity for user addiction, as reflected in the large and growing body of work on this topic. One modern phenomenon – the distracted mobile phone user in public, or 'smartphone zombie' – has received limited research attention. The purpose of the present study is to develop a robust measure of smartphone zombie behavior.

Design/methodology/approach

The research deign comprises three studies: A round of focus groups (*n*=5) and two online surveys (survey one *n*=373, survey two *n*=386), in order to develop and validate a three-factor, 15-item measure named the *Smartphone Zombie Scale* (SZS).

Findings

Following the round of focus groups conducted, Exploratory Factor Analysis and a Confirmatory Factor Analysis, the SZS measure (Cronbach's α = .932) is demonstrated to be robust and comprises three factors: *Attention Deficit* (Cronbach's α = .922), *Jeopardy* (Cronbach's α = .817), and *Preoccupation* (Cronbach's α = .835), that is shown to be distinct to existing closely related measures (Smartphone Addiction scale and Obsessive Compulsive Use).

Originality

The present study represents the first extant attempt to produce a measure of smartphone zombie behavior, and provides us with a reliable and valid measure with which we can study this growing phenomenon.

Keywords: Problematic smartphone use; Smartphone zombies; Public use of smartphones; Scale development.

Paper type: Research paper.

INTRODUCTION

Smartphones are pervasive in contemporary society; worldwide smartphone subscriptions exceed six billion and is estimated to rise a further several hundred million in next few years (O'Dea, 2021). In the USA, 97% of adults have a cell phone of some kind and 85% have a smartphone (Pew Research Center, 2021), while around half of American teenagers believe they have an addiction to their phone (Felt and Robb, 2016); other developed countries report comparable rates of problematic smartphone usage (Fischer-Grote *et al*. 2019). Both academics and the media have likened heavy smartphone usage to hypnosis or like being in a trance (Colic-Peisker and Flitney, 2018). While the Internet has traditionally been the principal subject of attention for studies of problematic behavioral outcomes and technology addiction (De-Sola Gutiérrez *et al*. 2016), in recent years cell phone technology – and particularly the advent of the smartphone – has supplanted the Internet as a prime potential source of addictive behavior (Lane and Manner, 2011; Lin *et al*. 2015), with recent studies indicating problematic smartphone use increasing globally (e.g., Olson *et al.,* 2022). One might argue that smartphone addiction is more important to study and understand than problematic Internet use as they offer a mobile computing platform (with GPS navigational services and Web browsers) with an ease of portability compared with other computing devices such as tablets and laptops, and addiction may therefore be more severe (Barnes *et al*. 2019; Jeong *et al*. 2016; Demirci *et al*. 2014; Kwon *et al*. 2013).

Since the introduction of the smartphone, numerous articles have been published on problematic usage and addiction. These focus on various facets of smartphone usage and addiction. However, an exploration of the distracted smartphone users' behaviour in public spaces is missing, which will help to clarify the psychology of distracted individuals and identify antecedents and outcomes of their behaviors. Hence, in a departure from previous empirical studies, the present study examines this problematic contemporary phenomenon:

distracted users of smartphone in public spaces – or so-called ‘smartphone zombies’ (Kim *et al*. 2018). The purpose of this paper, therefore, is to develop a valid and reliable multi-item, multi-factor, measure of smartphone zombie behavior that is related to, but distinct from, existing popular measures (the Smartphone Addiction scale and the Obsessive Compulsive Use scale), and that captures key smartphone zombie behavior. This would seem of importance owing to the growing dependence and fixation on smartphones and a proportion of pedestrians who are absorbed with their smartphone screens to such an extent that they are often oblivious to their environment and potential risks when in public, and with the significant number of reports in the media of accidents and injuries due to pedestrians distracted by their smartphones (Miciek, 2020). In addition, people tend to underestimate the amount of time spent on their smartphone (Lee *et al*. 2017) and heavy smartphone users report greater distortions in the perception of their screen time than do light smartphone users (Lin *et al*. 2015), suggesting intense smartphone use, and thus any associated issues, may be under-reported. This behavior might be harmful in private, but when extended to public spaces the lack of situational awareness and reduced attention can put smartphone users at significant risk (Kim *et al*. 2018). Further, modern urban environments are frequently not conducive to distracted smartphone users with their busy intersections and heavy traffic, street furniture, cycle lanes and high foot-fall of pedestrians, which all represent obstacles that might cause accidents to distracted users.

This research will make a significant contribution to extant knowledge, providing a robust Smartphone Zombie scale that is related to, but distinct from, related measures of smartphone behavior, and crucially, captures the behavior around the risks associated with public smartphone use, a relatively new phenomenon that is not captured in earlier measures. In this sense the Smartphone Zombie scale is needed because our traditional measures of problematic phone and computer usage present some limitations around the specific behaviors being measured in subtle, but important, ways.

The study is structured in the following way. Following this introduction, we examine the small body of work on distracted users of smartphones in public and smartphone zombies. The remainder of the study provides a series of robust tests (five focus groups and two online surveys) to develop a multi-dimensional measure of smartphone zombie behavior. The paper concludes with a discussion of the methodological, theoretical and policy implications of the study and suggestions for future research.

PREVIOUS RESEARCH ON SMARTPHONE ZOMBIES

Prior research on problematic smartphone (over)use is wide-ranging and comprehensive, with almost two decades of research on the subject (Jang, 2002). As Barnes *et al*. (2019: 247) note "Various facets of smartphone addiction have been examined and published in recent years, with an emphasis on the drivers of problematic smartphone usage", concluding that "smartphones may represent the preeminent technological device encouraging addiction for our time." Recent years has witnessed an abundance of studies published on the topic examining various facets of problematic smartphone usage (see, for example, Mason *et al.,* 2022; Busch and McCarthy, 2021; Geng *et al.,* 2021; Chen *et al*. 2019; Elhai *et al*. 2018; Lin *et al*. 2017; Nolin and Olson, 2016; Jeong *et al*. 2016; Sapacz *et al*. 2016; Samaha and Hawi, 2016; Cho and Lee, 2015; Al-Barashdi *et al*. 2015; Pearson and Hussain, 2015), which can result in negative outcomes such as lower well-being, loss of autonomy, impulsivity, alcohol use, anxiety and depression (Horwood and Anglim, 2019; Grant *et al*., 2019; Elhai *et al*., 2017). The present study takes a novel departure from this related body of research and examines the contemporary phenomenon of distracted users of smartphone in public spaces – the 'smartphone zombie'.

