



ELSEVIER

Contents lists available at ScienceDirect

Addictive Behaviors Reports

journal homepage: www.elsevier.com



Linking Internet Communication and Smartphone Use Disorder by taking a closer look at the Facebook and WhatsApp applications[☆]

Peng Sha^{a, **, 1}, Rayna Sariyska^{b, 1, 2}, René Riedl^{c, d}, Bernd Lachmann^b, Christian Montag^{b, e, **, *}

^a School of Journalism and Communication, Southwest University, Chongqing 400716, China

^b Institute of Psychology and Education, Ulm University, Ulm, Germany

^c School of Management, Digital Business Management, University of Applied Sciences Upper Austria, Steyr, Austria

^d Department of Business Informatics-Information Engineering, Johannes Kepler University, Linz, Austria

^e The Clinical Hospital of Chengdu Brain Science Institute, MOE Key Laboratory for Neuroinformaton, University of Electronic Science and Technology of China, Chengdu, China

ARTICLE INFO

Keywords:

Smartphone Use Disorder
Internet Communication Disorder
WhatsApp
Facebook
FoMo
Life satisfaction

ABSTRACT

Introduction: Smartphones are ubiquitous in the digital society. Although this powerful device is useful because it supports and simplifies many tasks in everyday life, a growing number of researchers is concerned that smartphones might have detrimental effects on the human brain and related psychological processes. Evidence indicates that social media platforms such as WhatsApp and Facebook are essential drivers of smartphone usage. Thus, a critical, yet unexplored issue is how excessive use of those platforms is related to Smartphone Use Disorder (SUD). Furthermore, since the role of life satisfaction and fear of missing out (FoMo) has been demonstrated to be of particular importance for Internet Use and Internet Communication Disorder, those constructs were examined in the context of SUD.

Methods: In total, $n = 2299$ participants filled in questionnaires assessing SUD, WhatsApp and Facebook Use Disorder, FoMo, life satisfaction, and reported owning a WhatsApp and Facebook account.

Results: The study revealed that SUD was linked to WhatsApp Use Disorder, and to a lesser extent, to Facebook Use Disorder. Associations between SUD and WhatsApp Use Disorder were most strongly pronounced in females. Additionally, FoMo predicted SUD, WhatsApp, Facebook Use Disorder, and (fully) mediated the relationship between life satisfaction and those variables.

Conclusion: The findings of the present study suggest that WhatsApp use plays an important role to understand SUD. Regarding the mediating role of FoMo, the present work might help disentangle inconsistent results on the link between life satisfaction and (excessive) SNS use.

1. Introduction

Smartphones are ubiquitous in modern societies and have dramatically changed how humans communicate and entertain themselves. According to latest statistics, 2.50 billion humans use a smartphone (Statista, 2018a). In other words, currently about a third of the world's population uses this device. In works from the research field of *Psychoinformatics* it has been demonstrated that the average smartphone user spends about 2.5h on the phone each day with

more than half an hour of WhatsApp usage (Montag et al., 2015). Therefore, more than one work day is spent on the phone each week, with several hours using WhatsApp only. Considering a growing body of scientific observations showing that humans spend time on their smartphones and the Internet mostly for leisure, rather than business purposes (Montag et al., 2018; Sariyska et al., 2014), it becomes evident, that much of this spent time could be invested in more meaningful activities, such as direct interactions between parents and their children.

[☆] Declarations of interest: none.

^{*} Corresponding author.

^{**} Correspondence to: C. Montag, The Clinical Hospital of Chengdu Brain Science Institute, MOE Key Laboratory for Neuroinformaton, University of Electronic Science and Technology of China, Chengdu, China.

Email addresses: a2352893@gmail.com (P. Sha); Rayna.Sariyska@uni-ulm.de (R. Sariyska); mail@christianmontag.de (C. Montag)

¹ Shared first authorship.

² Ulm University, Helmholtzstraße 8/1 89,081 Ulm, Germany.

Although the smartphone has many positive aspects (e.g., it facilitates access to information from nearly everywhere), a growing number of scientists is concerned that excessive usage of the smartphone might have detrimental effects on our brains and well-being. It has been argued that constant interruptions due to incoming messages might result in loss of productivity (Duke & Montag, 2017b) and first longitudinal studies demonstrated that smartphone usage characterized by frequent interruptions might result in ADHD-like (Attention Deficit Hyperactivity Disorder) behavioral tendencies (Hadar et al., 2017; Kushlev, Proulx, & Dunn, 2016). In addition, a recent work suggests a link between Smartphone Use Disorder³ (SUD⁴) and lower empathy and life satisfaction (Lachmann et al., 2018), relationships which are likely mediated by stress (Samaha & Hawi, 2016). However, potential causal pathways between these variables have not been established until now.

Mounting evidence further shows that overuse of smartphones in the evening might result in lower sleep quality and in some cases also in work depletion in the morning (Lanaj, Johnson, & Barnes, 2014). Recent work shows that the smartphone lying on the desk, when we need to concentrate on a task on the computer screen, can result in reduced cognitive capacity (Ward, Duke, Gneezy, & Bos, 2017). Although, it is currently not clear if SUD merits being recognized as a mental health disorder (see the recent development to include the related term Internet Gaming Disorder (IGD) in Section III of DSM-5 and Gaming Disorder, predominantly online in ICD-11⁵), overuse of smartphones clearly can cause severe problems. Moreover, Internet Use Disorder (IUD) and SUD overlap to some extent (e.g. see Montag, Sindermann, Becker, & Panksepp, 2016; Duke & Montag, 2017a) and therefore the scientific community has to develop a framework explaining if and how mobile Internet use devices differ from the non-mobile Internet use platforms such as a desktop computer.

Moreover, the contribution of problematic use of different applications on the smartphone for the development of SUD has hardly been investigated. Therefore, the aim of the present study is to examine the overlap between SUD and tendencies towards problematic use of social network applications. Additionally, to investigate further factors associated with SUD, we also investigated the role of Fear of Missing Out (FoMO) and life satisfaction in the context of SUD and different social media applications.

