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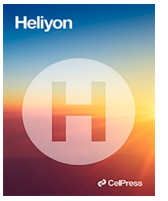

Research article

Validation of a modified problematic use of mobile phones scale to examine problematic smartphone use and dependence

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ABSTRACT

Over the past decade, the world population has experienced rapid and widespread adoption of smartphones due to their usefulness and convenience. However, researchers have identified a range of adverse behaviours associated with the adoption of smartphones and their higher use. These behaviours are collectively described as Problematic Smartphone Use and Dependence (PSUD). Despite growing research, the underlying processes and drivers leading to these behaviours are inadequately understood. This can partly be attributed to the absence of developed statistical tools and measures that allow researchers to build a comprehensive conceptual understanding of PSUD. To address this issue, this study proposes and evaluates a validated extension to the Problematic Use of Mobile Phones (PUMP) scale. The extension of this tool incorporates factors associated with substance dependence outlined in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), including additional items to measure PSUD accurately, referred to as the modified problematic use of mobile phones (MPUMP) scale. The newly developed tool was used in a cross-sectional online survey during September and October 2022, drawing on 1018 adult Australian participants. Principal Component Analysis (PCA) and Exploratory Factor Analysis (EFA) were conducted to derive the underlying factors. The EFA revealed two distinct factors: Distraction and Dysregulation. Both factors exhibited high internal consistency, with Cronbach's Alpha coefficients of 0.92 and 0.86, respectively. A one-way analysis of variance (ANOVA) revealed significant variations inthe identified factors' mean scores across different socio-demographic characteristics. The study provides evidence that the MPUMP scale is a validated and reliable measure for accurately assessing PSUD. The study findings offer novel insights into the psychosocial and physical aspects of PSUD, providing a foundation for exploring the causes and potential interventions for PSUD.

1. Introduction

The modern smartphone is an innovative device capable of performing nearly all the functions of a computer. While the terms 'cell phone,' 'mobile phone,' and 'smartphone' are often used interchangeably, a distinct contrast exists between modern smartphones and earlier generations of mobile phones. Earlier generations provided only basic functionality, such as calling and texting [1,2]. Smartphones have many additional functions compared to their predecessors, including improved accessibility features and apps to

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support social and professional interaction, entertainment and work. Consequently, smartphones have rapidly become the most commonly adopted mobile device globally [3]. Due to this "smart" functionality, people are spending an increasing amount of time using their mobile devices [4]. According to the State of Mobile 2022 report by App Annie, in 2021, users globally spent a staggering 3.8 trillion hours on mobile devices [5]. In the top 10 mobile markets, users spend an average of 4.8 hours daily on mobile devices. In the United States, the average time spent on mobile devices daily is 4.2 hours [5]. According to a poll in Britain, the average adult will spend the equivalent of 34 years of their lives staring at screens, including phones, laptops and televisions [6]. Australian users spend approximately 5.5 hours daily on their mobile devices [7]. This translates to 17 years of a human lifetime when considering the typical age at which individuals acquire their first mobile device in Australia. Consequently, mobile device usage constitutes approximately 33 % of a typical user's waking life [8]. In countries like Australia, these mobile devices are almost exclusively smartphones rather than earlier generation mobile phones. The prevalence, and indeed necessity, for smartphones became evident in Australia, as well as globally, during the recent COVID-19 pandemic when smartphone apps were not only heavily utilised but also virtually mandated for various purposes by health authorities (e.g. for location tracking) [3]. So, while our study focusses on Australia, and consequently smartphone usage, many past studies included usage of earlier generations of mobile phones alongside smartphones.

Increased and higher smartphone use often correlates with problematic smartphone use, leading to various negative issues in individuals' lives [9,10]. The effects include financial problems, sleep disturbances, impaired attention span and learning, sedentary behaviour, and strained personal relationships [9–12]. The issues intensify further when individuals develop maladaptive relationships with their smartphones due to their increased dependency, resulting in stress and separation anxiety when unable to use smartphones [11,12]. Various terms have been introduced to delineate the negative consequences related to smartphone use and dependence, including problematic smartphone use, smartphone dependence, smartphone addiction, smartphone dependency, excessive smartphone use and compulsive smartphone use. Recognising the diverse interpretations across studies is important as some use these terms interchangeably while others make distinctions [3,10,13–15]. Although smartphone dependency shares some similarities with addiction, it is not classified as such, but excessive use can result in severe functional impairments [4]. In this paper, we use the term Problematic Smartphone Use and Dependence (PSUD) to encompass a range of problematic behaviours associated with smartphone use [3]. PSUD results from the unique features of smartphone technology, which stem from the interplay of three essential components: hardware, an operating system, and available apps, all integrated into a convenient portable device [4,12]. Users interact with this combination, choosing which apps to use and how to engage with them [16,17].

While it is true that variations in the quality of each layer - hardware, software, and apps, can influence user engagement and addiction risk, our study treats the three tiers as one combined package in the investigation of smartphone use and dependence. For smartphones, apps functionality is a major attraction for users. However, apps offer both advantages and drawbacks. For example, some apps have been identified as using manipulative and deceptive design techniques known as "dark patterns," which lead users into taking actions they did not intend, such as making unwanted purchases, installing unnecessary apps, or excessively disclosing personal data [18]. Other drawbacks associated with smartphone use include addictive behaviours, such as pathological gambling and other non-substance-related dependencies [12,19]. In some cases, strategies reducing the impacts of these drawbacks have been identified, for example, recognising and naming dark pattern tactics can empower users to be more cautious [20]. While analysis of smartphone features, and even particular apps, is important for identifying causes of problems and possible solutions, this study intended to provide a comprehensive assessment of PSUD at a broader level while acknowledging the nuanced factors contributing to it.

Past studies have identified Australia as one of the countries where problematic smartphone use has been a growing concern [17,19,21,22]. One Australian study examined the relationships between age, technology use patterns, self-reported and objectively measured smartphone use, and problematic smartphone use among adults [21]. The study found that problematic smartphone use was relatively high in young adults but declined rapidly around the age of 40. The study findings also suggest that problematic smartphone use is a complex psychological construct influenced by subjective experiences and individual differences beyond the amount of use, emphasising the need for more nuanced measures and further research to explore the impact of smartphones on different age groups and the evolving concerns related to this technology. Australian users also exhibit some extreme behaviours involving use of smartphones in physically hazardous situations, such as driving or crossing a road, which results in safety concerns [17,19,21,22]. Another study explored smartphone usage and dependency among the adult population of Australia, with a specific focus on demographics [17]. It involved an examination of participants' perceived dependency levels in comparison to their perceived usage, and this is further compared with their peers. The research addressed existing gaps by exploring the influence of parental and occupational status, while ensuring a balanced representation across genders and age groups. Additionally, the study identified specific smartphone activities associated with low usage and dependency, such as phone calls and text messaging, as well as those associated with high usage and dependency, represented by social media and audio/video podcasts. By comparing findings with similar studies globally, the research revealed consistent problems and areas of ambiguity in the smartphone usage landscape.

Thus, findings from previous research highlight the varying attitudes towards smartphones and its potential effects among users, particularly Australians, with gender and age playing a role in individuals' concerns and behaviours. These previous findings suggest that PSUD in Australia and other countries could be better understood through analysing users' behaviour by: type of usage, frequency of usage, socio-demographic factors, and underlying motivations [17,19]. However, there is a lack of relevant research in Australia that measures PSUD using validated scales. Our study aims to fill this research gap by validating a modified Problematic Use of Mobile Phones (MPUMP) scale designed to examine PSUD in the adult Australian population. By doing so, our study seeks to provide deeper insights into the issue of PSUD in Australia, contributing to a more comprehensive understanding of smartphone usage patterns and their potential consequences.

2. Background

In today's digitally connected world, smartphones have emerged as digital companions that seamlessly integrated into our daily lives. These pocket-sized devices offer a variety of benefits, from enabling instant communication with loved ones and facilitating remote study and work to providing a gateway to vast information resources [17,19,23]. They have become essential tools for navigating the complexities of modern life, helping individuals stay organised, informed, and socially connected. While accompanied by undeniable advantages, the pervasive use of smartphones also casts a shadow of potential overuse and dependency [9,10]. In addition, this blurs the line between productive and unwarranted smartphone usage, highlighting the importance of delving into the intricate interplay of factors contributing to this shift. In some instances, this can even lead to Problematic Smartphone Use (PSU). PSU also represents the darker side of this digital age phenomenon, characterised by excessive, compulsive, and maladaptive usage patterns that disrupt the aspects of life they once enhanced [24]. A recent study reveals the emergence of dark patterns associated with smartphone use, where design elements and features are intentionally crafted to encourage prolonged engagement [25]. These patterns can trap users in cycles of compulsive checking, social comparison, and mindless scrolling, eroding not only time but also mental and emotional wellbeing [18,20,24,26]. In addition, factors such as the constant stream of notifications, gamified app interfaces, and the attraction of social validation through likes and comments contribute to the development of problematic use patterns.