Since the introduction of the smartphone, observable changes in human behavior when walking in urban areas have been evident; scores of pedestrians can be seen interacting with a mobile device while simultaneously walking along a pavement, waiting at traffic lights, and even while crossing the street (Basch *et al*. 2015). These distracted pedestrians in a state of inattention have a "distinct gait reminiscent of the 'walking dead'" (Appel *et al*. 2019) and has entered the common lexicon under the label 'smartphone zombies' in academic studies (Duke and Montag, 2017) and in the media (Wang, 2018). While it is tempting to trivialize and dismiss this phenomenon, serious accidents involving people using smartphones whilst walking in public have been reported in numerous countries (Miciek, 2020; BBC News, 2017; Kim *et al*. 2017). With the portability and increased processing power of smartphones compared with other computing devices such as tablets and laptops, as well as the addiction and deep levels of cognitive absorption experienced by many users of smartphones (Barnes *et al*. 2019; Jeong *et al*. 2016; Demirci *et al*. 2014; Kwon *et al*. 2013), it is logical to conclude that the prevalence of distracted walking and smartphone zombie behavior is unlikely to diminish in the near future. Our understanding of this behavior, however, is highly limited.

To-date, distracted smartphone usage whilst walking in public has attracted limited (and disciplinary fragmented) research attention, with only a handful of empirical studies having been published across a broad number of scholarly domains. The largest body of research on distracted walking has examined the consequences of pedestrians being distracted by a smartphone while crossing a street, where individuals distracted by smartphone usage were less likely to cross a street safely (Yadav, *et al.,* 2022; Gruden *et al.,* 2021; Tontodonato and Drinkard, 2021; Horberry, Osborne and Young, 2019; Stavrinos *et al*. 2018; Lin and Huang, 2017; Thompson *et al*. 2013; Byington and Schwebel, 2013; Chaddock *et al*. 2012). Heavy users of smartphones experience a greater occurrence of accidents in comparison to low and moderate users (Kim *et al*. 2017). In an observational study of pedestrians walking in the street in a medium-sized Spanish city, Fernandez *et al*. (2020) found that certain population groups (especially young women) have a high risk of being involved in accidents due to smartphone usage whilst walking. A related body of research has examined the possibility of introducing smartphone-aided pedestrian safety devices (apps) to alert users of hazards and obstacles whilst walking in public (Goh *et al*. 2020; Zhuang and Fang, 2020; Kim *et al*. 2018; Hincapé-Ramos and Irani, 2014; Foerster *et al*. 2014; Wang *et al*. 2012). Indeed, Kashimoto *et al.* (2020) developed such an app to monitor smartphone zombie behaviors over a 15-day period, but their small sample (*n*=7; n=5 with complete data) limits the scope of their findings.

Outside of this body of research, we are left with an interesting but fragmented and largely unrelated series of studies. Based on a two-item measure of distracted walking, Appel *et al*. (2019), found that an individual's Fear of Missing Out on social contact (as developed by Przybylski *et al*. 2013) predicted distracted walking, being involved in a dangerous traffic incident whilst walking, and also the propensity to participate in virtual social interactions whilst walking, regardless of respondents' gender and age.

In a natural observation study in Ghent (Belgium), Argin and Turkoglu (2020) analysed 350 smartphone users amongst the crowd in a public space (pre-COVID). They identified specific characteristics of pedestrians who exhibited smartphone zombie behavior: Small in number, staring with intense attention at their smartphone screen, reading or typing, smartphone zombies occasionally stop to give their full attention to their screen, and walking as fast as any other pedestrian around them with inattention to their surroundings. They concluded that "'smartphone zombie' is more than a buzzword … [pointing to] the frequent presence of smartphone zombies in public spaces" (p.15), with such people having distinct behavioral characteristics in comparison to other members of the public.

In one final related study, Olson, Stendel and Veissière (2020) found a positive correlation between hypnotisability (a higher susceptibility to suggestion whilst under hypnosis, focused attention, and a reduced peripheral awareness – Elkins *et al*. 2015) and problematic smartphone use, in a Canadian student sample (*n*=641). Although not studying public behavior whilst using a smartphone, the findings of this study have interesting implications for the present study and why some people might engage in this potentially dangerous behavior; this was attributed to higher levels of absorption and time distortion experienced by some users whilst using a smartphone. This would suggest that some individuals are more susceptible to problematic smartphone use than others due to personal characteristics outside of hypnosis, such as being ‘fantasisers’ (e.g. fantasising much of the time, vivid imagery perceptions, having an earlier than average age for a first childhood memory), and ‘dissociators’ (e.g. daydreamers who experience ‘spacing out’ for prolonged periods with short-term memory loss) (Barrett, 1991; Wilson and Barber, 1981).

In summary, we can identify a small but nascent corpus of research on distracted smartphone usage whilst walking in public. This promising contemporary body of research, however, is fragmented and dispersed across a variety of scholarly fields/domains. The majority of the research in this new field has approached the topic from a perspective of safety and examines ‘distracted walkers’ and smartphone usage, with the remainder of the research on the topic being largely unrelated to one another. Research on these topics has spanned a number of domains, including geography, environmental psychology, health and wellbeing, behavioral addiction, child development, internet research, and psychiatry, among other areas, which would suggest a broad interest in the topic across the social sciences. The findings of these studies point to the problematic behavior of distracted walkers using smartphones in public, and, most importantly, that they have distinct behavioral characteristics and constitute a sub-set of problematic smartphone users, suggesting future research is warranted in order to understand this phenomenon.