2. Related work

Humans are not addicted to the smartphone per se; rather, addiction typically refers to applications or functions provided by the smartphone (Pontes, Szabo, & Griffiths, 2015). Again, for a discussion on the overlap between the terms IUD and SUD please see the work by Duke and Montag (2017a).

³ This term will be used as a synonym to smartphone addiction or excessive smartphone use, and in accordance with the inclusion of (Internet) Gaming Disorder to Section III of DSM-5 (American Psychiatric Association, 2013) and to ICD-11 (World Health Organization, Beta Draft, 2018), and to Brand, Young, Laier, Wölfling, and Potenza (2016), where the term Internet Use Disorder was introduced for the first time. Please note that many authors currently prefer the term problematic smartphone use (Elhai, Dvorak, Levine, & Hall, 2017; Hussain, Griffiths, & Sheffield, 2017). So when referring to SUD in our paper, we also take into account studies from other groups investigating smartphone addiction, problematic smartphone use and so forth.

⁴ The following abbreviations will be used throughout the article: SUD = Smartphone Use Disorder; IUD = Internet Use Disorder; IGD = Internet Gaming Disorder; ICD = Internet Communication Disorder; FoMO = Fear of Missing Out.

⁵ ICD-11 (International Statistical Classification of Diseases and Related Health Problems, a medical classification list by the World Health Organization) Beta Draft: <https://icd.who.int/dev11/l-m/en>.

Theoretical frameworks to understand SUD are largely lacking, however, a few attempts have been made to better describe the phenomenon and its antecedents and consequences. Soror, Hammer, Steelman, Davis, and Limayem (2015) proposed a theoretical model to explain the negative consequences of mobile phone use, based on dual system theories. In this theoretical framework it is suggested that a conflict between the reflexive/automatic system (e.g. respond to a message when we hear our phone rings) and the reflective/control system (e.g. monitor if the situation is appropriate – phoning while driving) influence mobile phone use and in turn, can explain potential negative consequences due to the use of mobile phones. The authors demonstrated this link by examining the relationship between habits, related to mobile phone use, self-regulation and the negative consequences of mobile phone use. Another theoretical model was proposed by Billieux, Maurage, Lopez-Fernandez, Kuss, and Griffiths (2015) and describes three pathways which are linked to mobile phone use. According to the *excessive reassurance pathway* individuals with high anxiety and low self-esteem will experience the need for reassurance which could lead to excessive use of mobile phones. The *impulsive pathway* is characterized by low self-control, which might lead to problematic mobile phone use (accompanied by addiction symptoms), antisocial pattern of use (e.g. cyberbullying) or risky mobile phone use (e.g. using the smartphone while driving). Finally, the *extraversion pathway* is suggested to lead to addictive outcomes in extraverted individuals who have the constant need to socialize with others. However, here also the traits of high sensation seeking and high reward sensitivity are described as risk factors and linked to risky or antisocial use of mobile phones.

Elhai et al. (2017) summarize existing theoretical models on SUD, based on the role of positive and negative reinforcement. The authors propose that positive reinforcement is often linked to mood enhancement. Negative reinforcement, on the other hand, is described in theoretical models which highlight the role of habit formation (see model by Duke & Montag, 2017a), seeking excessive reassurance (Billieux et al., 2015) or the unwillingness to miss important information (known as FoMO; Przybylski, Murayama, Dehaan, & Gladwell, 2013). Last but not least, the pathways *extraversion* and *impulsivity* described by Billieux et al. (2015) can be assigned to models depicting both positive and negative reinforcement.

The importance of social media applications to understand smartphone behavior is confirmed by statistics. Major drivers of smartphone usage are social network applications such as Facebook, WhatsApp, or WeChat in China. While Facebook (56%) and WhatsApp⁶ (55%) are the leading messengers worldwide, WeChat (a Chinese application which serves as a messenger and a social platform, but also allows payment services) is the most popular one in China based on the number of memberships (Frobes, 2016). The use of social networking sites (SNS) is a particularly popular activity on smartphones since nearly 80% of time with SNS is spent using mobile technologies (Marketing Land, 2016). A study by Montag, Zhao, et al. (2018) demonstrated that WeChat might be used in a problematic/uncontrolled manner. In particular, tendencies towards problematic WeChat use were linked to smaller gray matter volume of the subgenual anterior cingulate cortex, a region which was shown to be of relevance in the context of other addictive behaviors. Additionally, the frequency of paying with WeChat was associated with smaller gray matter volumes of the nucleus accumbens, a region of particular

⁶ Please note that WhatsApp is not used with equal frequency in different parts of the world. Large countries such as the United States and China, where a lot of research on the topic of smartphone use, social networking use and addiction is conducted, use alternative messengers/features, such as WeChat in China and the Facebook messenger in North America (Statista, 2018b). Nevertheless, it is noteworthy that WhatsApp is owned by Facebook Inc.

importance as a part of the brain reward system. Structural changes particularly in the anterior cingulate cortex (ACC) and the nucleus accumbens have been linked to IGD, substance addiction and pathological gambling in earlier studies (for an overview see Lin & Lei, 2017). In short, alterations in the ACC could be associated with dysfunctions concerning conflict monitoring (drug intake is always a conflict – because the consumer decides on getting the rewarding drug effects now, but in the long-term problems due to usage appear), whereas the accumbens region of the striatum is associated with motivational aspects of drug usage (and cue-related reactivity). For more information on ACC functions see Bush, Luu, and Posner (2000), and for the top-down and bottom-up interactions between those brain areas concerning IUD, see the model by Montag, Duke, and Reuter (2017).

In this context, it has been argued, that Internet Communication Disorder (ICD, referred to as the problematic use of online communication applications), could constitute a distinct form of Internet Use Disorder (Montag, Zhao, et al., 2018; Wegmann & Brand, 2016). Probably, SUD, if mainly driven by excessive social media/messenger use, might be in large parts best described by ICD. As mentioned earlier it will be of relevance to understand if access to social media via mobile platforms has a stronger impact on the development of ICD than via non-mobile platforms. But the latter aspect is beyond the scope of the present research question.