In summary, PSU can lead to negative consequences and interfere with various aspects of an individual's life [27,28]. PSU involves a loss of control over smartphone use and a preoccupation with the device, resulting in difficulties in daily functioning, impaired social interactions, academic or work performance issues, and negative impacts on mental and physical wellbeing. On the other hand, Problematic Smartphone Dependence (PSD), also referred to as smartphone addiction or simply smartphone dependence, is a more severe type of problematic use [29]. It is characterised by a compulsive need to use a smartphone, an inability to control or reduce usage despite adverse consequences, withdrawal symptoms when not using the device, and a strong psychological and emotional attachment to the smartphone [30]. Individuals with PSD may experience significant distress or impairment due to excessive reliance on their devices. They may struggle to limit or regulate their smartphone use, even when they are aware of the adverse effects it has on their lives [10].

While there are similarities between PSD and substance addictions, it is essential to recognise that there are also significant differences that need careful consideration [27]. Research indicates that the parallels between PSD and well-established substance addictions are not always clear or consistent [12]. For instance, specific characteristics commonly linked to substance addictions, like loss of control, tolerance, and withdrawal, may not always apply to excessive smartphone use [27]. Unlike some substance addictions where the body adapts to increasing amounts of the substance, this effect does not always occur in behavioural addictions like PSD [31,32]. Thus, while there are similarities, PSD and substance addiction might differ when it comes to aspects such as loss of control, tolerance, and withdrawal. Together Problematic Smartphone Use (PSU) and Problematic Smartphone Dependence (PSD) are associated with similar behavioural patterns and adverse outcomes, resembling the characteristics of substance dependence [11,12,27]. In some research studies, the distinctions are not clear. Due to this lack of clear distinctions and multiple similar patterns and outcomes we refer to PSU and PSD combined as Problematic Smartphone Use and Dependence (PSUD) when evaluating the literature.

PSUD has similarities to substance-related dependencies and various forms of technology overuse disorders (e.g. dependencies on social media, internet and video games) [27,33–35]. According to Busch and McCarthy [2021], PSUD can disrupt relationships, work or academic performance, sleep patterns, and overall wellbeing. Several significant studies contribute to understanding self-reported adverse effects of PSUD on individuals' wellbeing and mental health. One such study by Abi-Jaoude et al. [2020] delves into the impact of smartphones on youth mental health, incorporating self-reported data from participants regarding the adverse effects of PSUD on their mood and overall wellbeing. Similarly, Duke and Montag's [2017] study explores the relationship between smartphone addiction, daily interruptions, and self-reported productivity, with participants highlighting negative impacts on work-related and non-work-related productivity. Additionally, Wilmer et al. [2017] present a comprehensive review of studies investigating the consequences of excessive smartphone usage on cognitive functioning [36]. Another notable study by Rozgonjuk et al. [2018] systematically reviews and meta-analyses the link between PSUD and symptoms of depression and anxiety [37]. In this context, self-reported measures are pivotal in assessing the self-perceived negative consequences of excessive smartphone use.

The research on PSUD remains relatively limited compared to other psychological and behavioural addictions, such as problematic internet use, online video gaming, and pathological gambling [38,39]. As discussed previously, similar to other addictions, PSUD can lead to various negative consequences in social and physical relationships and physical and mental health issues. Users may experience stress, anxiety, and even fear or depression when unable to use their smartphones. However, completely detaching from smartphone use can be challenging for some individuals due to its convenience in completing daily tasks [40,41]. Therefore, addressing the adverse effects and consequences associated with excessive smartphone use and dependence became an urgent matter. Recognition of these issues has led to exploring behavioural and psychological addictions in various research fields, including behavioural sciences, psychology, sociology, social sciences, and human-computer interactions [42,43]. The COVID-19 pandemic has not only exacerbated these issues, but also served as a catalyst, strengthening users' reliance on smartphones and other technological devices for communications and daily activities [10,44,45].

2.1. Existing scales to measure PSUD

Several scales have been developed and validated to measure PSUD [12]. Some of these scales are reviewed here. When describing the scales from a past study for reasons of consistency, we are using the same terminology as stated in that study. If the previous study uses the term 'mobile phone' encompassing all types of mobile phones, we adopt a parallel approach. Similarly, if the prior study uses

the term 'smartphone,' we employ the same terminology for consistency and coherence. The Mobile Phone Problem Use Scale (MPPUS), with 27 items, was developed in Australia to measure problematic mobile phone use of adults based on the behavioural addictions and perceived social aspects of mobile phone use [46]. A Cronbach's Alpha of 0.91 was observed to represent the scale's strong validation and reliability. A short scale with only ten items (MPPUS-10) was also developed and validated in a German sample [47]. This modified scale presented an Alpha of 0.85; low retest reliability was observed after one year. The measures on this scale indicated that some aspects of mobile phone use were problematic. The original MPPUS scale was also recently re-validated in Australia on an adult sample of 709 participants [19]. This reliability investigation discovered an overall Cronbach's Alpha of 0.95 for 26 items as item 4, "All my friends own a mobile phone", was excluded from the analysis as it had a factor loading <0.4, causing the multicollinearity issue. The overall Cronbach's Alpha value shows that the MPPUS exhibited high reliability in the Australian sample. The MPPUS offers advantages, such as a standardised approach for evaluating PSUD across diverse studies and populations. Its demonstrated reliability through good internal consistency, test-retest reliability, and convergent validity enhances its credibility as a tool for long-term measurement and comparison with related constructs. Moreover, the MPPUS's versatility allows its application across different age groups and populations, making it suitable for various research and clinical settings. However, its reliance on self-reported data leaves it vulnerable to biases like social desirability bias and potentially influencing accuracy. Furthermore, the scale's primary focus on problematic use might not fully encompass all mobile phone-related issues and dependencies. Finally, as it was developed within specific cultural contexts, the MPPUS might not capture the nuances of PSUD in diverse cultural or demographic groups.

Two of the most commonly utilised scales for identifying smartphone addiction are the Smartphone Addiction Scale (SAS), containing 33 items, tested on Korean adults [48], and its short version (SAS-SV), containing 10 items, tested on Korean young people [49]. The original SAS validation used six factors: positive anticipation, daily-life disturbance, withdrawal, tolerance, overuse and cyberspace-oriented relationship to validate the scale; however, in the SAS-SV, the positive anticipation factor was removed. Both scales have been validated in various parts of the world, such as China, Romania, Malaysia, Morocco, Turkey, Belgium, Spain and Italy [42]. The SAS and its shorter iteration, the SAS-SV, have been widely employed to assess smartphone addiction, offering well-established validity and reliability. These scales have demonstrated cross-cultural applicability through validation in diverse countries. However, their reliance on self-reported data introduces potential biases, as individuals may misrepresent their smartphone usage due to social desirability or lack of self-awareness. The exclusion of positive anticipation in the SAS-SV may also limit its ability to capture the positive aspects of smartphone use. Moreover, while the scales offer insights into addiction tendencies, they do not provide clinical diagnoses and might overestimate addiction prevalence due to their broad criteria.

The Smartphone Addiction Inventory (SPAI) scale with 26 items was developed to identify smartphone addicts among Chinese adults [50]. A Cronbach's Alpha of 0.94 and a test–retest reliability of 0.80–0.91 provided a satisfactory validity and reliability of this scale using four factors of compulsive behaviour, functional impairment, tolerance and withdrawal. The advantages of the SPAI include its ability to comprehensively assess smartphone addiction through multiple factors, ensuring a thorough evaluation of addictive behaviours. Its high internal consistency and test-retest reliability contribute to its credibility as a dependable measurement tool. However, potential disadvantages stem from its cultural specificity, as it was developed in a Chinese context and may not fully capture the nuances of smartphone addiction in other cultural backgrounds. Additionally, the self-reported nature of the scale could introduce biases, impacting the accuracy of reported addiction levels.