We currently have a series of measures related to problematic smartphone use, namely: Problematic Mobile Phone Use scale (Lopez-Fernandez, Honrubia-Serrano, Freixa-Blanxart and Gibson, 2013), Kwon *et al*’s (2013) Smartphone Addiction scale, the measure of Obsessive

Compulsive Use (Turel *et al*. 2011; Pallanti *et al*. 2005), and the Computer Addiction scale (Charlton, 2002). While these measures are undoubtedly valuable, they do not examine problematic public smartphone use, nor can they easily be adapted to measure this phenomenon. The 26-item Problematic Mobile Phone Use scale places much of its emphasis on the time and attention spent on mobile phone usage rather than distracted, and public, usage. The 10-item Smartphone Addiction scale focuses on compulsion and distraction, but does not consider the jeopardy and consequences of smartphone usage in public. The 10-item Obsessive Compulsive Use measure is a general measure of mobile phone usage that places a heavy emphasis on compulsion. Finally, the 14-item Computer Addiction scale unsurprisingly focuses on addiction and touches in part on user withdrawal symptoms.

With the absence of a reliable and valid measure of smartphone zombie behavior, the remainder of this study, therefore, seeks to develop and validate a multi-item and multi-factor measure of smartphone zombie behavior, and to understand its relationship to closely related measures. The development of such a scale will aid researchers and practitioners to identify the extent to which individuals exhibit problematic use associated with smartphone zombie behavior, and help identify any potential danger in which individuals may be placing their selves.

DEVELOPMENT AND VALIDATION: THE SMARTPHONE ZOMBIE SCALE

Three phases of research were conducted to develop and validate the first Smartphone Zombie Scale (SZS), guided by the scale development principles proposed by Churchill (1979), Eastman, Goldsmith and Flynn (1999), Stewart and Segars (2002), Malhotra, Kim and Agarwal (2004), and Osatuyi (2015). We followed a sequential multi-method approach to scale development (see Table I). To specify the initial pool of items, we conducted a blended approach. First, an initial item pool (*n*=45) was generated using an academic panel and influence from the broader literature available. The items were then refined (*n*=26) after completing a series of focus group discussions with members of the public, before quantitative data collection commenced.

Second, a survey was constructed to gather data from participants (*n*=373) for these 26 items, perform exploratory factor analysis, ascertain factor loadings and reduce the number of items where appropriate. Third, a second survey was undertaken (*n*=386) to perform confirmatory factor analysis, determine the convergent and discriminant validity, and examine the nomological validity of the SZS with related constructs from the extant literature – a process resulting in 15 scale items across three factors.

The scale development process followed was consistent with the literature on scale development (e.g. Churchill, 1979; Eastman *et al*. 1999; Stewart and Segars, 2002; Malhotra *et al*. 2004, and Osatuyi, 2015). Common method bias was considered in the design of the surveys in accordance with Viswanathan and Kayande (2012), noting that distinct samples were collected between research phases, reducing potential effects. Randomisation of the presentation of scale items was applied, and consideration was given to ensure the measurement instrument was neither overly laborious, nor too concise, as to cause response fatigue or validity issues, respectively. The results of the three studies are discussed in subsequent sections.

Table I about here

STUDY ONE: FOCUS GROUPS AND DEVELOPMENT OF SCALE ITEMS

Focus groups are valuable research methods to explore issues based on participants' own experiences. Additionally, using focus groups to inform the subsequent development of quantitative survey instruments is useful to develop items, refine the generated items and enhance the content validity of survey instruments (Nassar-McMillan *et al.* 2010).

In this study, we conducted five focus groups with 30 participants in total. Participants were all members of a British university, either student or staff, and awarded a gift card for their participation. Pre-screening criteria were employed to make sure all participants were active smartphone users. Group sizes were between 4 and 7 in accordance with the optimum group size for focus groups (Krueger and Casey, 2014). In total, there were 23 female and 7 male participants. Detailed information on focus groups and participants is summarised in Table II.

Table II about here

The focus groups were conducted with two moderators following the guidelines for dual moderator focus groups (Krueger and Casey, 2014). Each focus group started with one of the moderators explaining the purpose of the study and clarifying the ethical considerations (e.g. confidentiality, data storage). The remainder of the discussions were organised in a semi-structured way with both of the moderators asking questions based on the initial item pool, and probing participants to interact with each other and participate in the discussion. The focus groups were audio recorded after seeking permission from all of the participants and these recordings were then fully transcribed.

Participants were asked to elaborate on the ways they engaged, or observed others to engage, in smartphone zombie behaviors to ensure the initial item pool generated by the academic panel was consistent with their definitions. The respondents recognised the concept of the smartphone zombie as a sub-set of problematic smartphone users distracted in public, and although none of them felt that this was behavior they themselves exhibited, they had all witnessed such behavior in public including accidents and falls with distracted users of smartphones, noting that "*they* [distracted users] *do cause accidents*" (Group 4, Female, 37). This narrative, however, is questionable as several of the respondents described their use of smartphones in public that seemed consistent with distracted use: "*it's not like we don't consider it important, it's just that we trust ourselves in that situation*" (Group 1, Male, 19); **"***I will like slow down a little as well just to not bump into something*" (Group 1, Male, 20); and "*there has been a couple of times when it's a combination of me being late and receiving an important email so I had to check, I actually had to reply formally, and then it's the case of almost bumping into someone, realising they are 3-4 feet away and then moving around*" (Group 2, Male, 21).

The focus group participants touched on a broad number of subjects, including the importance of self-regulation: "*I don't text, or even if I do text or email, I will stop for this, I don't walk and text let's say that, because I'm afraid if I do this I will not be aware of the situation around me*" (Group 2, Female, 25); and "*when waiting to the cross the road or something I have a look* [at my phone] *and then put it back. If there is something important I will just like step back by the wall and then send it and then keep it back*" (Group 2, Female, 23). Personal safety and avoiding accidents were also mentioned by several participants: "*you need to have a good sense of your environment especially late at night if you are walking*" (Group 5, Female, 22).

Finally, a member of the focus groups with a young family reflected on the importance of setting an example to her children: "*I notice that there are people on their phone and as a driver you know you can see them but they cannot see you because they are walking along, looking at their phone, not looking up… so actually it can cause accidents. I don't want my kids to see me walking along when I'm with them using my phone*" (Group 4, Female, 39).

In sum, the focus groups provided rich insights into distracted smartphone users walking in public, and demonstrated that all items were easily understood by the participants. Subsequent coding of the transcripts resulted in three broad themes: 1) lack of attention to surroundings, absentmindedness and being immersed, 2) personal safety and risk of harm to self or others due to accidents, 3) constant engagement with their smartphone and distraction due its notifications. Based on the findings of the focus groups, a discussion amongst the research team identified that some of the items were redundant and this led to a reduction in the number of items in the measure (*n*=26). The findings of the two surveys conducted are reported next.