Given the significance of the phenomenon of SUD, along with its prominent drivers WhatsApp and Facebook, the present work aims to compare the problematic use of the WhatsApp and Facebook applications in the context of SUD. As more and more research has linked the overuse of the Internet and smartphones to lower life satisfaction (Lachmann et al., 2018; Lachmann, Sariyska, Kannen, Cooper, & Montag, 2016; Lachmann, Sariyska, Kannen, Stavrou, & Montag, 2017) and higher tendencies of FoMO (Wegmann, Oberst, Stodt, & Brand, 2017), these two constructs have been assessed as well, and contrasted over the different domains of problematic WhatsApp, Facebook, and smartphone use.

FoMo is defined as the tendency towards having fear to miss out on something rewarding that others are experiencing and the desire to constantly stay connected with others (Przybylski et al., 2013). Wegmann et al. (2017) distinguished between trait-FoMO and Internet specific FoMO, where the first refers to a dispositional characteristic (e.g. fearing that others are having fun without me) and the second is of more direct relevance in the context of online use (e.g. not wanting to miss out on anything online). Their study demonstrated that Internet specific FoMO mediated the effect of trait-FoMO and psychopathological symptoms (here depression and interpersonal sensitivity) on ICD. Furthermore, it was shown that the effects of trait-FoMO and Internet specific FoMO were specific to ICD since those variables could not predict IGD, another facet of specific IUD. These results are supported by other studies which reported a link between FoMO and SNS use and addiction (e.g. Blackwell, Leaman, Tramosch, Osborne, & Liss, 2017; Pontes, Taylor, & Stavropoulos, 2018). Chotpitayasunondh and Douglas (2016) also demonstrated the role of FoMO in the context of SUD. Elhai et al. (2018) reported that negative affect (among others, depression, anxiety and stress) mediated the relationship between FoMO and SUD. The same was true when FoMO was included as a mediator between negative affect and SUD (Elhai et al., 2018). Those results are supported by another study where FoMO mediated the effect of psychopathology (depression and anxiety) on the negative consequences of mobile phone use (Oberst, Wegmann, Stodt, Brand, & Chamarro, 2017). Moreover, the effect of FoMO on the negative consequences of mobile phone use was mediated by the intensity of SNS use. Summarizing the results from the above mentioned studies, it appears that FoMO is of importance as a risk factor particularly in the context of (excessive) SNS

use. However, the link between FoMO and specific social media channels accessed from a smartphone (here WhatsApp and Facebook) has not been examined so far to the authors knowledge.

Life satisfaction is described as the cognitive evaluation of one's life quality (Diener, Emmons, Larsen, & Griffin, 1985). Studies reported a negative association between life satisfaction and IUD/SUD (e.g. Lachmann et al., 2016; Lachmann et al., 2018). However, inconsistent results were reported on the link between Facebook Use (Disorder), and life satisfaction, where some studies report positive and others negative link to Facebook Use (Disorder) (e.g. Błachnio & Przepiórka, 2018; Kross et al., 2013; Valenzuela, Park, & Kee, 2009). Thus, the question arises if the relationship between life satisfaction and Facebook Use (Disorder) is mediated by a third variable (e.g. Samaha & Hawi, 2016). The link between satisfaction with life and FoMO has also been examined throughout different studies. In fact, Przybylski et al. (2013) demonstrated that high FoMO was linked to lower psychological need satisfaction, life satisfaction and mood, and mediated the relationship between those variables and higher engagement in social media. The negative link between FoMO and life satisfaction was also supported in a recent study by Błachnio and Przepiórka (2018). The relationship between WhatsApp Use (Disorder), FoMO and life satisfaction has not been investigated so far, to the authors' knowledge.

In the context of differentiating between specific (e.g. ICD or IGD) and unspecific IUD (Davis, 2001) it is of interest, if this distinction can also be applied in the realm of SUD. However, this question goes beyond the scope of the present study. Yet, comparing tendencies towards SUD with the problematic use of platforms such as WhatsApp and Facebook, which are often accessed via smartphones, might yield first insights if these concepts overlap in many ways. Here it was hypothesized that in particular tendencies towards WhatsApp Use Disorder would be more strongly related to SUD than tendencies towards Facebook Use Disorder. This hypothesis is based on findings in a study by Montag, Bey, Sha, et al. (2015), where it was demonstrated that WhatsApp was used longer on smartphones (minutes per day) than Facebook (the study was conducted with a German sample and the duration of use was assessed with an application that tracked participants' smartphone behavior over the period of four weeks). It could also be argued that this use/behavior mirrors the historical development of both platforms. Facebook started as a desktop computer application and later also developed into a smartphone application, whereas WhatsApp directly started as smartphone application.

Based on the findings from earlier studies, we developed the following hypotheses for the current study:

Hypothesis 1. Both Facebook and WhatsApp Use Disorder are positively linked to SUD. It is further hypothesized that the correlation between WhatsApp Use Disorder and SUD is higher than the correlation between Facebook Use Disorder and SUD.

Hypothesis 2. FoMO is positively linked to Facebook, WhatsApp Use Disorder and SUD, and negatively linked to life satisfaction.

Hypothesis 3. Both WhatsApp and Facebook Use Disorder mediate the relationship between FoMO and SUD.

Hypothesis 4. FoMO mediates the association between life satisfaction and Facebook, WhatsApp Use Disorder, and SUD.

3. Methods

3.1. Participants

Participants for the present study were recruited via the self-test platform (*anonymized for a blind review*). In total, N = 3510 persons

took part in the present project. Since we aimed at comparing the problematic use of WhatsApp, Facebook and smartphones in general, only participants who owned a WhatsApp and a Facebook account, and a smartphone were included in the following analyses ($n = 2299$; 2212 from Germany, 66 from Austria and 21 from Switzerland). Following this strategy, 1398 males and 901 females (mean age was 30.33, $SD = 9.80$, with a range between 12 and 75 years) were considered in the analyses of the present work. In total 0.8% of participants reported having no degree, 1.5% reported to have secondary modern school qualification, 11.5% O-level, 6.4% vocational baccalaureate diploma, 26.6% A-level, 11.4% polytechnic degree, and 41.8% university degree. The study was approved by the local ethics committee of university (*anonymized for a blind review*).