The Smartphone Addiction Proneness Scale (SAPS) is a 15-item self-report scale created in Korea to evaluate vulnerability of young people towards the hazards of smartphone addiction. SAPS uses the four factors of adaptive functions, virtual life, tolerance and withdrawal [51]. This scale was developed and validated using 795 Korean students with a Cronbach's Alpha of 0.88, proving it valid and reliable for screening the dangers of smartphone addiction in young people. The SAPS offers advantages such as its focused evaluation of critical factors contributing to addiction proneness and its suitability for assessing young populations. Its robust internal consistency reinforces its credibility as a dependable assessment tool. Nevertheless, potential disadvantages include its cultural specificity, as it was created in a Korean context and might not fully capture the complexities of smartphone addiction vulnerability in diverse cultural settings. Additionally, like many self-reported scales, the SAPS is subject to biases and inaccuracies due to its reliance on participants' self-perception.

The Nomophobia Questionnaire (NMP-Q) containing 20 items was developed to measure nomophobia in 301 undergraduate students in the US using the four dimensions of not being able to communicate, not being able to access information, losing connectedness and giving up convenience [52]. The NMP-Q was found to be valid and reliable with a Cronbach's Alpha of 0.94 and can be utilised to evaluate the seriousness of nomophobia. The advantages of the NMP-Q include its targeted focus on critical dimensions of nomophobia and its applicability for evaluating this phenomenon among undergraduate students. Its strong internal consistency underscores its reliability as an assessment instrument. However, potential drawbacks encompass its sample specificity, as it was developed within a US undergraduate context, possibly limiting its generalisability to different age groups or cultural backgrounds. Similar to the other discussed scales, as a self-reported measure, the NMP-Q might be biased and inaccurate due to participants' self-perception.

The Problematic Use of Mobile Phones (PUMP) scale with 20 items was developed to assess and measure the problematic use of smartphones [53]. Overall, the PUMP scale exhibited excellent internal consistency with a Cronbach Alpha of 0.94 while applied to an adult American sample of 244 participants. The PUMP scale's capabilities extend beyond its initial validation in the American context, as it has successfully undergone validation processes in diverse cultural settings, including German, Saudi Arabian, and South Korean. The PUMP scale exhibits several advantages, including its comprehensive coverage of problematic mobile phone use and demonstrated applicability across different populations and cultural contexts. The scale's excellent internal consistency bolsters its credibility as a reliable tool for assessing this phenomenon. However, potential disadvantages may arise from its self-reported nature, which could

introduce biases and inaccuracies in responses due to participants' subjectivity. While the PUMP scale has exhibited robust validation across multiple cultural samples, variations in interpretation and understanding of PSUD across cultures could still impact the scale's cross-cultural applicability.

However, there is a need for further validation and examination of these scales to ensure their reliability and accuracy and to improve the measurement and identification of PSUD [11]. The assertion regarding the necessity for additional validation and examination of existing scales to measure PSUD stems from several essential considerations. According to Harris, Regan et al. [2020], while acknowledging the utility of these scales, the emphasis on further validation and examination highlights the dynamic nature of smartphone usage and its associated challenges. The landscape of smartphone use is rapidly evolving, leading to shifts in behaviour and patterns that can influence the manifestation of problematic use. As such, a continual process of validation and examination becomes indispensable to ensure that these scales remain aligned with current usage trends and accurately capture the complexities of PSUD.

Further validation and examination will enhance the reliability and accuracy of these measurement tools. As smartphone usage patterns diversify and evolve, the existing scales might encounter limitations in capturing nuanced manifestations of PSUD. By subjecting these scales to rigorous validation processes, researchers can ascertain their continued relevance and refine their items to encompass emerging patterns and trends in smartphone use. This iterative approach ensures that the scales remain precise and accurate in detecting problematic usage across various scenarios. Moreover, the expected benefits of further validation and examination extend beyond reliability and accuracy. Enhanced measurement tools allow for more precise identification and differentiation of everyday smartphone use from problematic patterns. This differentiation is essential for effective interventions, as it aids in pinpointing individuals who may require support or behavioural modifications to manage their smartphone usage. Additionally, a comprehensive validation process can shed light on the underlying factors contributing to PSUD, enabling a deeper understanding of the psychological, social, and demographic drivers behind this behaviour.

2.2. Ambiguities in existing research on PSUD

In addition to existing scales measuring PSUD, establishing standards to determine when smartphone use becomes problematic remains a challenge in current research [12]. The exact definition of "problematic use" remains uncertain, as it is unclear whether it should be determined based on the quantitative parameters of smartphone use, patterns of use, reasons for use occurrence or the adverse outcomes associated with such use [11,17]. Previous research suggests that frequency and duration of use may be related to each other [42] but that evaluating problematic smartphone use based only on frequency and duration is too simplistic [17]. Elhai and Contractor [2018] and Linden et al. [2021] demonstrated that the duration and frequency of smartphone use could be exceptionally diverse due to varying motivations and purposes of use [17,54]. For example, higher duration and frequency of smartphone use can be for practical reasons (e.g., effectual use for study or work purposes) or habitual or compulsive (e.g., disproportionate social media, gaming and audio/video use). Therefore, it was considered essential to examine reasons for smartphone use and differentiate between different types of use [11].

While there is evidence of various socio-demographic and individual factors being associated with PSUD, the role and importance of various factors are currently inadequately understood. Some studies find evidence that younger users may be more prone to PSUD and explain this by poorer impulse control [55], yet other studies find no association between age and PSUD [56–58]. Similarly, there are mixed findings regarding gender differences with PSUD [17], where some studies found that females engage more in certain smartphone features than males [59–61], while others found males to be higher smartphone users than females [62,63], and in some cases, no significant gender differences were observed [64,65]. Furthermore, previous studies have mainly focused on student populations [14,66–68]. Thus, there is a lack of data for other occupational groups and age groups that are more representative of the user base. Given the various inconsistencies and limitations of previous research, further studies that address these problems are desirable to improve our understanding of PSUD. In addition, based on previous research suggestions [11,69–72], our study also considers additional socio-demographic factors, including parental and occupational status, as well as participants' location and daily smartphone usage levels. Relationships between these socio-demographics and smartphone usage levels, as well as association with various lifestyle activities, are also investigated to assist the development of more accurate predictions and targeted interventions.

Given the rapid technological changes over the past decade, it has become necessary to revisit the issue of PSUD to gain insights into its evolved nature [3]. However, despite a multitude of studies in Asia, Europe and the USA, there is a lack of information on the current situation in Australia. Few studies have focused on PSUD in Australia compared to other nations, making it necessary to explore this issue more deeply [17,19]. Australians are known to be heavy smartphone users, so investigating the prevalence of PSUD among Australians is likely to provide beneficial insights. Our study will address a significant gap in research and the gained insights will contribute to the global conversation on PSUD, aiding towards tackling this modern challenge. In addition, the scales used to measure PSUD need validation in specific contexts, and Australia, as a multicultural country, provides a rich context for the study. It is necessary to ensure that these scales are reliable and accurate for this heavy smartphone users population.

Understanding the boundaries between normal smartphone use and PSUD remains complex and requires deeper exploration. Just looking at how often and long people use smartphones does not provide the whole picture. There is a need to investigate the reasons behind smartphone use, which can differ significantly. Also, there are differing findings on how factors like age, gender, and socio-demographic details influence PSUD, which means further careful study is needed. By examining how these factors associate with smartphone use, strategies to manage PSUD can potentially be developed. Creating and validating scales that match the Australian situation, like the modified Problematic Use of Mobile Phones (MPUMP), is a significant step in filling these gaps. Our study aims to shed light on the extent of PSUD among Australian adults. By developing and validating scales specific to the Australian context (i.e.,

MPUMP) and evaluating the impact of socio-demographic variables, our study aims to address the identified gaps and contribute to a better understanding of PSUD in the adult Australian population.

2.3. Theoretical framework

The conceptual framework of substance dependence in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) was used as a theoretical framework for the current study. The integration of the DSM-5 framework into PSUD research is justified as follows.

1. PSUD and substance dependence share similar behavioural characteristics, such as compulsive use and negative consequences, indicating a conceptual alignment [53].
2. The DSM-5 framework provides diagnostic criteria for substance dependence that can be adapted to develop standards for diagnosing PSUD, ensuring consistency and clarity in identification [1].
3. The DSM-5 framework offers a standardised conceptual framework for addictive disorders, including smartphone addiction and dependence, enhancing the understanding of PSUD [28]. By aligning PSUD with the DSM-5 framework, researchers can draw upon established identification and management strategies for substance dependence to develop evidence-based interventions for smartphone addiction and dependence.
4. The DSM-5 framework has been utilised in various cultural contexts to understand non-substance-related problematic use and behavioural dependencies, including studies conducted in South Korea, Saudi Arabia, and Germany [1,51,53,73]. This cross-cultural applicability suggests that the DSM-5 framework can be adapted and applied to different populations, including the Australian context.