STUDY TWO: SURVEY ONE – EXPLORATORY FACTOR ANALYSIS

A Qualtrics survey was designed asking participants for basic demographic details, and responses to the 26-item smartphone zombie scale. Specifically, participants were asked, "To what extent do you agree with the following statements?", followed by the 26-items. Responses were given using a 5-point Likert scale (5 = Strongly Agree).

Participants were collected using prolific.co, a survey panel tool that pays a responsible hourly rate (pro-rata) for each survey response. Selection criteria were limited to those with a smartphone, over 18 years of age and in four native English speaking countries: UK, Ireland, Canada, and USA. No other selection criteria were used. Initial data (*n*=407) were cleaned to remove incomplete responses, those who failed attention checks and those who completed the survey in extremely short time-periods, resulting in 373 usable responses.

Participants comprised 263 females, and 110 males. The majority of participants were from the UK (*n*=337; 90.3%), with 18 (4.8%) from Ireland, 9 (2.4%) from Canada, and 9 (2.4%) from the USA. Age and education are reported in Table III.

Table III about here

Analysis

The 26-items demonstrated an initial strong internal consistency (Cronbach's α = .943). An exploratory factor analysis (EFA) was conducted using SPSS. Principal Axis Factoring was selected as the items were to be examined to identify latent factor(s), which cannot be directly measured (Costello and Osborne, 2005). Principal axis factoring is also useful when normality cannot be assumed (Fabrigar, Wegener, MacCallum and Strahan, 1999), which with a scale intended on measuring abnormal behaviors, is appropriate. Direct Oblimin rotation was used as the items were expected to be correlated with one another (Worthington and Whittaker, 2006). The Kaiser-Meyer-Olkin measure of sampling adequacy was .949, indicating that the sample size was 'superb' for the factor analysis performed (Field, 2009: 788), and Bartlett's test of sphericity was significant (p < .001), suggesting factor analysis was appropriate to conduct (Kim, Barasz and John, 2018).

The analysis resulted in three factors, accounting for 51.04% of the variance observed – noting 40-50% is deemed 'adequate' (Gorsuch, 1983 cited in Guay, Vallerand and Blanchard, 2000: 184); factor 1 = 40.35%; factor 2 = 7.38%; and factor 3 = 3.31%. Using the rotated factor matrix, items with loading weights < 0.5, and items loaded on more than one factor were not included in the factor structure (Kim *et al*. 2018; Aaker, 1997). Two items were therefore removed resulting in a three factor, 24-item scale, with a strong internal consistency (Cronbach's α = .939; see Table IV for the complete 26-item set). Factor 1 (Cronbach's α = .919) encapsulated the extent to which participants were inattentive to their surroundings and was subsequently labelled 'Attention Deficit'. Factor 2 (Cronbach's α = .870) represented the extent to which participants put their self at risk of harm or injury because of their smartphone use and was therefore labelled 'Jeopardy'. Factor 3 (Cronbach's α = .827) represented items which demonstrated participants being preoccupied by the use and alert mechanisms of their phone and was labelled 'Preoccupation'.

Table IV about here

STUDY THREE: SURVEY TWO – CONFIRMATORY FACTOR ANALYSIS, VALIDITY AND RELIABILITY

In order to validate the identified three factor, 24-item structure of the Smartphone Zombie Scale, a further data set was collected. In addition to basic demographics and the SZS, two other validated scales were used to test the relationship of the SZS with similar, known constructs to demonstrate nomological validity. The measures included Kwon *et al*'s (2013) Smartphone Addiction scale and the Obsessive Compulsive Use scale (Turel *et al*. 2011; Pallanti *et al*. 2005). For the Obsessive Compulsive Use scale, participants were asked "To what extent do you agree with the following statements?", followed by the scale. Responses were given on a 5-point Likert scale (5 = strongly agree). Due to the nature of the wording for the items on the Smartphone Addiction Scale, participants were asked instead, "To what extent do you agree that the following statements reflect you and/or your behavior?", to which participants responded using the same 5-point Likert scale. Both scales were adapted to the context of the present study while ensuring that the original meaning of the scale and its items were retained.

Participants were recruited using prolific.ac using the same selection criteria as Study Two, with the added exclusion that they could not have participated in Study Two, to ensure an independent sample for the provision of validity and reliability metrics for the SZS. A total of 417 responses were collected, which were cleaned using the same procedure as Study Two (*n*=386).

Participants were 284 females, and 102 males. Participants were predominantly from the UK (*n*=325; 84.2%), with 24 (6.2%) from Ireland, 14 (3.6%) from Canada, and 23 (6.0%) from the USA. Age and Education are reported in Table V.

Table V about here

Analysis

For rigour, a further identical EFA to Study Two was undertaken. This demonstrated an identical factor structure, with no indication of further item removal, and supported the reliability of the core construct with a new participant sample. Harman's Single Factor test was conducted to assess common method variance, and indicated a single factor to be responsible for 40.35% of total variance, sufficiently below the cut-off value of 50.00% (Marder *et al.* 2018).

To confirm the three factor, 24-item SZS identified in Study Two, confirmatory factor analysis (CFA) was performed. CFA was conducted using the consistent PLS (PLSc-SEM) procedure in SmartPLS 3, rather than covariance based (CB-)SEM (e.g., in AMOS). The nature of the SZS will produce non-normally distributed data, further compounded through the use of ordinal Likert-scales, to which PLS-SEM is suited (see Garson, 2016). PLS-SEM does not rely on the same assumptions regarding distribution of data (ibid) and can produce bias-corrected bootstrap results, as well as validity tests such as the Heterotrait-Monotrait (HTMT) ratio, which is robust at detecting violations of discriminant validity (Henseler, Ringle and Sarstedt, 2015). Specifically, the use of PLSc-SEM (cf. PLS-SEM) ensures the advantages of PLS-SEM are retained, but also mimics the process and approach of CB-SEM for factor structures (see Hair *et al* 2016, p.300-305), making it a suitable tool for CFA with this specific data set.