3.2. Questionnaires

First, sociodemographic data (age, gender, education, country) and smartphone use data (owning a smartphone, smartphone brand, time of smartphone use for leisure/business activities, installed messengers including WhatsApp and Facebook) was collected. Participants filled in questionnaires assessing SUD, WhatsApp and Facebook Use Disorder, FoMO and life satisfaction.

SUD was assessed with the German short version of the Smartphone Addiction Scale (d-KV-SSS; Montag & Reuter, 2017), a 10-item measure translated from Kwon, Kim, Cho, and Yang (2013). Items were answered on a 6-point Likert scale, ranging from “strongly disagree” (1) to “strongly agree” (6). Higher scores indicate higher tendencies towards SUD. The possible range lies between 10 and 60 points. For the English version of the short Smartphone Addiction Scale, good reliability and validity were demonstrated (Kwon et al., 2013). Cronbach's α for the present study was $\alpha = 0.80$. WhatsApp and Facebook Use Disorder were assessed with slightly changed versions of this questionnaire (Cronbach's $\alpha = 0.88$ for WhatsApp d-KV-SSS and Cronbach's $\alpha = 0.90$ for Facebook dv-KV-SSS); we changed the word “smartphone” to “WhatsApp” or “Facebook” to assess the respective content. The concept of FoMO was assessed with 10 items according to Przybylski et al. (2013) on a 5-point Likert scale ranging from 1 = “not at all true for me” to 5 = “extremely true for me” (Cronbach's α of 0.76 in the present study). Here, a range of 10–50 points was possible. The German translation as provided by Spitzer (2015) (see Table 1 in his work) was used in the present work. Relia-

bility and validity were confirmed in the original study by Przybylski et al. (2013). Finally, life satisfaction was assessed with five items according to Diener et al. (1985). We used the German translation according to the following source (bildungswissenschaften.uni-saarland.de; see detailed deep-link in the reference section), which did not deviate in the context of its meaning from the English or German versions provided on Ed Diener's homepage, who designed the original questionnaire (internal.psychology.illinois.edu; see deep-link in the reference section). Items of the Satisfaction with Life Scale (SWLS) are answered on a 7-point Likert scale ranging from 1 = “strongly disagree” to 7 = “strongly agree”. Therefore, points on this scale can range between 5 and 35. Diener et al. (1985) reported good reliability and validity of the original scale. Internal consistencies for the present study were high: Cronbach's $\alpha = 0.88$.

It is also important to note that there was no missing data in the current study. The study was conducted online and participants were given feedback on missing items and asked to fill them in to be able to proceed with the study.

3.3. Statistical analyses

First, the factor structure of every questionnaire was assessed by means of a confirmatory factor analysis (CFA) using R and the package Lavaan (Rosseel, 2012) (see Section 4.1). To assess the model fit we used the root mean square error of approximation (RMSEA), the standardized root mean square residual (SRMR), comparative fit index (CFI) and Tucker-Lewis-Index (TLI). CFI and TLI values > 0.90 represent a good fit, > 0.95 an excellent fit. RMSEA and SRMR values close to 0.06 represent an excellent model fit while values < 0.08 indicate a good model fit (Hu & Bentler, 1995, 1999). Second, the distribution of the investigated variables was assessed by inspection of the skewness and kurtosis of the variables. Only the variable Facebook Use Disorder showed marginal values (see Miles & Shevlin, 2001, p. 74). Given the non-normal distribution of the variable Facebook Use Disorder, where applicable non-parametric test were used. In Section 4.2, descriptive statistics of all investigated variables were presented, Mann-Whitney- U test was used to assess the influence of gender on the aforementioned variables and a correlation analysis was conducted to examine the link with age. Finally, Hypotheses 1–4 were tested using correlation, regression and mediation analyses (see Sections 4.3 and 4.4). The mediation analyses were conducted using the PROCESS macro, developed by Hayes (2017). For this purpose the variable Facebook Use Disorder was transformed, using Blom rank-based transformation (Solomon & Sawilowsky, 2009). For examining Hypothesis 3, a single mediation analysis with two mediators was run. For Hypothesis 4, three separate mediation analyses were run.

4. Results

4.1. Confirmatory factor analysis

For the Smartphone Addiction Scale, the model showed a good fit with the data: CFI = 0.92; TLI = 0.89; RMSEA = 0.08, $p < .01$, CI [0.070; 0.082]; SRMR = 0.05.⁷ Similar results were found for the questionnaires assessing WhatsApp and Facebook Use Disorder: CFI = 0.93; TLI = 0.91; RMSEA = 0.09, $p < .01$, CI [0.087; 0.100]; SRMR = 0.04 for WhatsApp, and CFI = 0.94; TLI = 0.92; RMSEA = 0.10, $p < .01$, CI [0.092; 0.104]; SRMR = 0.04 for Facebook Use

⁷ The initial models were slightly improved by allowing the correlation between some residuals, as suggested by the modification indices. We took into account those indices that made theoretical sense.

Table 1
Descriptive statistics on SUD, Facebook/WhatsApp Use Disorder, FoMo and life satisfaction (medians, means and standard deviations (SD) are presented).

