Are smartphones really that bad? Improving the psychological measurement of technology-related behaviors

Abstract

Understanding how people use technology remains important, particularly when measuring the impact this might have on individuals and society. To date, research within psychological science often frames new technology as problematic with overwhelmingly negative consequences. However, this paper argues that the latest generation of psychometric tools, which aim to assess smartphone usage, are unable to capture technology related experiences or behaviors. As a result, many conclusions concerning the psychological impact of technology use remain unsound. Current assessments have also failed to keep pace with new methodological developments and these data-intensive approaches challenge the notion that smartphones and related technologies are inherently problematic. The field should now consider how it might re-position itself conceptually and methodologically given that many 'addictive' technologies have long since become intertwined with daily life.

Key Words: *behavioral analytics; psychometrics; smartphones; technology use*

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1. Introduction

Behavioural science has spent many years attempting to understand how our interactions with technology might impact on related psychological outcomes (Shaw, Ellis & Ziegler, 2018). This lends itself to a wide variety of research questions from problematic use (e.g., do smartphones cause depression or anxiety?), to the effects of engaging with feedback as part of a behavior change intervention (e.g., does monitoring physical activity improve health?) (Ellis & Piwek, 2018). Approaches within psychology have almost exclusively focused on correlational research that involves asking people to consider their personal experience with a technology rather than measuring their actual behavior (Ellis et al., 2018a). This reflects a general trend within social psychology as a whole (Baumesiter et al., 2007; Doliński, 2018), but remains surprising when considered alongside automated systems (e.g., smartphones (Miller, 2012)) that can record human-computer interactions directly (Piwek, Ellis & Andrews, 2016). For example, behavioral interactions can be measured 'in situ' with applications. However, this is not an avenue explored by the majority of psychological research, despite having spent over a decade attempting to define 'problematic' or 'addictive' smartphone behaviors (Panova & Carbonell, 2018). Conclusions surrounding use have therefore been largely negative and smartphones have repeatedly been associated with depression (Elhai et al., 2017), anxiety (Richardson, Hussain, & Griffiths, 2006), disrupted sleep (Rosen et al., 2016), cognitive impairment (Clayton, Leshner, & Almond, 2015), and poor academic performance (Lepp, Barkley & Karpinski, 2015). This repeats a pattern of research priorities, which previously focused on the negative impacts of many other screen-based technologies, systematically moving from television and video games, to the internet and social media (Rosen et al., 2014).

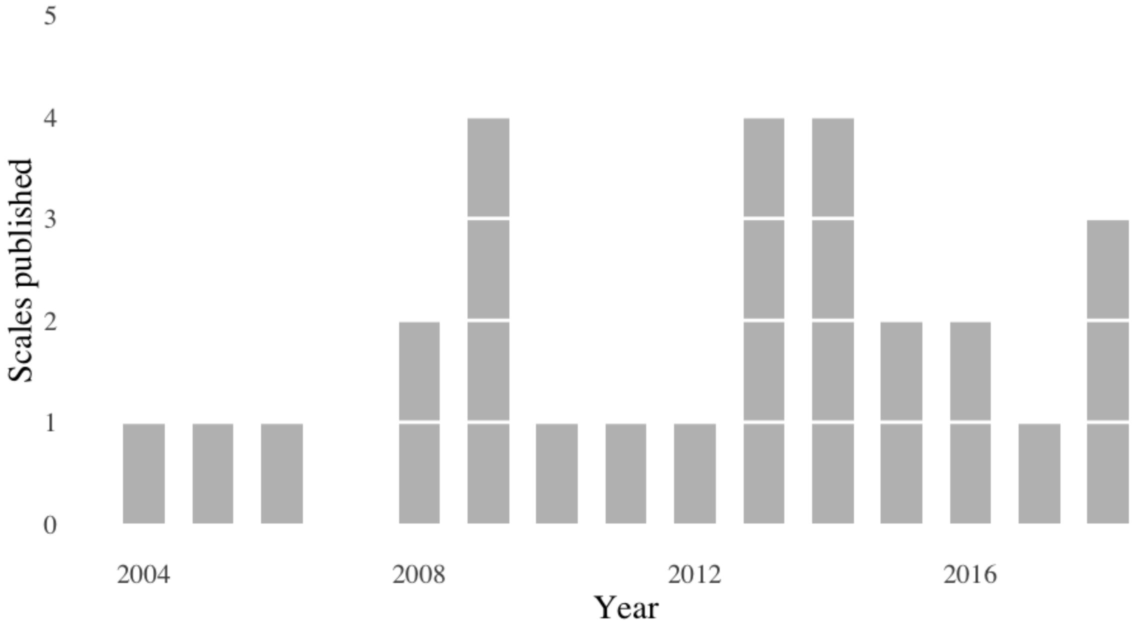
While some research has reported many beneficial effects of technology use (e.g., Barr et al., 2015; Przybylski & Weinstein, 2017; Ward et al., 2018), ominous results have had a far greater impact on public opinion. This has recently led to a UK government enquiry concerning the effects of screen time on health (UK Parliament, 2018). However, regardless of whether research aims to focus on narrow or broad definitions of technology use, our current understanding is based around a set of popular measures that present several methodological shortcomings (Shaw, Ellis & Ziegler, 2018; Ryding & Kaye, 2017). This has become particularly pertinent as methods of investigation have remained static despite exponential changes in the availability and processing power afforded by modern technology (Shaw, Ellis & Ziegler, 2018).

