GUEST EDITORIAL

Problematic smartphone use and mental health problems: current state of research and future directions

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Empirical research on relations between problematic smartphone use (PSU) and mental health problems has made substantial advances in recent years. PSU is a construct involving excessive use of a smartphone, with accompanying functional impairment in everyday life (1). Specifically, what distinguishes PSU from healthy levels of smartphone use are PSU's maladaptive symptoms resembling substance use disorder criteria. For example, PSU can involve psychological withdrawal when one is unable to use one's phone (e.g., after battery drain), tolerance for engaging in increasingly greater use to feel satisfied, dangerous use (e.g., when driving), and social/relationship interference from overuse (2).

For several years, research on relations between PSU and psychological constructs have involved two fairly distinct areas. First, one strand of the literature found associations between PSU severity and personality constructs, including small to moderate associations with neuroticism and impulsivity (reviewed in 3). Second, another strand of literature found PSU severity correlated with several psychopathology variables – depression, anxiety, stress, and low self-esteem. In this second strand, the most frequently studied and consistently found associations with PSU severity were

for depression (moderate effects), and anxiety severity (small to medium effects) (reviewed in 4, 5).

More recently, the literature on PSU's relations with mental health has advanced by moving beyond studying traditional correlates such as depression and anxiety. Several additional psychopathology-related variables were recently examined and supported, including behavioral activation (6), rumination and worry (7-9), and emotion dysregulation (10-12). Furthermore, PSU was related to low self-control (13), fear of missing out on rewarding experiences (14-19), and proneness to boredom (20). Many of these newly studied psychopathology-related variables can be considered "transdiagnostic" constructs in that they appear in numerous mental disorders. Such transdiagnostic variables are increasingly important in psychopathology research, as they are involved in the etiology, maintenance, and treatment outcomes for mental disorders (21).

In fact, many of these transdiagnostic psychopathology variables have been examined not only in relation to PSU severity, but also as moderators and mediators between traditional psychopathology variables and PSU. The focus on exploring mechanisms underlying PSU represents another significant advance in research. Theoretical frameworks conceptualize PSU and other forms of

problematic internet use (PIU) as coping strategies that people use to regulate negative emotion (22). Because not all individuals with negative affectivity engage in PSU, understanding mechanisms that may account for this relationship is an important area of inquiry.

Studies examining transdiagnostic psychopathology variables as mechanisms of PSU began doing so, perhaps as a result of, or perhaps coincidentally after the development of the Interaction of Person-Affect-Cognition-Execution (I-PACE) theoretical model (23, 24). I-PACE proposes that internet feature use and PIU/PSU are influenced by personal predisposition, including genetic, biological, personality, psychopathology, cognition, and internet use motives. I-PACE also proposes intermediate variables that play an important role in accounting for relations between predisposition and PIU – specifically, affective and cognitive responses such as cognitive and attention bias, internet use expectancies, coping strategies, inhibitory control, and craving. Numerous studies have supported I-PACE in explaining PIU and PSU (e.g., 18,25,26). Thus I-PACE and the associated focus on mechanisms underlying PSU go hand in hand, and are important advances in this area.

We should point out that much of the literature on PSU has measured smartphone use with self-report survey measures. However, research demonstrates that the frequency of smartphone and internet use is typically inaccurately estimated by self-report methodology (27,28). Newer studies have measured smartphone use through objective collection of data through participants' phone logs (27,29,30), which is an important advance in measuring smartphone use and PSU. Such research practice is becoming more feasible now, as large technology companies are building screen time calculations into their software (31,32). Such measurement can also be used to assess objective phone use by participants over time (29,30).

The recent advances in research on PSU are important for this area of study and have a significant impact. We believe that researchers should continue on this trajectory by further examining transdiagnostic psychopathology constructs in relation to PSU and focusing on mechanisms between psychopathology and PSU. Research should continue objective measurement of smartphone use using repeated measures designs, with more fine-grained analysis of various features of smartphone use.

We also believe that new advances in research on PSU should be attempted at this time. First, few studies have used person-centered or mixture modeling analyses to examine smartphone use or PSU (7,33). Such investigation can elucidate diverse subtypes of smartphone users based on their ways of interacting with the device. Additionally, network analysis is a method increasingly used to examine covariation between symptoms of psychopathology constructs (34) but has not yet been applied to smartphone research. Mobile sensing studies and ecological momentary assessment studies can also advance our understanding of the association between PSU and psychopathology. Finally, advances in machine learning can be applied to a better detection of PSU based on smartphone use data (35).

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