	Total sample (N = 2299)	Male group (n = 1398)	Female group (n = 901)
SUD (range: 10–60)	Mean = 27.36 (SD = 8.10) Median = 27	Mean = 26.91 (SD = 8.09) Median = 27	Mean = 28.06 (SD = 8.08) Median = 28
WhatsApp use disorder (range: 10–60)	Mean = 21.57 (SD = 8.75) Median = 20	Mean = 20.70 SD = 8.45 Median = 19	Mean = 22.91 (SD = 9.04) Median = 22
Facebook use disorder (range: 10–60)	Mean = 16.10 (SD = 7.47) Median = 13	Mean = 15.52 SD = 7.27 Median = 13	Mean = 17.01 (SD = 7.67) Median = 15
Fear of missing out (range: 8–40)	Mean = 20.29 (SD = 5.75) Median = 20	Mean = 20.37 SD = 5.72 Median = 20	Mean = 20.16 (SD = 5.80) Median = 20
Life satisfaction (range: 5–35)	Mean = 24.42 (SD = 6.34) Median = 26	Mean = 24.06 SD = 6.45 Median = 25	Mean = 24.97 (SD = 6.12) Median = 26

Disorder, respectively. For the SWLS questionnaire the results were as follows: CFI = 0.99; TLI = 0.98; RMSEA = 0.07, $p < .01$, CI [0.058; 0.089]; SRMR = 0.02. For those questionnaires all factor loadings were > 0.300 . The initial model for the FoMO questionnaire did not show a good fit with the data. Here, items 8 (“When I have a good time it is important for me to share the details online (e.g. updating status).”, Przybylski et al., 2013, p. 1847) and 9 (“When I miss out on a planned get-together it bothers me.”, Przybylski et al., 2013, p. 1847) demonstrated loadings smaller than 0.300. After exclusion of those items an acceptable model fit was achieved (CFI = 0.95; TLI = 0.93; RMSEA = 0.08, $p < .01$, CI [0.067; 0.083]; SRMR = 0.05). Cronbach’s Alpha after the exclusion of items 8 and 9 did not deviate from Cronbach’s Alpha before the exclusion of those items ($\alpha = 0.76$). The correlation between the original questionnaire and the shorter form was $r = 0.98$, $p < .001$.

4.2. Descriptive statistics and analysis of age and gender in the context of the relevant variables

In Table 1, we present descriptive statistics on the questionnaire data. Given some influences of gender on the aforementioned variables, results are also depicted for gender subgroups. Mann-Whitney *U* tests indicated significant differences between males and females for SUD ($Z = -3.20$, $p < .01$), WhatsApp Use Disorder ($Z = -5.89$, $p < .01$), Facebook Use Disorder ($Z = -5.83$, $p < .01$) and life satisfaction ($Z = -3.15$, $p < .01$). In all mentioned domains females scored higher than males. No significant differences between females and males could be observed with respect to FoMO. Age correlated negatively with SUD ($\rho = -0.17$, $p < .01$), WhatsApp Use Disorder ($\rho = -0.25$, $p < .01$) and FoMO ($\rho = -0.31$, $p < .01$) and positively with life satisfaction ($\rho = 0.06$, $p < .01$). Therefore, age and gender were considered as potential confounding variables in the following analyses.

In total, the sample can be described as having rather high scores in life satisfaction (according to Diener et al., 1985, 25–29 scores are high scores), low scores in the domains of Facebook Use Disorder, low to moderate scores in the domains of WhatsApp and SUD and moderate scores in the domain of FoMO. Note that there is no recommendation in the literature with respect to cut-off values of the latter scales and we come to this conclusion by taking a look at the score in the context of the possible range.

4.3. Correlation analyses on the link between SUD, WhatsApp and Facebook use disorder in the context of life satisfaction and FoMO

In Table 2, we provide all correlation analyses on total sample level (with age as a covariate), whereas in Table 3 we provide this information split for males and females. In the complete sample the

Table 2
Correlation analyses on the link between SUD, WhatsApp and Facebook Use Disorder, life satisfaction and FoMO (total sample).

	SUD	WhatsApp Use Disorder	Facebook Use Disorder	Life satisfaction	FoMO
SUD	–	0.68**	0.47**	–0.12**	0.40**
WhatsApp Use Disorder		–	0.48**	–0.08**	0.39**
Facebook Use Disorder			–	–0.06**	0.31**
Life satisfaction				–	–0.25**

Note: ** $p < .01$, * $p < .05$. Spearman correlations are presented. The effect of age was controlled for.

Table 3
Correlation analyses on the link between SUD, WhatsApp and Facebook Use Disorder, life satisfaction and FoMO (male sample above diagonal and female sample in bold-italics below diagonal).

	SUD	WhatsApp Use Disorder	Facebook Use Disorder	Life satisfaction	FoMO
SUD	–	0.65**	0.45**	–0.13**	0.41**
WhatsApp Use Disorder	0.72**	–	0.49**	–0.10**	0.41**
Facebook Use Disorder	0.49**	0.44**	–	–0.06*	0.31**
Life satisfaction	–0.13**	–0.07*	–0.08*	–	–0.25**
FoMO	0.40**	0.38**	0.32**	–0.24**	–

Note: ** $p < .01$, * $p < .05$. Spearman correlations are presented. The effect of age was controlled for.

largest overlap was found between SUD and WhatsApp Use Disorder ($\rho = 0.68$, $p < .01$), followed by an overlap between Facebook and WhatsApp Use Disorder ($\rho = 0.48$, $p < .01$), and SUD and Facebook Use Disorder ($\rho = 0.47$, $p < .01$). The correlation between SUD and WhatsApp Use Disorder was significantly higher than between SUD and Facebook Use Disorder ($z = 13.207$, $p < .01$; Dunn & Clark, 1969). Thus, Hypothesis 1 was confirmed. The relationships were a bit weaker in males if compared to females (see Table 3). The correlation between WhatsApp Use Disorder and SUD was significantly higher in females than in males as demonstrated by the results of a Fisher’s *z*-test ($z = 3.093$, $p < .01$). Moreover, the data showed that FoMO was linked to higher SUD, WhatsApp, and Facebook Use Disorder and lower life satisfaction. These results confirmed Hypothesis 2. Finally, life satisfaction was negatively associated with all addiction variables, however, those associations were rather weak.

4.4. Regression and mediation analyses

In a first (stepwise) hierarchical regression analysis we added age to the first block, the WhatsApp and Facebook variables to a second block and FoMO and life satisfaction to a third block to predict SUD. All variables reached significance ($F(5,2293) = 593.660$, $p < .001$), with age explaining 3.7% of the variance in SUD, WhatsApp Use Disorder 48.5% additional variance, Facebook Use Disorder 2.8% additional variance, FoMO 1.3% and life satisfaction 0.2% additional variance (see Table 4).