2. Capturing Smartphone Behaviors from Self-Report

Historically, time has been the primary focus when attempting to quantify experiences with technology. Respondents are often asked to report their frequency or duration of use, but even simple self-reported estimates concerning mobile phone use (e.g., number of calls made, or text messages sent) have been described as 'sub-optimal' when compared to phone operator data (Boase & Ling, 2013). Nevertheless, many studies continue to rely on estimates alone when making links between technology use and other psychological constructs (Butt & Phillips, 2008). When such estimates are scaled to larger samples, these often explain very little of the variance when predicting health or subsequent behavior (Przybylski & Weinstein, 2017; Twenge et al., 2017). The use of multiple technologies simultaneously (e.g., a smartphone and a laptop) also make such estimates problematic due the level of cognitive burden required to quantify many different types of automatic behavior (Boase & Ling, 2013; Doughty et al., 2012; Jungselius & Weilenmann, 2018).

Perhaps in response to this criticism, a growing number of prominent self-report instruments have been developed in an attempt to quantify smartphone related technology experiences (Figure 1; Table 1). These scales, built around a conceptualization of problematic use, are often derived from previous measures that were developed to assess a specific type of technology engagement (e.g., social media or video game use). This in itself is problematic as issues associated with smartphone use may be secondary to another behavior (Panova & Carboell, 2018). For example, while a smartphone can be used to engage with addictive behaviors such as gambling, its use can also support and maintain a healthy lifestyle (Piwek, Ellis & Andrews, 2016).

Figure 1: Publication of self-report instruments between 2004-2018, which aim to assess ‘problematic’ or ‘addictive’ smartphone usage within the general population.



Following traditional methods associated with scale development, factor analyses ensure that tools are reliable, but their validity remains highly questionable (Table 1). While measures are framed around ‘smartphone behaviors’, the language used to describe subsequent results becomes misleading. Paper titles including the words ‘smartphone use’ are inaccurate when this has simply not been measured, causing confusion for casual readers, policy makers and even those who work within the field (Ellis et al., 2018a). There is also little evidence to support the existence of the constructs under investigation (e.g., ‘addiction’), yet many papers and scales continue to use language associated with a specific diagnosis (see Panova & Carbonell, 2018 for a recent review).

Table 1: Psychometric tools developed to assess general smartphone usage (direct translations are not included). Many of these are conceptually similar to those that assess internet, social media or video game 'addiction' (e.g., Kwon et al., 2013a). Validation typically relies on duration estimates, which are themselves poorly aligned with related behaviours (Boase & Ling, 2013) or by demonstrating a relationship with other constructs that are assumed to be related with increased technology use (e.g., impulsivity). Some measures (not listed) are built entirely around duration-based estimates or frequencies of use via likert scales (e.g., Elhai et al., 2016). Others (not listed) ask about specific mobile functions (e.g., text messaging (Rutland, Sheets, & Young, 2007)). Many non-peer reviewed scales are simply adapted directly from measures used to assess other technology behaviors (e.g., video games) without any subsequent reliability or validation checks (e.g., Hussain et al., 2017).