The model was defined as a reflective model, with the specified items reflecting the three factors as latent variables (9 for Attention Deficit; 10 for Jeopardy; 5 for Preoccupation, see Table IV). Analysis was conducted using the factor-weighting procedure and significance calculated using complete, bias-corrected bootstrapping set to 10,000 samples.

SRMR is reported as .063, which is below the more stringent accepted cut-off value of .08 (Hu and Bentler, 1999) as well as the moderate criteria of .10 (Garson, 2016), and represents a good model fit. However, the Normed Fit Index (NFI) was <.9, suggesting a better fitting model may be available (Bentler, 1992). Multi-collinearity was assessed using the outer Variance Inflation Factors (VIFs) for each scale item, which were all within the accepted range of 0.2-5.0 (Hair *et al*. 2016), ranging from 1.453-2.889. Convergent validity is confirmed by examining the Average Variance Extracted (AVE), composite reliability and Cronbach's α for each latent variable (see Table VI). The AVE values for two of the latent variables (factors) were above the minimum threshold of 0.5 (see Garson, 2016, p. 65), with one factor (Jeopardy) scoring 0.483, suggesting it to be slightly problematic. Strong reliability is demonstrated using both the composite reliability and Cronbach's α values for each factor. Overall (24-item) reliability is confirmed (Cronbach's α = .939).

Table VI about here

Discriminant validity was confirmed using both the Fornell-Larcker criteria, and the HTMT ratio. The Fornell-Larcker criteria assesses the square root of AVE against the latent variable (factor) correlations. Discriminant validity is achieved when the square root of AVE for a specific factor is greater than the correlation coefficient of any correlation involving that specific factor with any other factor (Fornell and Larcker, 1981; Garson, 2016: 67). The values in Table VII demonstrate discriminant validity using this criteria. The HTMT ratio confirms discriminant validity to have been achieved if the ratio is <.9 between any two factors (Garson, 2016; Henseler, Ringle and Sarstedt, 2015). All values were demonstrated to be below this limit, ranging from .555 to .753.

Table VII about here

Having examined the factor structure, convergent and discriminant validity, and reliability, we examine the individual item loadings on each factor (Table VIII). Fifteen of the 24 items achieved the ideal accepted loading of >.7, with nine items identified as loading <.7 for their respective factor. Given the proportion of low item loadings (9/24, 37.5%), the low NFI value for model fit and discriminant validity weakness for the factor *Jeopardy* (AVE <.5), re-specification of the Smartphone Zombie Scale was considered appropriate.

Table VIII about here

Scale re-specification

The nine items with loadings <.7, identified in Table VIII, were removed from the factor structure, and the reflective model re-analysed with 15-items using the same processing criteria as the original 24-item CFA. The factors *Attention Deficit*, *Jeopardy* and *Preoccupation* comprised 8, 4 and 3 items respectively.

SRMR = .039, significantly below the more stringent accepted cut-off value of .08 (Hu and Bentler, 1999), and NFI = .926, noting 'excellent models having NFI values above .9 or so' (Bentler, 1992, p.401), both indicating an improved model fit over the 24-item scale. All outer VIF values were within the accepted range of 0.2-5.0 (Hair *et al.* 2016), specifically in the range of 1.601-2.870.

Convergent validity is confirmed using AVE, composite reliability and Cronbach's α (see Table IX). The AVE values all factors were above the minimum threshold of 0.5 (see Garson, 2016, p. 65), an improvement on the previous model. Reliability is demonstrated using both the composite reliability and Cronbach's α values for each factor. Overall (15-item) reliability is also confirmed (Cronbach's α = .932).

Table IX about here

The Fornell-Larcker criteria (Table X) was assessed for discriminant validity. The square root of AVE for Attention Deficit was smaller than the correlation of Attention Deficit with Preoccupation, suggesting that these two factors do not discriminate from one another sufficiently, although the values are close. Next, the HTMT ratio was assessed, which according to Henseler, Ringle and Sarstedt (2015) is better at detecting violations of discriminant validity. All HTMT values were below the limit of 0.9, ranging from .673 to .777, suggesting the scale to have sufficient discriminant validity.

Table X about here

Having examined the factor structure, convergent and discriminant validity, and reliability of the scale, we examined the individual item loadings on each factor (Table XI). Only two of the item loadings were $<.7$, but were still $>.6$, so were retained.

Overall, considering the improved model fit, greater convergent validity, substantial reliability and acceptable discriminant validity, we consider this to be a reasonably robust factor structure for the Smartphone Zombie Scale.

Table XI about here

Nomological validity

To achieve nomological validity, a scale needs to demonstrate reasonable closeness to theoretically similar, yet distinct, constructs within its wider 'nomological network' (Malhotra *et al* 2004). As noted above, the underlying theoretical conceptualisation of the SZS is that the examined behavior is similar to, but distinct from, that of addiction, obsession or compulsive use. Two scales in particular were related to these constructs and remain in the theoretical network of the definition of a Smartphone Zombie, but also remain conceptually distinct. The 10-item Smartphone Addiction scale (Kwon *et al* 2013) focuses on compulsion and distraction, but does not consider the jeopardy and consequences of smartphone usage in public. The 10-item Obsessive Compulsive Use scale (Turel *et al* 2011; Pallanti *et al* 2005) is a general measure of mobile phone usage that places a particular emphasis on compulsion, which is related to subjects feeling the need to check their smartphones, but is still distinct from the overall concept of being a Smartphone Zombie.

Therefore, to assess nomological validity a Spearman's correlation was conducted between the full Smartphone Zombie Scale (all 15-items), each factor of the Smartphone Zombie Scale, and Obsessive Compulsive Use and the Smartphone Addiction scale. Results are given in Table XII, and demonstrate a significant correlation (99.9% CI) between all scales. While these relationships are significant, and thus demonstrate similarity to constructs in the nomological network of Smartphone Zombies, the factors of the Smartphone Zombie Scale correlate more strongly with Smartphone Zombies (15 item) than with Obsessive Compulsive use or Smartphone Addiction, and the full Smartphone Zombie Scale (15 items) correlates only moderately with Obsessive Compulsive Use (rho = .532) and Smartphone Addiction (rho = .633).