In a second (stepwise) hierarchical regression analyses the variables age (first block), FoMO and life satisfaction (second block) were entered to predict Facebook Use Disorder. Here, only age (0.2% explained variance) and FoMO (9.7% explained additional variance) reached significance ($F(2,2296) = 125.088$, $p < .001$). A third (stepwise) hierarchical regression analyses was conducted with the same variables to predict WhatsApp Use Disorder. Here, age (5.6% explained variance) and FoMO (15.7% explained additional variance) reached significance ($F(2,2296) = 311.477$, $p < .001$) (see Table 4).

The results from the mediation analyses using PROCESS demonstrated that both WhatsApp Use Disorder (BootCI⁸[0.21; 0.28]) and Facebook Use Disorder (BootCI[0.05; 0.07]) partially mediated the association between FoMO and SUD (see Fig. 1). Thus, Hypothesis 3 was confirmed. Additionally, FoMO fully mediated the link between life satisfaction and WhatsApp Use Disorder (BootCI[–0.12; –0.08]),

⁸ BootCI = bootstrap confidence intervals for the completely standardized indirect effect(s) of X on Y.

Table 4
Results of the hierarchical regression analyses regarding SUD, WhatsApp and Facebook Use Disorder as dependent variables.

	SUD		WhatsApp Use Disorder		Facebook Use Disorder	
	β	p	β	p	β	p
Age	-0.01	0.70 ^a	-0.10	<0.01	0.06	<0.01
WhatsApp Use Disorder	0.58	<0.01				
Facebook Use Disorder	0.18	<0.01				
FoMO	0.12	<0.01	0.42	<0.01	0.33	<0.01
Life satisfaction	-0.04	0.01				

Note: SUD: Smartphone Use Disorder; β : standardized regression coefficient. Displayed are the models, which contributed with the highest explained variance.

^a Age reached significance as a predictor in the first block of the analysis. However, after including WhatsApp Use Disorder and FoMO as predictors, age was not a significant predictor of SUD anymore.

Facebook Use Disorder (BootCI[-0.10; -0.06]), and SUD (BootCI[-0.12; -0.08]), thus, confirming Hypothesis 4 (see Fig. 2).

When the same analyses were run separately for male and female participants, results remained the same.

5. Discussion

The present work investigated SUD and related concepts, namely WhatsApp and Facebook Use Disorder. First, a direct comparison of tendencies towards SUD, and WhatsApp and Facebook Use Disorder demonstrated that Use Disorder (addiction) scores are highest on the

Smartphone Addiction Scale, closely followed by WhatsApp with a larger gap to Facebook Use Disorder. The close overlap between SUD and WhatsApp Use Disorder is mirrored in the significantly higher correlation between those variables ($\rho = 0.68$, hence 46% shared variance) as compared to the link with Facebook Use Disorder (Hypothesis 1). This means that large parts of individual differences in tendencies towards SUD can be accounted for by problematic use of WhatsApp and only much less by problematic use of Facebook. This seems in particular true for females, where the overlap even is in the area of $\rho = 0.72$ (hence 52% shared variance). For males other factors such as gaming could therefore explain as an additional factor, why persons are addicted to their smartphones. Earlier studies have demonstrated the role of using mobile social networking applications in general for mobile phone addiction (e.g. Salehan & Negahban, 2013). The present study adds to this literature by examining specific channels such as WhatsApp and Facebook and their contribution for the development of SUD.

Aside from the correlation analyses, the results from the regression and mediation analyses demonstrated that FoMO was a robust predictor of Facebook, WhatsApp Use Disorder and SUD (as proposed in Hypothesis 2). These results support findings from the literature linking FoMO with SNS use and addiction (e.g. Blackwell et al., 2017; Pontes et al., 2018). Additionally, WhatsApp and Facebook Use Disorder mediated the association between FoMO and SUD. This result supports findings from earlier studies, showing that FoMO is of particular importance specifically for ICD and not for other forms of specific or generalized IUD, although we could not test this for other specific facets such as IGD in our sample (see Wegmann et al., 2017). This result further supports existing theoretical models describing

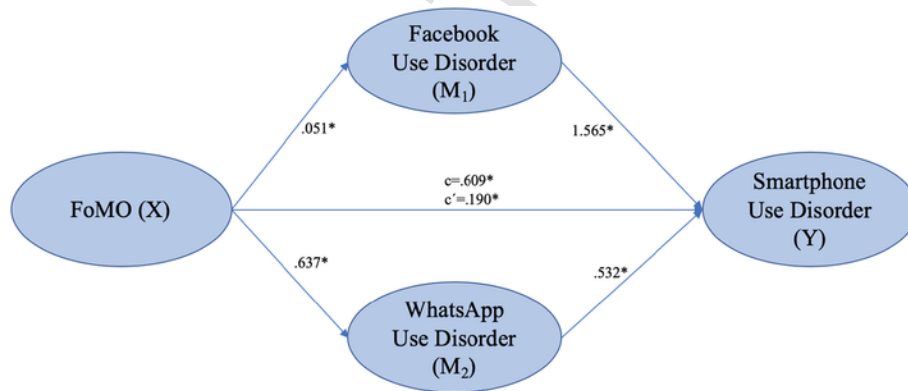


Fig. 1. Parallel multiple mediator model on the association between FoMO and SUD, with two mediators (WhatsApp/Facebook Use Disorder). X = independent variable, Y = dependent variable, $M_{1,2}$ = mediators, c = total effect, c' = direct effect. The unstandardized coefficients/effects are presented. Age was entered as a covariate. * $p < .05$.