Reference	Items	Scale
Bianchi & Phillips (2005)	27	Mobile Phone Problem Use Scale (MPPUS)
Billieux, van der Linden & Rochat (2008)	30	Problematic Mobile Phone Use Questionnaire (PMPUQ)
Chóliz (2012)	22	Test of Mobile Phone Dependence (TMD)
Chóliz et al. (2016)	12	Brief Multicultural Version of the Test of Mobile Phone Dependence Questionnaire (TMD brief)
Csibi et al. (2018)	6	Smartphone Application-Based Addiction Scale (SABAS)
Foerster et al. (2015)	10	Mobile Phone Problem Use Scale: short version (MPPUS-10)
Ha et al. (2009)	20	Excessive Cellular Phone Use Survey (ECPUS)
Jenaro et al. (2009)	23	Cell Phone Over-Use Scale (COS)
Kawasaki1 et al. (2006)	20	Cellular Phone Dependence Tendency Questionnaire (CPDQ)
Kim et al. (2014)	15	Smartphone Addiction Proneness Scale (SAPS)
King et al. (2014)	29	Mobile Phone Use Questionnaire (MP-Use)
Koo (2009)	20	Cell Phone Addiction Scale (CAS)
Kwon et al. (2013a)	33	Smartphone Addiction Scale (SAS)
Kwon et al. (2013b)	10	Smartphone Addiction Scale (SAS short version)
Lee et al. (2017)	28	Smartphone Overuse Screening Questionnaire (SOS-Q)
Leung (2008)	17	Mobile Phone Addiction Index (MPAI)
Lin et al. (2014)	26	Smartphone Addiction Inventory (SAI)

Lopez-Fernandez et al. (2014)	26	Mobile Phone Problem Use Scale for Adolescents (MPPUSA)
Lopez-Fernandez et al. (2018)	15	Short Version of the Problematic Mobile Phone Use Questionnaire (PMPUQ-SV)
Martinotti et al. (2011)	10	Mobile Addiction Test (MAT)
Marty-Dugas et al. (2018)	20	Smartphone Use Questionnaires (SUQ-G & A)
Merlo, Stone & Bibbey (2013)	22	Problematic Use of Mobile Phones Scale (PUMP)
Rosen et al. (2013)	9	Media and Technology Usage and Attitudes Scale (subscale measures smartphone usage)
Rozgonjuk et al. (2016)	18	Short version of Estonian Smartphone Addiction Proneness Scale (E-SAPS18)
Toda et al. (2004)	20	Cellular Phone Dependence Questionnaire (CPDQ)
Walsh et al. (2010)	8	Mobile Phone Involvement Questionnaire (MPIQ)
Yen et al. (2009)	12	Problem Cellular Phone Use Questionnaire (PCPU-Q)
Yildirim & Correia (2015)	20	Nomophobia Questionnaire (NMP-Q)

These measures generally assess a respondent's attitudes and feelings towards their smartphone or technology usage. While no less important, the constructs under investigation may be fundamentally different to the very behavior they seek to explain. To date, current self-report measures do not align well with or predict simple objectively measured smartphone behaviors (Table 2). It would appear that objectively measured time spent on a device may correlate with some self-report scales or duration estimates, but this relationship appears patchy. Current scales have therefore yet to demonstrate an ability to predict comparatively simple behaviors that appear to be stable within participants (Ellis et al., 2018a; Wilcockson et al., 2018).

Even if current measures do correlate with behavior, there is still reason to question the extent to which they measure constructs as expected. First, given the range of activities that can be performed on a smartphone, scores will have little bearing on a person's overall experience with that technology. One may speculate that active versus passive use will be an important mitigating factor when quantifying outcomes. For example, engaging in positive conversation online can bring many health benefits, with passive consumption likely to be less valuable (Day et al., 2018). Second, scales present leading questions that focus on worries surrounding a participant's relationship with their smartphone, which may be more representative of general traits. For example, measures used to assess problematic smartphone use are also likely to detect core elements of impulsivity, anxiety, or extraversion. Items that ask participants about levels of impatience associated with reduced use may instead reveal a general impulsivity that is not smartphone specific and could apply to any other personal product used on a regular basis (Belk, 2013). Indeed, how unique these results are to a specific technology and not a globalized behavior that filters into other daily activities (e.g., exercise, coffee consumption) remains unknown.