Table XII about here

CONCLUSIONS AND IMPLICATIONS

As Rudi Volti (1995: 3) has observed "[our] inability to understand technology and perceive its effects on our society and on ourselves is one of the greatest, if most subtle, problems of an age that has been so heavily influenced by technological change." Smartphone technology is a key example of what Mick and Fournier (1998) refer to as a 'paradox of technology'; technology that has the potential to be both emancipating and enslaving concurrently. Smartphones allow us to easily communicate and socialise, as well as search for information and undertake tasks in ways almost inconceivable two decades ago; smartphone technology, however, can also lead to deleterious user outcomes such as user dependency (Barnes, Pressey and Scornavacca, 2019). As such, understanding the contemporary phenomenon of smartphone zombies, particularly in urban areas, would seem an issue of importance.

The purpose of the three present studies was to develop and validate a measure of Smartphone Zombie behavior. Study One demonstrated that respondents felt strongly that Smartphone Zombies were a distinct sub-set of individuals who dangerously extended their problematic smartphone usage into the public sphere, and helped establish the key themes related to this behavior. Studies Two and Three provide strong support for the psychometric properties of the Smartphone Zombie Scale. First, results from exploratory and confirmatory factor analyses revealed that the SZS has a three-factor structure: Attention Deficit, Jeopardy and Preoccupation. Second, the internal consistency values for each subscale were satisfactory. Third, the convergent and discriminant validity of the SZS was supported through the results of the multiple analyses undertaken. Finally, the nomological validity of the SZS in its theoretical network with Smartphone Addiction and Obsessive Compulsive Use was also confirmed. These findings lead to a series of methodological, theoretical and policy implications, which are detailed below. We also conclude by outlining the limitations of the present studies and suggest areas for future research that merit attention.

Methodological Implications

The most significant methodological implication of the present studies is the empirical support for a new instrument that measures an aspect of problematic smartphone usage that has not previously been studied. The introduction of the multidimensional 15-item SZS therefore overcomes the limitations of related scales that were not designed to measure problematic smartphone usage in public that are popular among researchers, such as Problematic Mobile Use, Smartphone Addiction, Obsessive Compulsive Use, and Computer Addiction. These earlier measures are well-placed to capture general behavior and attitudes around problematic smartphone and computer usage, but not particularly well suited to examine problematic public behavior. In addition, many of these earlier related studies are unidimensional and based on young adult subjects (often college students), while the SZS is based on data from subjects with a broader age span as well as a variety of educational backgrounds, more representative of the general public.

As the SZS measures a facet of problematic smartphone usage not covered by these earlier studies and measures, this, therefore, presents researchers with the possibility of a new trajectory of research around public problematic smartphone usage that appears to be growing. Given the increased media reports of smartphone zombie behavior across the world, including in diverse cultural settings (see, for example, Hayward, 2019; Park, 2021; Robertson, 2016; Sharp, 2015; Squires, 2022), the introduction of a measure would appear timely. The SZS provides us with an instrument to measure with more precision the problematic public behavior of individuals and information and communications technology, and their attention deficit, exposure to jeopardy, and general preoccupation.

Theoretical Implications

This study provides a number of theoretical contributions. First, to the best of our knowledge, the SZS is the first robust scale to measure problematic smartphone usage in public. This scale is related to, but distinct from, related measures of smartphone behavior, and crucially captures the public behavior around Attention Deficit, Jeopardy and Preoccupation. In so doing, we have established a valid and reliable new scale to measure the relatively new phenomenon of problematic smartphone usage in public that is not captured in earlier measures. In this sense the SZS is needed because our traditional measures of problematic smartphone and computer usage present some limitations around the specific behaviors being measured in subtle, but important, ways.

Some individuals are clearly extending their problematic smartphone usage from private spaces (such as the home) to public spaces, such as the classroom, offices, as well as when walking in public or crossing a road. We can speculate that these individuals are experiencing a Fear of Missing Out (Appel *et al*. 2019; Przybylski *et al*. 2013) to a heightened extent, and possibly being “sucked down a rabbit hole of unproductivity” (Newport, 2019) or “into some mindless … black hole” (Lukoff *et al*. 2018). People frequently report a loss of self-control related to using their phone (Lukoff *et al*. 2018), particularly if they regard themselves as being addicted to using them (Tossell *et al*. 2015).

Writing some time ago, psychologist Stanley Milgram (1970) wrote an early theoretical piece concerning the psychology of living in cities, highlighting the challenge of individuals as they are exposed to an abundance of social stimuli leading to overload and 'urban stress' (Glass and Singer, 1972). Consequently, distracted walking and smartphone zombie behavior could also be considered as a method to manage the vast amount of social stimuli experienced in most urban areas (Appel *et al*. 2019).

Policy Implications

The present study has a number of policy implications as well as wider implications for technology usage and society more generally. Smartphone zombie behavior might seem trivial when we see clips online of humorous trips and falls when pedestrians are not paying attention in public, but it is clearly not amusing when pedestrians are seriously hurt or even lose their lives. For example, in 2018 in Great Britain, 25% of all fatalities by road user type (454 deaths) were pedestrians – the second highest category after car occupants – and the number of pedestrians killed or seriously injured on Britain's roads in that year alone was 6,710 (Department for Transport, 2019). In comparison, in the US pedestrian deaths increased by 35% between 2008 and 2017, and distracted walking while using a smartphone has been identified as a contributory factor for some of these fatalities (Miciek, 2020). While we do not know how many of these accidents can be attributed to distracted smartphone usage, we can speculate that this may have played a role in some accidents. Consequently, it would seem of merit to understand the causal factors of distracted public smartphone usage.

Many of the apps available on smartphones are designed to be deliberately addictive; the trigger-action-reward design of many social media apps creates a self-validating feedback loop with functions including 'share' and 'like' (and other customer engagement functions, see Naqvi *et al*., 2020), with some companies drawing on neuroscience and artificial intelligence techniques to design apps. This has created an 'attention economy', where developers compete to capture users' data and drive advertising revenue, which provide a strong economic incentive to keep them immersed and absorbed, and to make smartphone usage automatic behavior (Wu, 2017). These features might lead to smartphone overuse in private (akin to web features in gamification, see Naqvi *et al*., 2021), but in public it could distract users and expose them to possible accidents and injury. Our civic infrastructure is frequently not designed to take into account 'shared space', particularly in some urban areas, where there might be heavy traffic, busy public transport lanes, cyclists, intersections, street furniture, and a high foot-fall of pedestrians in close proximity. Products such as Google Glass (smart glasses) may reduce the potential for harm to pedestrians as a safer alternative to the smartphone in urban areas, or the mandatory use of apps on smartphones that warn users of obstacles or else uses GPS navigational services to alert users to their proximity to busy roads and intersections (see Kim *et al*. 2018). Research examining the practical implications of such interventions should be encouraged.