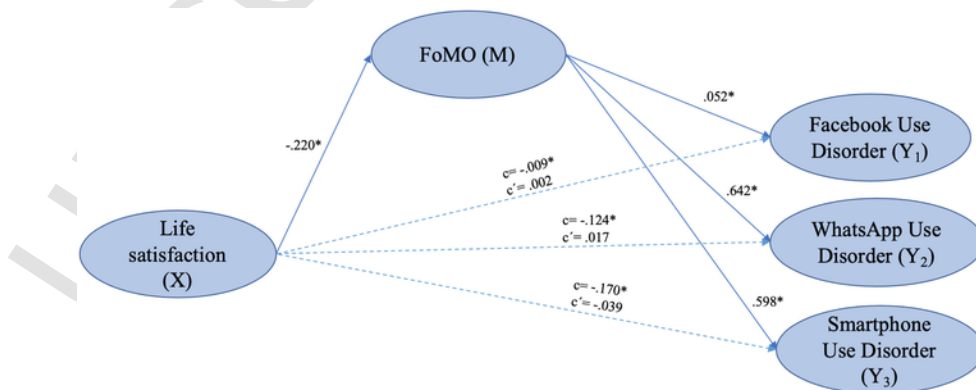


Fig. 2. Mediation models on the associations between life satisfaction and Facebook, WhatsApp Use Disorder, and SUD, with FoMO as a mediator variable. X = independent variable, $Y_{1,2,3}$ = dependent variables, M = mediator, c = total effect, c' = direct effect. The unstandardized coefficients/effects are presented. Age was entered as a covariate. * $p < .05$.

risk factors important for the development of IUD/SUD and their specific facets (see I-PACE model by Brand et al., 2016). In particular personality characteristics are believed to be of importance as predisposing factors for IUD/SUD. In the present study, trait-FoMO was assessed. Its association with high neuroticism (e.g. Blackwell et al., 2017) on the one hand, as well as the link between high neuroticism and different forms of IUD and SUD (for an overview see Montag & Reuter, 2017) further support the relevance of negative emotionality for those variables. The interplay between neuroticism and FoMO, thus, needs to be examined in future studies to further shed light on predisposing factors for IUD and SUD.

Regarding the results concerning life satisfaction, this construct was only indirectly related to SUD, WhatsApp and Facebook Use Disorder over FoMO. These results support earlier findings in the context of social media engagement (e.g. Przybylski et al., 2013) and add to those, since in the present study, the relationship between life satisfaction, FoMO and specific social networking channels used on a smartphone (WhatsApp, Facebook) and generalized SUD were investigated for the first time. The results suggest that low satisfaction with life could strengthen one's fear to miss out on friends' rewarding experiences and, in turn, influence one's attitudes and behavior towards online social media in particular. However, the causal relationship between life satisfaction and the use of smartphones and social networking channels needs to be examined in a longitudinal design before further (firm) conclusions can be drawn (e.g. see study by Kross et al., 2013). As already described in the introductory section of this manuscript, studies have delivered inconsistent results on the link between life satisfaction and the (problematic) use of social media channels (e.g. Błachnio & Przepiórka, 2018; Kross et al., 2013; Valenzuela et al., 2009). Through the investigation of FoMO as a mediator between life satisfaction and Facebook, WhatsApp Use Disorder and SUD, the present study helps to better understand the role of life satisfaction for SUD in general. However, these associations need to be replicated in future studies.

Last, but not least, to the authors' knowledge, this is the first study to examine the link between the problematic use of different social networking channels used on a smartphone, and SUD in general. The high and significant associations between WhatsApp, Facebook Use Disorder and SUD, demonstrated in the present study, support existing findings on the overlap between unspecific IUD and ICD as outlined by Montag et al., 2015 and Müller et al. (2017). However, the fact that SUD was more strongly associated with WhatsApp Use Disorder than Facebook Use Disorder demonstrates the different role of those applications for SUD. It is important that future studies examine specific social networking applications adding to measures assessing generalized ICD when it comes to their link to SUD. Moreover, scientists need to work on a theoretical framework linking the term SUD stronger to the already large literature dealing with IUD (as the smartphone is a vehicle to access many application to the Internet, although some of these applications have been specifically designed for the smartphone and not for other technological devices).

The results of the present study are of high importance for different reasons. First, our findings shed light on the under investigated topic of SUD by demonstrating the role of social networking applications and their uncontrolled use for SUD. This might not only help to better understand and characterize SUD, but also extend our knowledge concerning the rapidly developing field of behavioral addictions in general. Additionally, the investigation of FoMO and life satisfaction, variables often being examined in the context of (un)specific IUD, allows the comparison with literature on IUD and, thus working out the similarities and differences between the two phenomena (for such a research endeavor see also the work by Lachmann et al., 2018).

Future studies need to examine additional smartphone applications including (excessive) usage of apps for games, gambling, video or music streaming, shopping etc. next to social network applications to test if those applications play similar role as described in the older literature dealing with the term IUD. This research question needs to be further explored by also examining country-specific applications (e.g. WhatsApp in Germany and WeChat in China), to see if results from a study are app-dependent and/or function-dependent (see also a recent review by Montag, Becker, & Gan, 2018, comparing functions of WeChat, Facebook and WhatsApp).

Finally, the present findings on the link between FoMO and SUD are also of interest with respect to clinical practice. It is suggested that spending time in real-life with family, friends and concentrating on real-life relationships might fulfill the need for connectedness, enhance one's satisfaction with life, and in turn reduce FoMO and lower the probability of developing problematic use of smartphones or social network applications (e.g. work by Tromholt, 2016, observed that quitting Facebook elevates life satisfaction and emotional well-being). However, the presented associations between those variables should be validated in future studies using a longitudinal design.