Our current understanding is therefore based around a set of measures, which will struggle to capture and understand the subsequent impact of technology. However, this has not prevented the development of theoretical models that are based entirely around data generated from these psychometric tools (Billieux et al., 2015). Of course, and as with any psychological phenomenon, several of these scales and the constructs they aim to measure are likely to go beyond behavior. However, the scales are routinely used without this broad conceptualization in mind and are framed as an assessment of usage alone. In recent years, these problems have become magnified further as theoretical and methodological advances have allowed for dynamic and fluid approaches to data collection. These can provide greater specificity and flexibility when exploring our relationship with technology (Jankowska, Schipperijn, & Kerr, 2015).

3. Objective Measures of Smartphone Usage

If technology use cannot be controlled experimentally, then exposure to general (e.g., hours of smartphone use) or specific use (e.g., hours of Facebook use on a device) provides an alternative source of objective data (Scharkow, 2016). This removes issues concerning social-desirability and cognitive burden. However, while those in computer science have been measuring such interactions with smartphone technology since around 2010, these developments have had very little impact on how psychology attempts to quantify, explain, and understand technology use more generally (Oliver, 2010). For example, only a handful of papers have attempted to validate existing scales against self-report, with mixed results (Table 2).

These objective-based studies confirm that people use devices like smartphones and associated applications frequently and habitually (Andrews et al., 2015). However, this alone does not equate to any form of problematic usage. It may seem reasonable to assume that those who spend a long time in front of a screen have problematic use. However, heavy users are not necessarily the same as problematic users (Andrews et al., 2015; Oulasvirta et al., 2012). This research also challenges the notion that mobile technology use is becoming more prevalent. For example, the quantity of short checking behaviors observed in research conducted in 2018 for example, (Ellis et al., 2018b) are remarkably consistent with those recorded in 2015 and 2009 (Andrews et al., 2015; Oulasvirta et al., 2011). In addition, while at a population level it would appear that smartphone use is high, within-participant patterns are consistent and establishing a true absolute baseline of typical usage for an individual appears possible (Fullwood et al., 2017; Wilcockson et al., 2018).

In recent years, objective studies have also started to focus on the potential negative impacts of smartphones on mood however, their conclusions are dramatically different from previous findings, which rely on self-report alone. For example, Rozgonjuk and colleagues (2018) observed that depression and anxiety severity were not associated with total smartphone usage. In addition, higher depression scores correlated with less phone checking over a week, suggesting that periods of low-mood may lead to less engagement with technologies that primarily enable social interaction. This supports the notion that a sudden lack of smartphone use may be an early warning sign of social withdrawal (Mou et al., 2016). Machine learning approaches have also demonstrated that smartphone use alone does not predict negative well-being. Katevas and colleagues (2018) combined an experience sampling methodology with 23 objective measures of behavior including phone unlocks, calls received, and battery drain. In one of the largest studies of its kind, participants who reported lower levels of well-being tended to use their smartphones more at night. However, this relationship was unidirectional as late-night smartphone usage was independent of low mood, which was assessed throughout the day over several weeks.

While these results and methods are compelling, they remain difficult to place in context because the majority of psychological research continues to rely on a very different methodological framework. They are also largely exploratory in nature and consider a very limited definition of technology use. It is also important to keep in mind that these remain correlational in nature. However, objective studies do appear to repeatedly challenge the notion that smartphones are problematic for a large percentage of the population.

Table 2: Research that has attempted to validate single estimates or self-report smartphone usage scales against objective behaviors.

Reference	N	Time (days)	Findings
Andrews et al. (2015)	23	14	Estimated time spent using a smartphone correlated moderately with actual usage. Estimates concerning the number of times an individual used their phone did not correlate with actual smartphone use. Neither estimated duration nor number of uses correlated with the Mobile Phone Problem Use Scale (MPPUS).
Elhai et al. (2018)	68	7	No overall correlation between likert estimations of use and average daily minutes. Weak overall relationship between average daily minutes and Smartphone Addiction Scale (SAS short version). Likert estimates and SAS scores predicted weekend, but not weekday averages.
Ellis et al. (2018b)	238	6	Weak relationships observed between objective smartphone measures and a variety of self-report measures (including single duration estimates).
Foerster et al. (2015)	234	N/A	Weak relationships observed between short version of Mobile Phone Problem Use Scale (MPPUS-10) and phone call/sent SMS messages. Moderate correlation between MPPUS-10 and data traffic volume. Note: objective data was available for up to 6 months for some, but not all participants.
Rozgonjuk et al. (2018)	101	7	Weak relationship between Smartphone Addiction Scale (SAS) and minutes of screen time in a week (Spearman). No relationship between SAS and the number of times an individual used their smartphone (Spearman).
Lin et al. (2015)	66	7	Estimated time spent using a smartphone correlated moderately with actual usage.