Research has shown that smartphone addiction rates have increased globally in teenagers and young adults in recent years (Olson *et al*. 2022). People tend to benefit psychologically if they walk with a friend in an urban environment (Johansson *et al*. 2011). If no friend is available (and given that many people would not favour solitary walking – particularly at night), smartphones provide an obvious substitute for people to talk to others or else interact on social media platforms – even if the psychological benefits are outweighed by risks to health and safety (Appel *et al*. 2019). Given the ubiquity and diffusion of smartphones – particularly in the developed world – it would seem unlikely that distracted public smartphone use is likely to decline in the coming years; therefore, the public policy risk that this presents could be a very real and disturbing one.

Limitations and Future Research Directions

Although the present study provides strong support for the psychometric properties of the SZS, there are several limitations that need to be taken into consideration when interpreting the findings of the study. Initially, two surveys administered were based on a self-report instrument, which have many advantages, but can potentially suffer from a number of disadvantages including respondent exaggeration of behaviors, social desirability bias, and rely on voluntary participation (Northrup, 1996; Garcia and Gustavson, 1997; Heppner, Wampold, Owen, Thompson, and Wang, 2016). Next, one confirmatory survey was administered, and replication studies will be needed to ensure construct validity and internal consistency values. Our three studies are also grounded in Western data and subjects; while smartphone zombie behavior is being reported across diverse cultural settings, it may be the case that such behaviors might differ between some countries owing to potential cultural differences or variations in behavior. Finally, the samples for both of the surveys administered, as well as the focus groups conducted, comprised more female respondents than males, and may have some degree of bias not present in a more balanced sample.

Several promising theoretical directions for future research present themselves. These, include – but are not limited to – understanding the antecedents and outcomes of smartphone zombie behavior, as well as the psychology of individuals with these behaviors and their motivations (e.g., susceptibility to hypnotisability) and psychological needs (e.g. fear of missing out). It would be of interest to know if smartphone zombie behavior persists over the life span of an individual or if it is heightened at key periods (e.g., socialization at high school and college), as well as the extent to which this is a problem across age groups, gender and level of education. Given the increase in the use of social networking sites in recent years (Jiang *et al.*, 2020; Naqvi *et al.,* 2019; Naqvi *et al.,* 2020;; Yushi *et al.,* 2018), it would also be valuable to understand the relationship between smartphone zombie behavior and design characteristics of social media apps.

The addition of the SZS presents a potentially new trajectory for research on one important aspect of problematic smartphone usage – the use of mobile technology in public places. While additional research needs to be conducted on the SZS – particularly in terms of replication studies to establish its validity across cultural settings – the present study indicates that the scale has satisfactory psychometric properties and has the potential to be useful in studying problematic smartphone usage in public. We currently have no accurate data related to users distracted by smartphones while walking in public. Given, however, that smartphone usage practices are evolving swiftly, more detailed information and insight would seem necessary.

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Table I: Scale Development Process

Study	Method	Instrument	Sample	Purpose
One	Qualitative analysis	Focus groups	Five groups *n*=30	Item refinement (*n*=26)
Two	Quantitative study one	Survey one	*n*=373	Exploratory Factor Analysis (*n*=24)
Three	Quantitative study two	Survey two	*n*=386	Confirmatory Factor Analysis, Validity and Reliability (*n*=15)

Table II – Demographic Profile of Focus Participants

	Focus Group Number					
	One	**Two**	**Three**	**Four**	**Five**	**Total**
Length	52 min 16 sec	59 min 30 sec	1 hr 05 min 27 sec	1 hr 10 min 01 sec	59 min 17 sec	5h 06 min 31 sec
Group Size	6 participants	7 participants	7 participants	4 participants	6 participants	30 participants
Participants' gender	3 female 3 male	5 female 2 male	7 female	4 female	4 female 2 male	23 female 7 male

Table III: Participant Age and Education for Study Two

	n	%
Age (Years)		
18-24	87	23.3
25-34	152	40.8
35-44	80	21.4
45-54	35	9.4
55-64	18	4.8
65+	1	0.3
Education		
High School	140	37.5
Undergraduate degree	150	40.2
Postgraduate degree	68	18.2
Other	15	4.1

Table IV: EFA Item Loadings for 26-Item Scale

Item	Attention Deficit (α = .919)	Jeopardy (α = .870)	Preoccupation (α = .827)
I am sometimes inattentive when using my smartphone in public	*.707*		
I sometimes feel guilty for not paying attention to things around me when using my smartphone in public	*.691*		
I sometimes feel guilty about not paying attention to my surroundings when using my smartphone	*.674*		
I sometimes feel I lack attention to my surroundings when using my smartphone in public	*.814*		
I am sometimes oblivious of my surroundings when using my smartphone in public	*.795*		
I am sometimes absentminded when using my smartphone in public	*.639*		
When using my phone I often find myself not paying attention to my surroundings	*.805*		
I usually filter out my surroundings when using my phone	*.650*		
I have lost sense of my surroundings while using my smartphone	*.660*		
***I have sometimes been negligent while using my smartphone in public	.407	.380	
***I have put myself at risk by being distracted by my smartphone while walking in public	.316	.446	
I have fallen down steps in public while I was using my phone		*.644*	
I have had an injury when using my smartphone by not paying attention to my surroundings		*.703*	
I have injured someone else by being distracted when using my smartphone in public		*.701*	
I sometimes put my wellbeing in jeopardy while being on my smartphone in public		*.476*	
I have accidentally walked in front of a car while using my smartphone		*.642*	
I have been late to a meeting or class due to focusing on my phone while out walking		*.432*	
I have put other people at risk by being distracted by my smartphone while walking in public		*.512*	
I have occasionally unintentionally stepped into the road when using my smartphone		*.594*	
I have tripped in public while using my smartphone because I have been preoccupied		*.488*	
I have had an accident (a trip or a fall) when using my phone at home		*.641*	
I am often preoccupied with my smartphone while walking in public			*.533*
I obsessively check my smartphone when walking in public			*.705*
I am often distracted by my smartphone (e.g. checking updates) when walking in public			*.552*
When I hear my phone notification while I am walking I feel compelled to check it			*.521*
When I am walking in public I always carry my phone so that I can check notifications and updates			*.635*

NB: Cronbach's alpha values based on refined 24-item structure. ***item removed.