2.4. The present study

Overall, using the DSM-5 framework provides a solid foundation for studying PSUD, offering a standardised and recognised approach for identification, diagnosis, and treatment. By adopting this framework, researchers can build upon established knowledge and interventions, facilitating a better understanding of PSUD and its management. Our study builds upon this framework by adopting a comparative approach used in previous research on non-substance-related problematic use and behavioural dependencies, consistent with the DSM-5 framework [1,51,53,73–75]. By adding additional items to measure PSUD accurately, the study aims to enhance the understanding of problematic smartphone use within the framework. By integrating the DSM-5 framework, our study not only validates the MPUMP scale but also aims to provide insights into the prevalence of PSUD in the general population. Furthermore, our study seeks to identify predictive socio-demographic variables and explore additional factors associated with problematic smartphone use, providing a comprehensive understanding of PSUD within the Australian context. This approach aligns with the DSM-5 framework's goal of standardised identification, diagnosis, and management of addictive disorders, enabling researchers to develop evidence-based interventions for addressing PSUD.

3. Materials and methods

3.1. Participants and procedure

An online cross-sectional survey was conducted to collect data on the Australian population during September and October 2022. The inclusion criteria for this study were set to include adult residents in Australia, who are regular smartphone users, competent in English and willing to participate in this study. Participants provided consent along with the submission of the online survey. Institutional ethics approval was obtained before starting this project. The survey was administered using Qualtrics.com. The sample size for the study was determined according to Hair's [2010] suggestion that a sample of 480 would be good enough to run a factor analysis with 24 items [76]. This study collected data from a sample of 1020 participants. After eliminating the missing and incomplete responses, the final sample contained responses from 1018 participants. The target population for the study was adult Australians (i.e., 18 years old and above) from different genders, occupations, marital and parental statuses, and geographical locations (i.e., different states, urban and rural).

The study employed a non-probability sampling approach, explicitly utilising a combination of purposive and convenience sampling methods. This choice was driven by the pragmatic considerations of achieving an appropriate sample size given the limitations of time and resources. Despite the absence of formal random or probability sampling techniques, the research strategically incorporated diverse recruitment strategies to replicate the benefits of randomisation. This involved disseminating recruitment materials across various platforms like social media, forums, and email lists. The strategies included paid promotions on Instagram and Facebook, posts on the Facebook research pages of different universities, and physical notices at selected locations, such as one of the universities and Parish of the Parks Hall in Melbourne. Introducing an element of randomness in participant selection aimed to attract individuals with diverse backgrounds. Additionally, a stratified purposeful sampling approach identified key subgroups within the population and intentionally recruited participants from each subgroup to prevent demographic skewing. Allowing for anonymous participation added an extra layer of unpredictability, fostering a more diverse and candid representation of perspectives. These intentional measures aimed to enhance the depth and breadth of the participant pool, contributing to the overall representativeness of the study. All recruited participants were explicitly informed about the voluntary nature of their participation in the study. All surveys were completed anonymously, online, at a time and place convenient to each participant.

3.2. Measures

Previous studies have used various tools to measure the existence of PSUD and related adverse consequences, as discussed in Section 2.1. For example.

- Mobile Phone Problem Use Scale (MPPUS), e.g., Bianchi and Phillips [2005]
- Smartphone Addiction Scale (SAS), e.g., Kwon et al. [2013]
- Problematic Use of Mobile Phones (PUMP), e.g., Merlo et al. [2013]
- Smartphone Addiction Inventory (SPAI), e.g., Lin et al. [2014]
- Nomophobia Questionnaire (NMP-Q), e.g., Yildirim and Correia [2015]
- Smartphone Addiction Proneness Scale (SAPS), e.g., Graben et al. [2020],

Utilising the PUMP scale for a study in Australia offers several justifications that set it apart from alternative scales. While various scales such as the MPPUS, SAS, SAS-SV, SPAI, SAPS, and NMP-Q have demonstrated their applicability globally, the unique advantage of the PUMP scale lies in its suitability to multiple cultural contexts, including German, Saudi Arabian, and South Korean samples. However, its validation has not been extended to Australia. By selecting the PUMP scale for an Australian study, there is an opportunity to assess PSUD while potentially contributing to its cross-cultural validation. This choice also enables the exploration of nuances specific to the Australian context, bridging the gap between global assessments and local realities. Furthermore, the PUMP scale's comprehensive coverage of problematic mobile phone use and its reliability in diverse settings makes it a promising choice to gauge this phenomenon in the Australian population.

Beginning from a theoretical premise, the PUMP has arisen as a valuable and brief scale with 20 items that can be used to assess and measure the problematic use of smartphones [53,77]. The scale items were motivated by the factors for substance dependence in the DSM-5, such as tolerance, withdrawal, a longer time than intended, a great deal of time spent, craving, activities given up or reduced, use despite physical or psychological problems, failure to fulfil role obligations, use in physically hazardous situations and use despite social or interpersonal problems. However, the PUMP scale does not guarantee that the excessive use of smartphones is an addiction or dependence [51]. Merlo et al. [2013] produced items from a survey of measures evaluating the results of excessive internet use and interviews with a few self-recognised smartphone addicts. In addition, there are other avenues related to excessive smartphone use (for example, the feeling of over-reliance on smartphones, living and surviving without smartphones, not using smartphones appropriately in terms of duration and frequency and using them simultaneously while performing other tasks), which should be considered while measuring PSUD. Considering these apprehensions, our study includes some additional items to validate the PUMP scale. Our study evaluates and validates the MPUMP with four additional items on an adult Australian sample. Specifically, our study examines the components of problematic smartphone use in Australia and the impact of age, gender, occupation, marital status, parental status, location and daily smartphone usage levels.

PUMP has been translated into different languages and validated in multiple cultures by experts from dependence, technology, and psychiatry. The PUMP scale consists of items related to potential feelings, thoughts, and behaviours connected with problematic smartphone use; for example, the first item starts with "*When I decrease the amount of time spent using my smartphone, I feel less satisfied*". The degree to which these assertions fit with the respondent's self-perception was evaluated on a 5-point Likert Scale, from 1 = "*strongly disagree*" to 5 = "*strongly agree*". For our study, the PUMP scale was extended by adding four items to create Modified Problematic Use of Mobile Phones (MPUMP). In line with the PUMP theoretical framework, these additional items were also designed based on the DSM-5 [53,77] to capture information on users' over-reliance on smartphones, their ability to live and function without smartphones, their smartphone usage in terms of appropriate duration and frequency, and their tendency to use smartphones simultaneously while performing other tasks. The four items added to MPUMP are worded similarly to the original PUMP scale items with the identical 5-point Likert Scale. The suitability of the modified 24-item MPUMP scale was measured by summarising the scores for the singular items with the aim that higher scores would show more elevated levels of PSUD. MPUMP has also been validated for the presented study (details below). The MPUMP questionnaire has three sections: seven added socio-demographic items, four additional newly validated items, and twenty previously validated PUMP scale items (available in Supplementary materials). For sensitivity and specificity purposes, the developed questionnaire for this study was piloted on ten adult participants from different backgrounds. Afterwards, based on their feedback, the phrasing of some items was changed before being broadly distributed. For example, the term "cell phone" was switched to "smartphone".

The collected data included respondents' critical socio-demographic information and their self-perceived data on daily smartphone use as covariates. The overall scores of the MPUMP were considered dependent variables while examining the variances between independent variables based on their categories. The socio-demographic factors were considered as covariates, and these are age (*18+ and categorised into 18–40 years old and 41+ years old*), gender (*male, female, and others*), occupational status (*student, employed/self-employed, retired/unemployed*), marital status (*single/divorced/widowed and in a relationship/de facto/married*), parental status (*parents and non-parents*), and location (*urban area and rural area*). In addition to the socio-demographic factors, the participants answered single-item questions on their daily smartphone usage time by choosing from three response options (*less than 3 h, between 3-6 h, and more than 6 h*).