Wilcockson et al. (2018)	27	14	No relationship observed between Mobile Phone Problem Use Scale (MPPUS) with actual usage or the number interactions with a smartphone lasting less than 15 seconds (Spearman).

4. Conceptual and Methodological Challenges

Research that attempts to develop methods to quantify smartphone and related technology use often sits within a conceptual framework that problematizes usage without considering how typical these behaviors are within the general population. Conceptually, the field appears to have taken this approach with video games, the internet, and social media however, smartphones may finally be the point where psychologists consider going beyond these clinical definitions (Ellis et al., 2018a). Similarly, while psychology now has access to new technologies that would improve current practices, a number of methodological challenges also remain if new data collection methods and analytical routines are to prosper.

4.1 Conceptual

Conceptual misunderstandings may, in part, help drive research that focuses on the negative implications of technology, despite many obvious benefits (Days, 2018; Surrat, 1999). For example, the idea that problematic technology use can be framed as a behavioral addiction is widely accepted despite being poorly defined (Van Rooij et al., 2018). As before, the enormity of activities that can be performed on a smartphone immediately make this definition difficult (Doughty et al., 2012; Ellis et al., 2018a; Ryding & Kaye, 2018). This has, in turn, led to the proliferation of 'treatment' programs that lack empirical support. Based on associations between reduced objective use and social withdrawal, such programs could result in unintended negative consequences (Stieger & Lewetz, 2018). Of course, some forms of use could satisfy a diagnostic criterion, but the evidence base required to support such a claim has yet to appear and existing smartphone 'addiction' scales do not correlate with the rapid checking behaviors one would associate with a behavioral addiction (Andrews et al., 2015; Rozgonjuk et al., 2018). It therefore remains difficult to classify something as a behavioral addiction without actually measuring behavior. A growing body of evidence now supports the notion that psychology should start to move away from a behavioral addictions framework when studying technology use (Panova & Carbonell, 2018).

The repeated tendency to problematize technology behaviors can also be explained by considering how little work in psychology has attempted to conceptualize technology use in a broader context. There is some overlap with models, which emphasize the formation of habits and planned behavior. Specifically, repeating a technology interaction behavior in response to a cue over time will quickly lead to the automaticity of that behavior (Lally et al., 2010). Other recent attempts have considered everyday smartphone use in the context of attentional lapses and mind wandering, which are of an arguably greater concern to public health and include phone use that can demonstrably interfere with driving or walking (Ioannidou, Hermens & Hodgson, 2017; Marty-Dugas et al., 2018). However, other models derived from computer science, information systems, marketing, and management provide several high-level constructs that also attempt to explain impacts associated with continued use. These range widely from the measurement of individual differences to specific features of the technology under investigation (Shaw, Ellis & Zeigler, 2018).

Perhaps before considering the impact of technology on our psychology, more resources need to be devoted to defining what we mean by usage itself. Does the use of a smartphone, for example, only register when actively creating something with the device (e.g., writing a tweet), or would this also include time spent passively viewing content (e.g. reading the news)? Current definitions of use may be too narrow, particularly when online and offline identities are intertwined. Much of the population are now permanently online (Vordere et al., 2016) and smartphones have become a core part of a person's digital identity. Qualitative accounts often reflect the ability of these devices to help support existing social activities. This in part explains why many people develop strong psychological attachments to them (Belk, 2013; Bodford et al., 2017; Fullwood et al., 2017; Shaw et al., 2016). This 'individualized' perspective of smartphone usage fits well within the framework of the Uses and Gratifications model and reflect consistent, yet individualized patterns of behavior (Katz et al., 1974; Wilcockson et al., 2018). Therefore, people appear to often use technology in order to gratify very personal needs. However, such conceptualization is very much at odds with the majority of research, which focuses on technology as a problem, rather than a device, which supports everyday activities (Shaw, Ellis & Ziegler, 2018).