Table V: Participant Age and Education for Study Two

	n	%
Age (Years)		
18-24	97	25.1
25-34	133	34.5
35-44	94	24.4
45-54	46	11.9
55-64	14	3.6
65+	2	0.5
Education		
High School	171	44.3
Undergraduate degree	157	40.7
Postgraduate degree	49	12.7
Other	9	2.3

Table VI: Convergent Validity and Reliability

Factor	AVE	Cronbach's Alpha	Composite Reliability
Attention Deficit	*.580*	*.925*	*.925*
Jeopardy	*.483*	*.906*	*.901*
Preoccupation	*.523*	*.840*	*.838*

Table VII: Discriminant Validity Using the Fornell-Larcker Criteria

	Attention Deficit	**Jeopardy**	**Preoccupation**
Attention Deficit	***.761***		
Jeopardy	*.612*	***.696***	
Preoccupation	*.756*	*.595*	***.723***

NB: Diagonal values (bold) represent the square root of AVE, values below for each column (correlations) should be smaller than the diagonal.

Table VIII: Item Loadings for the Three Established Factors of the SZS

Item	Attention Deficit (α = .925)	Jeopardy (α = .906)	Preoccupation (α = .840)
I am sometimes inattentive when using my smartphone in public	.749		
I sometimes feel guilty for not paying attention to things around me when using my smartphone in public	.706		
I sometimes feel guilty about not paying attention to my surroundings when using my smartphone	.716		
I sometimes feel I lack attention to my surroundings when using my smartphone in public	.803		
I am sometimes oblivious of my surroundings when using my smartphone in public	.840		
I am sometimes absentminded when using my smartphone in public	.823		
When using my phone I often find myself not paying attention to my surroundings	.794		
****I usually filter out my surroundings when using my phone*	.668		
I have lost sense of my surroundings while using my smartphone	.736		
****I have fallen down steps in public while I was using my phone*		.562	
****I have had an injury when using my smartphone by not paying attention to my surroundings*		.682	
****I have injured someone else by being distracted when using my smartphone in public*		.475	
I sometimes put my wellbeing in jeopardy while being on my smartphone in public		.951	
****I have accidentally walked in front of a car while using my smartphone*		.646	
I have been late to a meeting or class due to focusing on my phone while out walking		.715	
I have put other people at risk by being distracted by my smartphone while walking in public		.754	
I have occasionally unintentionally stepped into the road when using my smartphone		.731	
****I have tripped in public while using my smartphone because I have been preoccupied*		.653	
****I have had an accident (a trip or a fall) when using my phone at home*		.685	
I am often preoccupied with my smartphone while walking in public			.877
I obsessively check my smartphone when walking in public			.806
I am often distracted by my smartphone (e.g. checking updates) when walking in public			.840
****When I hear my phone notification while I am walking I feel compelled to check it*			.449
****When I am walking in public I always carry my phone so that I can check notifications and updates*			.537

***item removed in subsequent scale re-specification.

Table IX: Convergent Validity and Reliability

Factor	AVE	Cronbach's Alpha	Composite Reliability
Attention Deficit	*.596*	*.922*	*.922*
Jeopardy	*.531*	*.817*	*.817*
Preoccupation	*.629*	*.835*	*.836*

Table X: Discriminant Validity Using the Fornell-Larcker Criteria

	Attention Deficit	**Jeopardy**	**Preoccupation**
Attention Deficit	***.772***		
Jeopardy	*.677*	***.729***	
Preoccupation	*.779*	*.700*	***.793***

NB: Diagonal values (bold) represent the square root of AVE, values below for each column (correlations) should be smaller than the diagonal.

Table XI: Item Loadings for the Three Established Factors of the SZS

Item	Attention Deficit (α = .922)	Jeopardy (α = .817)	Preoccupation (α = .835)
I am sometimes inattentive when using my smartphone in public	.758		
I sometimes feel guilty for not paying attention to things around me when using my smartphone in public	.701		
I sometimes feel guilty about not paying attention to my surroundings when using my smartphone	.714		
I sometimes feel I lack attention to my surroundings when using my smartphone in public	.801		
I am sometimes oblivious of my surroundings when using my smartphone in public	.846		
I am sometimes absentminded when using my smartphone in public	.821		
When using my phone I often find myself not paying attention to my surroundings	.789		
I have lost sense of my surroundings while using my smartphone	.736		
I sometimes put my wellbeing in jeopardy while being on my smartphone in public		.870	
I have been late to a meeting or class due to focusing on my phone while out walking		.648	
I have put other people at risk by being distracted by my smartphone while walking in public		.702	
I have occasionally unintentionally stepped into the road when using my smartphone		.674	
I am often preoccupied with my smartphone while walking in public			.828
I obsessively check my smartphone when walking in public			.761
I am often distracted by my smartphone (e.g. checking updates) when walking in public			.790

Table XII: Nomological Validity Correlations

Scale	Obsessive Compulsive Use	Smartphone Addiction	SZS 15-items	SZS Attention Deficit	SZS Jeopardy	SZS Pre-occupation
Obsessive Compulsive Use	*1.000*					
Smartphone Addiction	*.795****	*1.000*				
SZS 15-items	*.532****	*.633****	*1.000*			
SZS Attention Deficit	*.460****	*.561****	*.960****	*1.000*		
SZS Jeopardy	*.453****	*.515****	*.743****	*.620****	*1.000*	
SZS Preoccupation	*.541****	*.629****	*.828****	*.687****	*.598****	*1.000*

*** Correlation is significant at the .001 level (2-tailed).