The decision to stratify participants based on age into distinct cohorts (18–40 and 41+), including Generation X and Generation Y, part of Generation Z, aims to capture the diverse technological habits and preferences that often accompany different life stages. By examining smartphone usage patterns across these generational groups, this study seeks to unveil insights into how evolving societal and technological landscapes influence distinct age demographics. Additionally, the inclusion of parental status as a socio-

demographic factor stems from the recognition that parenthood introduces unique dynamics and responsibilities, potentially influencing technology usage. Understanding the differences in smartphone behaviours between individuals who are parents and those who are not contributes to a nuanced exploration of the impact of family life on technology use. Furthermore, consideration of gender, occupational status, marital status, and location (urban or rural) serves to uncover the nuanced ways in which societal and environmental factors may shape smartphone use. Exploring these socio-demographic differences enriches our understanding of the multifaceted influences on technology usage behaviours, contributing to a more comprehensive and contextually relevant analysis.

3.3. Statistical analysis

Participants' socio-demographic characteristics were analysed using descriptive statistics and cross-tabulation. To investigate the pattern of relationships among the variables in 24-item MPUMP to understand the dimensions underlying users' choice, an exploratory factor analysis (EFA) was conducted. Initially, the suitability of the factor analysis was tested using Kaiser-Myer-Olkin (KMO) and Bartlett's test. A principal common factor analysis and exploratory factor analysis were then performed on the 24 survey items to find the latent variables (factors), which provided an unpolluted factor structure with two-factors. Decisions on the number of factors were formed based on Kaiser's criterion, the scree plot, parallel analysis and minimum average partial (MAP) test. The reliability and validity of the derived factors were assessed using variance, item-total correlation, squared multiple correlation and Cronbach's alpha. To evaluate the associations between the derived factors and socio-demographic variables, a one-way analysis of variance (ANOVA) technique was used along with post hoc tests using Bonferroni correction and Student-Newman-Keuls (S–N–K) tests as needed. A G-Power analysis indicates that with moderate Effect Size f = 0.30 and Alpha = 0.05, a sample of 111 participants in each group (for three groups) would be adequate for at least 80 % statistical power when performing ANOVAs. A p-value of <0.05 was utilised to report the results statistical significance. The data were analysed using SPSS versions 28 and 29.

4. Results

The sample demonstrates a relatively balanced distribution of marital and parental status, with the split being approximately equal. Occupation-wise, among the 1018 study participants, the majority were employed (61.2 %), followed by students (25.5 %), and retired/unemployed (13.3 %). Participant's demographic characteristics, including age, gender, occupational status, marital status, parental status, location and daily smartphone usage level, are presented in Table 1.

4.1. PUMP and MPUMP validity and reliability

The primary purpose of our study is to update the problematic use of mobile phones (MPUMP) scale for assessment of PSUD in the adult Australian population. First, the internal consistency of the original PUMP with 20-items was assessed using Cronbach's Alpha, which was found to be 0.93, showing a high internal consistency. To test the PUMP reliability, item statistics were checked, and all the items had a variance (Std. Deviation) of at least one or above. The Inter-Item Correlation Matrix showed that all items had one or more values of 0.30, and all values were less than or equal to 0.60, representing an absence of multicollinearity issues. All items

Table 1
Socio-demographic characteristics of the participants (n = 1018).

Socio-demographic factors	Frequency (n)	Percentage (%)
Age		
18–40 Years Old	812	79.8
41+ Years Old	206	20.2
Gender		
Male	610	59.9
Female	408	40.1
Occupation		
Student	260	25.5
Employed/Self-Employed	623	61.2
Retired/Unemployed	135	13.3
Marital Status		
Single/Divorced/Widowed	455	44.7
In relationship/De-facto/Married	563	55.3
Parental Status		
Yes	540	53.0
No	478	47.0
Location		
Urban	769	75.5
Rural	249	24.5
Daily smartphone usage time		
Less than 3 h	171	16.8
Between 3–6 h	551	54.1
More than 6 h	296	29.1

demonstrated positive corrected item-total correlations, ranging from 0.47 to 0.67. All squared multiple correlations were above 0.30, indicating no items inconsistent with the rest of the scale. Moreover, item deletions were not associated with improvements in internal consistency for any items. The aforementioned statistics can be found in Supplementary materials (see Table S1).

In addition, the internal consistency of the modified scale was assessed using Cronbach's Alpha, which was found to be 0.94 for the full scale, representing a high internal consistency. To further test the reliability, item statistics were checked, and all the items had a variance (Std. Deviation) of at least one or above. The Inter-Item Correlation Matrix showed that all items had one or more values of 0.30, and all values were less than or equal to 0.60, representing an absence of multicollinearity issues. All items demonstrated positive corrected item-total correlations, ranging from 0.44 to 0.66. All squared multiple correlations were above 0.3, indicating no items inconsistent with the rest of the scale. In addition, Item deletions were not associated with improvements in internal consistency for any items. Adding these four additional items slightly improved the validity of the developed scale (Cronbach's Alpha), and these items covered some of the measures that were not included in the previously developed 20-item PUMP scale. All these statistics are presented in the Supplementary material (see Table S2).

4.2. Exploratory factor analysis

Initially, a principal components analysis was used to evaluate the suitability of a factor analysis of the 24-item MPUMP scale. The items correlation matrix, Kaiser–Mayer–Olkin index (KMO=0.96) and Bartlett's test of sphericity ($\chi^2_{(276)}$=10949.50; p<0.001) supported the use of exploratory factor analysis for the data set. Different extraction and rotation methods were used with 1, 2 and 3-factor solutions to resolve the issues related to communities, residuals, total percentage of explained variance and cross-loading. However, some MPUMP items had cross-loading issues in the component matrix. Item loadings were checked on each factor, as the factors might correlate due to the theoretical construction of the survey. Item S4 was removed as it had an equal cross-loading on both factor 1 and factor 2, and some other items (S1-When I decrease the amount of time spent using my smartphone, I feel less satisfied; S2–I need more time using my smartphone to feel satisfied than I used to need; S3-When I stop using my smartphone, I get moody and irritable) were present measuring similar properties as item S4. All other 23 items were retained in the further analysis. Their validity and reliability statistics are provided in Supplementary materials (see Table S3). Finally, the principal component extraction method, along with a Promax rotation method, produced a simple structure without any significant cross-loading with two-factor solutions for the 23 items. This process produced two factors with eigenvalues greater than 1, fulfilling Kaiser's criterion and Cattell's scree plot [78,79] along with parallel analysis and MAP test [80], similar to the factors extracted in the problematic smartphone users study by Kim et al. [2015].

The two-factors solution explained 49.02 % of the variance, almost equal to the overall 50%, and communalities ranged from 0.3 to 0.7; thus, this was considered to be the best suitable solution for this data set. Table 2 depicts the pattern matrix of the final two-factor solutions. The first identified factor, comprised of 40.57 % of the explained variance with 13 items, was named "Distraction" (Cronbach's Alpha 0.92; variances are larger than one inter-item correlations between 0.3 and 0.6) (see Table S6 in Supplementary materials). The second factor comprising 8.45 % of the explained variance with 10 items, was named "Dysregulation" (Cronbach's

Table 2
Pattern matrix for 2-factor solutions of 23-items MPUMP (n = 1018).

	Factor 1 – Distraction	Factor 2 – Dysregulation
S20–I have continued to use my smartphone even when someone asked me to stop.	0.848	−0.120
S15–I have gotten into trouble at work or school because of my smartphone use.	0.840	−0.131
S18–I have almost caused an accident because of my smartphone use.	0.835	−0.122
S19-My smartphone use has caused me problems in a relationship.	0.823	−0.113
S10–I feel anxious if I have not received a call or message in some time.	0.802	−0.060
S9-When I am not using my smartphone, I am thinking about using it or planning the next time I can use it.	0.696	0.037
S3-When I stop using my smartphone, I get moody and irritable.	0.695	0.043
S8-People tell me I spend too much time using my smartphone.	0.617	0.113
S1-When I decrease the amount of time spent using my smartphone, I feel less satisfied.	0.613	0.155
S2–I need more time using my smartphone to feel satisfied than I used to need.	0.535	0.216
S16-At times, I find myself using my smartphone instead of spending time with people who are important to me and want to spend time with me.	0.498	0.258
S11–I have ignored the people I'm with in order to use my smartphone.	0.489	0.267
S17–I have used my smartphone when I knew it was dangerous to do so.	0.460	0.217
S7–I think I might be spending too much time using my smartphone.	−0.070	0.770
AddS1-I think I might be over-reliant on my smartphone.	−0.192	0.769
S13–I have used my smartphone when I knew I should be sleeping.	−0.111	0.742
S12–I have used my smartphone when I knew I should be doing work/schoolwork.	−0.019	0.715
AddS3-I do not use my smartphone appropriately in terms of duration and frequency.	0.020	0.654
S6–I have thought in the past that it is not normal to spend as much time using a smartphone as I do.	0.079	0.604
AddS4-My urge to simultaneously use smartphone while doing other tasks causes concern.	0.101	0.581
S5-The amount of time I spend using my smartphone keeps me from doing other important work.	0.105	0.573
S14-When I stop using my smartphone because it is interfering with my life, I usually return to it.	0.189	0.571
AddS2-I could not live and survive without my smartphone.	0.101	0.531

Note. Pattern matrix for a three-factor solution using Principal Component Analysis and Promax rotation.