4.2 Methodological

The use of duration estimations in isolation no longer seem suitable when contrasted directly with how people describe their usage patterns, especially when this involves multiple devices (Doughty et al., 2012). Once a technology has become intertwined with daily life, people are less able to accurately report on these behaviors, particularly when it comes to estimating the number of single interactions in a 24-hour period (Andrews et al., 2015). At the same time, research that aims to improve our understanding of technology use has become increasingly more technical, which poses a number of methodological challenges for psychologists (Piwek, Ellis & Andrews, 2016). Standard measurements produce small data sets and rarely go beyond interviews and psychometric assessment. However, smartphone applications can measure both where and how a device is being used allowing for distinctions to be made between active (e.g., typing/photo taking) or passive (e.g., reading tweets) use. It is also possible to distinguish between spontaneous use and response-based usage patterns, the latter of which involves responding to a specific notification (Piwek, Ellis & Andrews, 2015). This leaves many new methodological avenues open to exploration whereby technology use can be assessed longitudinally (Shaw, Ellis & Ziegler, 2018).

Accordingly, it is essential that results and research materials are openly available for all researchers to scrutinize and build upon. Generally, research that focuses on the effects of technology are single studies that do not engage with pre-registration or the sharing of data. Recent attempts to validate self-report measures (Table 2) also make replication very difficult (McKiernan et al., 2016). Commercial applications, for example, have not been robustly validated to ensure that they are measuring behaviors reliably, store data securely, and comply with ethical guidelines (Elhai et al., 2018; Rozgonjuk et al., 2018). On the other hand, source code, datasets and related materials are available from Andrews et al., (2015) and Wilcockson et al., (2018). However, the smartphone framework originally used to collect data is no longer actively maintained (Piwek, Ellis & Andrews, 2016). Therefore, smartphone applications and associated analytical tools that have been developed specifically for the purposes of research are now urgently required. Apple and Google are now providing more objective data that can be used directly by researchers, but these approaches alone will not capture the complexity of psychological processes associated with everyday technology use (Ellis et al., 2018b). An alternative, but more elaborate proposition might focus on the development or adaption of hardware attachments, which capture behaviors outside of a technology ecosystem (Liu et al., 2018). For example, small sensors which measure light can be attached to screens directly. The reverse side could simultaneously measure movement or detect a face to confirm, in addition to a measure of screen activity, if someone is actively using the device (McGrath, Scanaill & Nafus, 2014).

5. Conclusion

Results concerning the negative impact of smartphones on psychological well-being may surprise rather than worry many psychologists. Smartphones are primarily used to facilitate social interactions and psychology has spent many years convincingly arguing that social support and social integration has many positive health benefits (Day et al., 2018; Haslam et al., 2017; Jao et al., 2018; Pachucki et al., 2015). Even priming topics associated with smartphones appears to make relationship concepts become more accessible (Kardos et al., 2018). New technology also offers a host of new possibilities to improve physical and mental health (Ellis & Piwek, 2018). Conclusions from psychological science are therefore completely at odds with what might be expected in the general population and a new wave of research is starting to challenge previous findings (e.g., Elhai et al., 2018). Given our current understanding, one might argue that the biggest threat facing those who engage regularly with a smartphone is that these interactions take up time, which might have been traditionally spent elsewhere. For example, a lack of physical activity is of a far greater demonstrable risk to young people with previous research highlighting clear links between media exposure and childhood obesity (Chekroud, 2018; Lee et al., 2012; Vioque et al., 2000).

When it comes to understanding the impact of technology more generally, there is an intrinsic lack of high-quality evidence (Ellis et al., 2018a). Revised psychometric tests may hold some value in the future, provided they are grounded in relevant theory and validated accordingly. However, psychological science should be in a position to go beyond these, particularly as social psychology appears to be acknowledging the limitations associated with a lack of behavioral measurement and validation of existing measures across the field (Doliński, 2018). Moving forward, researchers may also wish to consider how behavioral data might be captured from other digital devices that can capture real-world behavior. Perhaps more importantly, a frank an open debate is required regarding how psychologists might conceptualize, measure, and understand general technology usage, which has long since become a core component of daily life (Shaw, Ellis & Ziegler, 2018).

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