Alpha 0.86; variances are larger than one inter-item correlation between 0.3 and 0.5) (see Table S7 in Supplementary materials). The factor correlation matrix also confirms the adequate associations between the factors (see Table S5 in Supplementary materials), such as there is a strong positive correlation between Factor 1 (distraction) and Factor 2 (dysregulation) (r=0.61), indicating that individuals who are highly distractible and have difficulties with self-regulation are more likely to engage in problematic smartphone use and tend to develop dependency on their devices. The structure matrix for these two-factors is also provided in Supplementary materials (see Table S4).

4.3. Analysis of variance (ANOVA)

One-way ANOVAs were performed to assess the associations between the developed factors and the socio-demographic characteristics. The results are presented in Table 3. One-way ANOVA conducted on Factor-1 revealed significant differences in mean distraction scores between parents and non-parents ($p<0.001$), with parents reporting a higher level of distractions related to smartphone use as opposed to non-parents.

Significant differences were found between participants' locations with respect to average distraction scores related to smartphone use ($p<0.001$), with participants living in rural areas reporting higher smartphone usage distraction compared to their counterparts. The participants' occupational status was found to be significantly associated with their smartphone usage related distraction ($p<0.001$), retired/unemployed participants showed the highest distraction mean score, and students had the lowest distraction mean score. A post-hoc Student-Newman-Keuls (S–N–K) test revealed that retired/unemployed participants' distraction related to smartphone use were significantly higher than employed/self-employed and students' participants ($p<0.05$). In addition, employed/self-employed also reported significantly higher distractions related to smartphone use compared to student participants ($p<0.05$). The relationship between distraction and participants daily smartphone usage level was found to be significant ($p<0.001$); participants with more than 6 hours of daily smartphone usage reported a significantly higher level of smartphone usage related distraction, compared with the participants with daily smartphone usage levels between 3 and 6 hours and less than 3 hours (Table 3). A post-hoc S–N–K test found that participants with more than 6 hours of daily smartphone usage reported significantly higher levels of smartphone usage related distraction compared to those who used daily between 3 and 6 hours and less than of 3 hours (p-<-0.05). Moreover, participants with between 3 and 6 hours of daily smartphone usage had a significantly higher smartphone usage related distraction compared to participants with less than 3 hours of daily smartphone usage ($p<0.05$). The associations between participants' age, gender, and marital status, and distraction scores related to smartphone use were not significant ($p>0.05$).

One-way ANOVA conducted on Factor-2 revealed a significant difference of average dysregulation score between males and females ($p<0.001$), females reporting higher level of dysregulation related to smartphone use as compared to males (Table 3). Significant differences were also found between participants' parental status with respect to average dysregulation scores related to smartphone use ($p=0.001$), non-parents reporting higher smartphone usage dysregulation compared to parents (Table 3). The participants' occupational status was found to be significantly associated with their smartphone usage related dysregulation ($p=0.002$). Overall, the

Table 3
Comparison of mean scores of factors of sample characteristics using One-Way ANOVA (n = 1018).

Socio-demographic Characteristics	*MPUMP Mean (SD)*	Factor – 1 Distraction			Factor – 2 Dysregulation		
		Mean (SD)	*F*	*p-value*	Mean (SD)	*F*	*p-value*
Age							
18–40 years old	74.99 (15.36)	41.08 (9.99)	3.57	0.059	33.91 (6.96)	0.54	0.463
41+ years old	76.93 (17.99)	42.62 (12.16)			34.31 (6.81)		
Gender							
Male	74.20 (15.16)	41.01 (9.59)	2.02	0.156	33.19 (6.86)	20.61	<0.001*
Female	77.14 (16.91)	41.96 (11.66)			35.18 (6.87)		
Marital status							
Single/Divorced/Widowed	74.54 (14.67)	40.96 (9.70)	1.36	0.244	33.57 (6.68)	2.96	0.086
In a relationship/De facto/Married	76.06 (16.88)	41.74 (11.03)			34.33 (7.12)		
Parental status							
Parents	76.11 (16.09)	42.79 (9.84)	20.88	<0.001*	33.32 (7.10)	10.75	0.001*
Non-parents	74.55 (15.75)	39.81 (10.95)			34.74 (6.67)		
Location							
Urban	74.61 (16.51)	40.63 (10.72)	16.99	<0.001*	33.98 (7.26)	0.01	0.961
Rural	77.76 (13.81)	43.75 (9.30)			34.01 (5.82)		
Occupational status							
1. Student	72.22 (15.15)	38.64 (10.21)	38.87	<0.001*	33.58 (7.03)	6.10	0.002*
2. Employed/Self-Employed	74.85 (15.84)	41.10 (10.19)			33.74 (6.98)		
3. Retired/Unemployed	83.93 (15.05)	48.01 (9.49)			35.91 (6.23)		
Daily smartphone usage time							
1. Less than 3 h	66.15 (15.78)	35.65 (10.28)	115.64	<0.001*	30.50 (7.02)	118.04	<0.001*
2. Between 3–6 h	72.21 (14.16)	39.58 (9.61)			32.63 (6.34)		
3. More than 6 h	86.62 (12.80)	48.08 (8.67)			38.54 (5.56)		

*. The mean difference is significant at the 0.05 level.

retired/unemployed participants reported highest level of dysregulation and students had the lowest level of dysregulation on average. A post-hoc S–N–K test revealed that retired/unemployed participants' dysregulation related to smartphone use significantly higher than employed/self-employed and students' participants ($p<0.05$). In addition, employed/self-employed also reported significantly higher dysregulation related to smartphone use compared to student participants ($p<0.05$).

The relationship between dysregulation score and participants daily smartphone usage level was found to be significant ($p<0.001$); participants with more than 6 hours of daily smartphone usage reported a higher smartphone usage related dysregulation, compared with the participants with daily smartphone usage between 3 and 6 hours and less than 3 hours (Table 3). A post-hoc S–N–K test also revealed that participants with more than 6 hours of daily smartphone usage reported significantly higher smartphone usage related dysregulation compared to the participants who used smartphone daily between 3 and 6 hours and less than of 3 hours ($p<0.05$). Moreover, participants with between 3 and 6 hours of daily smartphone usage had a significantly higher level of smartphone usage related dysregulation compared to participants with less than 3 hours of daily smartphone usage ($p<0.05$). The associations between participants' age, marital status and location and dysregulation due to smartphone use were not found to be statistically significant.

5. Discussion

The primary objective of our study is to update and validate the existing PUMP scale by incorporating additional items to measure PSUD effectively. The study included an assessment of the association of the developed factors of the MPUMP scale with the added 4 items with selected socio-demographic variables. These additional items were strategically designed to address specific aspects of smartphone usage and to improve the adequacy of the previously developed original 20-item PUMP scale. Their inclusion serves to enhance both the comprehensiveness and validity of the scale in several ways. The four new items cover important dimensions of smartphone use that were previously unaddressed. 'Over-reliance on smartphones' reflects the extent to which individuals excessively depend on their devices, a fundamental aspect of problematic use. 'Functioning without smartphones' assesses an individual's ability to perform daily tasks without excessive reliance on their smartphone, which is a significant indicator of healthy usage. 'Appropriate duration and frequency of smartphone use' directly evaluates whether users adhere to the recommended usage guidelines, which supports the assessment of problematic usage. 'Multitasking with smartphones' reflects contemporary usage patterns where individuals often use their smartphones concurrently with other activities, which can be indicative of dysregulated use.

These added items provide additional facets to assess problematic smartphone use by considering a broader spectrum of behaviours and dependencies. They enable us to capture nuances in smartphone usage that are relevant to the diagnostic criteria for substance dependence in the DSM-5, ensuring alignment with well-established psychological principles. By addressing these specific aspects of smartphone use, the modified PUMP scale has improved discriminatory power. It can now distinguish between individuals who exhibit various forms of problematic smartphone use, enhancing its ability to identify individuals at risk of PSUD with higher accuracy. The modified scale, MPUMP, incorporating these additional items, demonstrates improved content, construct, and criterion-related validity. It aligns more closely with the theoretical underpinnings of PSUD and can better predict adverse outcomes associated with excessive smartphone use, including psychological and social impairments.

The EFA revealed two distinct and internally consistent and reliable factors (Distraction and Dysregulation) for the 23-items MPUMP scale with good psychometric properties.

5.1. Identified factors associated with PSUD

Due to the scarcity of comparable studies utilising the PUMP scale to measure PSUD, the comparison of our study findings with other similar studies is limited. However, the two-factors of distraction and dysregulation identified by this study for the MPUMP scale have been investigated by past studies on PSUD [10,73,81–83].

5.1.1. Distraction

Our study identified the distraction dimension as a key contributing factor to PSUD (incorporating 13 MPUMP scale items), as smartphones are designed to be highly engaging, with bright screens, constant notifications, and easy access to social media and entertainment apps. These features make it difficult for individuals to resist the temptation to constantly check their phone, even when it is not necessary or appropriate. Previous research has demonstrated that the constant distraction of smartphones can lead to several adverse outcomes, including reduced attention span, decreased productivity, and increased stress and anxiety [81,82]. People who are highly dependent on their smartphones may experience these negative effects to a greater degree, as they may be more likely to prioritise their smartphone use over other activities or responsibilities. In addition to the impact on individual wellbeing, distraction related to smartphone use can also have wider societal implications. For example, being distracted by smartphone activities while driving could cause traffic accidents, including fatalities [19]. These findings highlight the significance of distraction as a contributing factor to PSUD. This heightened distraction has implications such as reduced attention span, decreased productivity, and increased stress.

5.1.2. Distraction related socio-demographic differences

Our study found significant associations between the distraction dimension caused by smartphones and participants' parental status, occupational status, and location. Individuals who were parents reported higher levels of distraction associated with smartphone use than those who were not parents, which is consistent with the literature [84,85]. However, contrary to previous research, our study found that participants from rural areas experienced higher levels of distractions compared to their urban counterparts [86,

87]. Our study indicated that retired/unemployed individuals had the highest distraction levels caused by smartphone use, followed by employed/self-employed and students participants. None of the identified previous studies considered this covariate in their research. In support of findings from previous research, our study found that people who used their smartphones for more than 6 hours per day experienced higher distraction related to smartphone use than those who used it for 3–6 hours and less than 3 hours per day [10,88]. Also similar to previous studies' findings, our study also found no significant association between participants' age and gender and their smartphone usage related distractions [82,89], but these findings were contradicted by the study of Sciandra et al. [2019].

The significant associations identified between the distraction dimension and various socio-demographic variables in our study carry noteworthy implications. Parents' higher reported distraction aligns with existing literature, potentially due to the increased demands and responsibilities associated with parenthood, which may lead to divided attention between smartphone use and caregiving [84,85]. The finding of higher distraction levels among participants from rural areas could be attributed to factors like communication issues and novelty effects, where smartphone use might be more engaging for those less accustomed to urban environments. The observed pattern of distraction among occupational statuses, with the highest reported distraction among retired/unemployed individuals, might reflect varied patterns of smartphone utilisation during different life stages and activity levels. The correlation between higher daily usage and greater distraction reinforces the possibility of excessive smartphone usage leading to higher distractions, likely due to the continuous availability and engagement with the device. The absence of age and gender associations contradicts some prior research findings but could signify shifts in smartphone usage patterns across generations and changing gender dynamics.

5.1.3. Dysregulation

Dysregulation, or the inability to regulate one's own thoughts, emotions, and behaviours, was another contributing factor to PSUD identified in this study incorporating 10 MPUMP scale items. There are several associated aspects related to dysregulation, which further result in excessive use of smartphones that interfere with daily activities and cause negative consequences, such as social isolation, decreased productivity, and impaired relationships. A similar finding was reported by van Velthoven et al. [2018] and Pearson and Hussain [2016] that a psychological and behavioural reliance on smartphones often results in withdrawal symptoms and damaging consequences when access to the device is limited [90,91]. Previous research has also demonstrated that dysregulation is associated with PSUD [10]. Individuals experiencing difficulty in regulating their emotions and behaviours may turn to their smartphones to cope with stress and negative emotions [92]. They may also have trouble controlling their smartphone use, leading to excessive and problematic use. Dysregulation may also contribute to poor self-control and impulse control, further exacerbating PSUD [93,94]. For example, individuals who are unable to regulate their impulses may be more likely to engage in compulsive smartphone use, even when it interferes with other important activities or responsibilities. Moreover, dysregulation can also contribute to the development of addiction-like symptoms associated with problematic smartphone use, such as tolerance, withdrawal, and craving [83]. These symptoms can further reinforce dependence on smartphones and make it difficult to reduce or eliminate PSUD. The identification of dysregulation is another key factor contributing to PSUD, which aligns with prior research emphasising the role of self-regulation in smartphone usage patterns. These aspects encompass difficulties in managing stress and negative emotions, inadequate impulse control, and reliance on smartphones as coping mechanisms. The expanded discussion also delves into the link between dysregulation and addiction-like symptoms, including tolerance, withdrawal, and craving, thereby reinforcing the connection between dysregulation and PSUD.

5.1.4. Dysregulation related socio-demographic differences

Our study found significant associations between participants' gender, parental status, occupational status and daily smartphone usage time and smartphone usage related dysregulation. In line with previous research, females reported higher levels of dysregulation than males [95]. Our findings also revealed that non-parents reported higher smartphone use-related dysregulation than parents, which has not been investigated in the past. Retired/unemployed participants had higher smartphone usage related dysregulation compared to employed/self-employed and students participants. To the best of our knowledge, none of the previous research has investigated associations between occupational status and smartphone use-related dysregulation. Our finding that participants with more than 6 hours of daily smartphone usage had higher smartphone usage related dysregulation than those with 3–6 hours and less than 3 hours of daily usage was partially supported by previous research [83]. Consistent with prior research, no significant associations were found between participants' age and their smartphone use related dysregulation [96]. In contrast with previous research, our study did not find significant associations between participants' marital status and location and their smartphone use related regulation [87,97]. The findings of our study provide valuable insights into the practical utility of the MPUMP scale in assessing PSUD, particularly in relation to socio-demographic disparities.

The significant associations observed between socio-demographic variables and smartphone usage-related dysregulation in our study offer insightful implications for understanding the multifaceted dynamics of PSUD. The higher dysregulation reported by females corresponds to prior research highlighting potential gender-specific differences in emotional regulation and coping mechanisms. The intriguing finding of lower dysregulation among parents compared to non-parents may be attributed to parental responsibilities fostering a sense of structure and self-regulation, mitigating potential dysregulation arising from excessive smartphone use. The elevated dysregulation experienced by retired/unemployed individuals could stem from increased leisure time, leading to more smartphone use and potentially fostering dependence. The unique link between occupational status and dysregulation emphasises the need to explore how different life stages and routines influence smartphone usage and psychological outcomes. The contrasting findings regarding daily smartphone usage time highlight the intricate interplay between usage patterns and psychological dysregulation. Higher dysregulation among individuals with longer usage periods may suggest a heightened risk of losing control and

becoming disruptively engrossed in smartphone activities, which aligns with studies linking excessive use to negative psychological outcomes. The absence of associations between age and dysregulation resonates with some research, suggesting that age might not be a primary predictor of smartphone-related dysregulation. Contrary to some prior studies, the lack of significant associations between marital status and location highlights the need to study contextual nuances in understanding smartphone usage dynamics. The acknowledged factors 'distraction' and 'dysregulation' align with the empirical referents identified in numerous prior studies [81,82]. These referents specifically pertain to time disturbance, where individuals struggle to disengage from smartphone usage and allocate more time and resources to it, even when it negatively affects their daily lives. According to the existing literature, these aspects could be considered significant risk factors or indicators of PSUD [45]. In line with these findings, previous research suggests that individuals who are highly distractible and have difficulties with self-regulation are more likely to engage in problematic smartphone use and develop a dependence on their devices [92]. For example, some prior studies found that individuals scoring high on distractibility and impulsivity were likelier to report PSUD [98,99]. Similarly, individuals with higher levels of emotional dysregulation were also more likely to experience PSUD [83,100]. In general, the combination of distraction and dysregulation can create a cycle of PSUD, with distractions from smartphone use leading to difficulties with self-regulation and difficulties with self-regulation, in turn, leading further to PSUD [92,101,102].

The identified connections between "distraction" and "dysregulation" in relation to PSUD could be explained by several potential reasons and consequences. Distractions stem from the captivating nature of smartphones, compelling individuals to frequently check their devices and resulting in reduced attention, lower productivity, and heightened stress. This issue has broad implications, impacting personal wellbeing and even safety as individual do not notice their surroundings. Likewise, dysregulation, involving difficulties in self-regulation of emotions and behaviours, could employ excessive smartphone use as a coping mechanism. This can lead to unintended consequences, such as compulsive smartphone use and impaired impulse control, which further cause PSUD. These challenges could negatively affect relationships, productivity, and overall mental health. Together, these connections between "distraction" and "dysregulation" emphasise the intricate interplay of cognitive and emotional factors in shaping PSUD.

5.2. Limitations and future research suggestions

Our study had some limitations. Firstly, the collected data was self-reported, which can induce personal bias in the participants' responses. Ideally, a mixture of methods should be utilised in further studies to measure and validate PSUD issues and to improve self-reported bias. Secondly, the generalisability of results to the overall populace could be restricted as the study was conducted on adult participants using a purposive and convenience sample technique. To address this, future research could benefit from incorporating random sampling techniques such as simple or stratified random sampling. Ideally, uniform random sampling should be used. Thirdly, our study was cross-sectional which prevents reliable causal interpretation of the results. To further enrich current findings, future studies should incorporate a larger, randomly selected sample. Finally, our study acknowledges the limitation of not including certain socio-demographic differences, such as education level, race, and ethnicity. These exclusions could potentially limit the comprehensive understanding of the relationship between PSUD and socio-demographic variables, but it can be addressed by future research. Our analysis did not reveal statistically significant associations between age groups and the identified factors. This could be attributed to the broad age range used in our classification. Future studies may consider grouping age categories based on Generation Alpha (0–9 years old), Generation Z (10–24 years old), Generation Y (25–39 years old), Generation Z (40–54 years old) and Baby Boomers (55–69 years old) for a more refined analysis. By encompassing a more diverse set of variables, researchers can obtain a more nuanced understanding of how various socio-demographic factors contribute to problematic smartphone use, further enriching the depth of knowledge in this field. It is important to note that the categorisations used in our study, as well as those used by other researchers who utilised the original PUMP scale, are not directly linked to established diagnostic criteria for PSUD as a disorder, as such diagnostic criteria do not yet exist in the DSM-5 [1,51,53,73]. To establish the specificity and sensitivity of these measures for diagnosing PSUD, it would be desirable to adopt more rigorous diagnostic categorisations if smartphone use disorder were to be included in future versions of the DSM [42]. Thus, the existing PUMP and MPUMP scales do not ascertain that excessive smartphone use constitutes addiction or dependence. Further research and development are needed to refine the measurement of PSUD using MPUMP, considering the potential inclusion of diagnostic criteria and involving interdisciplinary expertise. In addition, it is possible that this scale could exhibit differential psychometric properties in these examples because of socio-demographic and cultural differences in smartphone use, and the philosophy of PSUD still needs to be investigated further. Thus, it is essential to enrich the body of knowledge to decide if smartphone use has become an unavoidable issue today, particularly in the Australian context. At present, there is a lack of literature regarding the latest tendencies of problems related to smartphone use, precise PSUD identification, differentiating it from effectual use and findings of practical approaches to managing it, particularly in the Australian population.

6. Conclusion

This paper presented a study investigating PSUD using a modified and validated scale: MPUMP. MPUMP was used to sample adult Australians and their association with smartphone usage and common socio-demographic factors. The study results demonstrate that the modified version of the MPUMP scale maintains its psychometric properties when validated using a population-based survey on the adult Australian population, making it a valid and reliable tool for assessing PSUD. The conducted EFA and PCA on the developed scale revealed two distinct factors associated with smartphone usage: distraction and dysregulation. These two-factors varied based on specific socio-demographic characteristics. Distraction was found to be associated with participants' parental status, location, occupational status, and daily smartphone usage. Dysregulation was also found to be associated with participants' gender, parental status,

occupational status, and daily smartphone usage. Thus, these two-factors could be useful for identifying higher risk users; however, further analysis of the influencing socio-demographic characteristics is still needed. Some socio-demographic groupings identified in the study, such as non-parents, retired/unemployed, living in rural areas and with higher daily smartphone usage, were found to be at a higher risk of PSUD and may require additional attention in developing strategies to address this growing issue. Based on the study findings, it is suggested that future scale modifications should incorporate items that aim to capture the multi-layered motivations and purposes behind smartphone usage for study, work, socialising, and entertainment.

Our study makes a theoretical contribution to measuring the severity of PSUD by incorporating additional items into the PUMP scale. The items shed light on behaviour related to over-reliance on smartphones, functioning without smartphones, appropriate duration and frequency of smartphone use, and multitasking with smartphones. These additional items enhance the accuracy and reliability of PUMP based on the factors for substance dependence in the DSM-5 in measuring PSUD. Our study's findings bring forth novel contributions and research implications that enhance our understanding of problematic smartphone use dynamics. The identification of key factors, such as distraction and dysregulation, provides a comprehensive perspective on the complex interplay between socio-demographic variables and smartphone use behaviour. By delving into the specific dimensions of distraction and dysregulation, our study corroborates existing research and offers nuanced insights into the underlying mechanisms driving excessive smartphone use. These findings have significant implications for interventions and policies aimed at reducing PSUD. The differential experiences of dysregulation based on parental status, occupational status, and daily smartphone usage time underscore the importance of tailored approaches for distinct socio-demographic groups. For instance, interventions targeting parents could focus on bolstering coping strategies to manage dysregulation, while retired/unemployed individuals might benefit from interventions promoting healthier leisure activities to mitigate excessive smartphone use. Additionally, our study's examination of socio-demographic disparities within the context of smartphone usage-related dysregulation opens new avenues for future research. Exploring the underlying psychological and sociocultural factors that contribute to dysregulation among different groups can shed light on the intricate mechanisms at play. Furthermore, the uniqueness of my study is the incorporation of additional items in the MPUMP scale to align with DSM-5 criteria, which enhances its applicability and reliability in assessing problematic smartphone use. This adaptation addresses contemporary usage patterns and nuances, underscoring the relevance of a holistic approach to measurement.

Our findings also emphasise the necessity of a multidisciplinary perspective in understanding the broader implications of smartphone usage on individuals' wellbeing. Insights from psychology, sociology, and technology studies can collectively inform interventions, public health policies, and digital wellbeing initiatives. By integrating knowledge from diverse fields, researchers can uncover more holistic strategies to mitigate the negative consequences of excessive smartphone use and promote healthier digital habits. Our study's novel contributions offer valuable insights into the intricate relationship between socio-demographic variables and PSUD. The identified factors, implications for interventions, and directions for future research collectively enrich the discourse on digital wellbeing and lay the foundation for targeted efforts to address the challenges posed by modern smartphone usage. To improve problematic smartphone screening and reduce its impact on mental health further, it is necessary to increase public awareness, promote screen time management, collaborate with smartphone manufacturers for digital wellbeing initiatives, provide support and treatment options, and conduct further research on underlying motivations. Implementing these suggestions may pave the way for healthier smartphone habits and mitigate the adverse consequences of excessive smartphone use on individuals' wellbeing.

Ethics statement

This research project was approved by the Swinburne University of Technology in line with the National Statement on Ethical Conduct in Human Research in Australia (Approval Reference Number: 20223022–10886). The study was a web platform-based questionnaire that included informed consent at the beginning of the survey, where the participants were informed of the purpose of the study. All participants provided their voluntary acceptance in accordance with the Human Research Ethics Committees Australia. All the processes used in this study ensured the generation of completely anonymised datasets.

CRediT authorship contribution statement

Saqib Nawaz: Writing – review & editing, Writing – original draft, Validation, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Jahar Bhowmik:** Writing – review & editing, Validation, Supervision, Software, Resources, Methodology, Formal analysis, Conceptualization. **Tanya Linden:** Writing – review & editing, Validation, Supervision, Software, Resources, Methodology, Conceptualization. **Matthew Mitchell:** Writing – review & editing, Validation, Supervision, Software, Resources, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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enter a draw with the chance to win one of three $50 Mastercard vouchers after completing the anonymous online survey. The draw was conducted immediately following the completion of the survey, and the prizes were distributed among the successful applicants. The researchers used their personal funds to accommodate these prizes. This approach was adopted to enhance participant engagement and acknowledge their contribution to the study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e24832.

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