The present work has some limitations, which need to be mentioned. First of all, the sample is not representative for the overall population in the geographic domain in which this study was conducted, namely the German-speaking countries in Europe (Germany, Austria, Switzerland). Additionally, the cross-sectional design of the study does not allow for causal interpretation of the results. Moreover, although the engagement of users in terms of the time spent on the smartphone for leisure/business activities was assessed in the present study, the associations with those variables are not presented in the current article since empirical research demonstrated that the self-reported use of smartphones may significantly deviate from objectively measured use (see Montag et al., 2015; Lin et al., 2015). Moreover, due to missing data and responses outside of the possible range, regarding those variables, we would have excluded nearly 60 participants from the analyses of the study. However, for transparency reasons we report the results with the smaller sample after re-running the correlation, regression and mediation analyses with the variables "time spent on the smartphone for leisure/business activities". The results of the study did not change after the two variables were considered. Solely, the two variables explained additional variance in the regression analyses (see Supplementary material). Future studies need to address this question by assessing the engagement of users through objective measures and taking it into account as a confounding factor when investigating IUD or SUD. Another critical point is that we assessed problematic use of Facebook and WhatsApp. Whereas Facebook is a complex social network with manifold functions and can be accessed via many channels, the messenger WhatsApp has been originally developed for smartphones only to exchange text messages and pictures or videos between two or more persons. Note, that in the meanwhile also a Facebook messenger exists, which is more comparable to WhatsApp. Additionally, new WhatsApp features such as status updates resemble some typical Facebook features. Of note, WhatsApp has been bought by Facebook in 2014 and officially belongs to the Facebook group. The different forms of the Facebook applications need to be stronger considered in future works. Of note, 55.5% of the present investigated sample stated to have Facebook installed on the phone, thereby clearly showing that it plays an important role also on their phones, and not only on desktop computers.

6. Conclusion

In sum, the present work shows that when talking about Smartphone Use Disorder, indeed we deal in large parts with Internet Communication Disorder, a term coined earlier by Brand et al. (2016), but also by Montag, Zhao, et al. (2018). The overlap between the concept of WhatsApp Use Disorder and SUD is robust, and in particular pronounced in the female subsample, where a very high correlation of $\rho = 0.72$ was observed. WhatsApp plays an important role to understand SUD also in males, yet additional factors such as Gaming Disorder might also be of relevance. The present work underlines again that FoMO presents an important concept to understand why smartphone users develop tendencies towards SUD, WhatsApp, and Facebook Use Disorder. Additionally, FoMO mediated the association between life satisfaction and WhatsApp, Facebook Use Disorder, and SUD. These last results might shed light on inconsistent findings from previous studies on the link between life satisfaction and SNS use and addiction.

Uncited references

Lachmann et al., 2017
Montag, 2017

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.abrep.2018.100148>.

References

- American Psychiatric Association, 2013. Diagnostic and statistical manual of mental disorders (DSM-5®). American Psychiatric Pub.
- Bildungswissenschaften.uni-saarland.de. In: http://bildungswissenschaften.uni-saarland.de/personal/jacobs/diagnostik/tests/free/swls_deutsche_normen.php Accessed 18 March 2018.
- Billieux, J., Maurage, P., Lopez-Fernandez, O., Kuss, D.J., Griffiths, M.D., 2015. Can disordered mobile phone use be considered a behavioral addiction? An update on current evidence and a comprehensive model for future research. *Current Addiction Reports* 2 (2), 156–162. <https://doi.org/10.1007/s40429-015-0054-y>.
- Blachnio, A., Przepiórka, A., 2018. Facebook intrusion, fear of missing out, narcissism, and life satisfaction: A cross-sectional study. *Psychiatry Research* 259, 514–519. <https://doi.org/10.1016/j.psychres.2017.11.012>.
- Blackwell, D., Leaman, C., Trampusch, R., Osborne, C., Liss, M., 2017. Extraversion, neuroticism, attachment style and fear of missing out as predictors of social media use and addiction. *Personality and Individual Differences* 116, 69–72. <https://doi.org/10.1016/j.paid.2017.04.039>.
- Brand, M., Young, K.S., Laier, C., Wölfling, K., Potenza, M.N., 2016. Integrating psychological and neurobiological considerations regarding the development and maintenance of specific internet-use disorders: An interaction of person-affect-cognition-execution (I-PACE) model. *Neuroscience & Biobehavioral Reviews* 71, 252–266. <https://doi.org/10.1016/j.neubiorev.2016.08.033>.
- Bush, G., Luu, P., Posner, M.I., 2000. Cognitive and emotional influences in anterior cingulate cortex. *Trends in Cognitive Sciences* 4 (6), 215–222.
- Chotpitayasuonondh, V., Douglas, K.M., 2016. How “phubbing” becomes the norm: The antecedents and consequences of snubbing via smartphone. *Computers in Human Behavior* 63, 9–18. <https://doi.org/10.1016/j.chb.2016.05.018>.
- Davis, R.A., 2001. A cognitive-behavioral model of pathological Internet use. *Computers in Human Behavior* 17 (2), 187–195. [https://doi.org/10.1016/S0747-5632\(00\)00041-8](https://doi.org/10.1016/S0747-5632(00)00041-8).
- Diener, E., Emmons, R.A., Larsen, R.J., Griffin, S., 1985. The satisfaction with life scale. *Journal of Personality Assessment* 49 (1), 71–75. <https://doi.org/10.1207/s15327752jpa490113>.
- Duke, , Montag, C., 2017. Smartphone addiction and beyond: Initial insights on an emerging research topic and its relationship to internet addiction. In: *Internet Addiction* Springer, pp. 359–372. https://doi.org/10.1007/978-3-319-46276-9_21.
- Duke, , Montag, C., 2017. Smartphone addiction, daily interruptions and self-reported productivity. *Addictive Behaviors Reports* 6, 90–95. <https://doi.org/10.1016/j.abrep.2017.07.002>.
- Dunn, O.J., Clark, V., 1969. Correlation coefficients measured on the same individuals. *Journal of the American Statistical Association* 64 (325), 366. <https://doi.org/10.2307/2283746>.
- Elhai, J.D., Dvorak, R.D., Levine, J.C., Hall, B.J., 2017. Problematic smartphone use: A conceptual overview and systematic review of relations with anxiety and depression psychopathology. *Journal of Affective Disorders* 207, 251–259. <https://doi.org/10.1016/j.jad.2016.08.030>.
- Elhai, J.D., Levine, J.C., Alghraibeh, A.M., Alafnan, A.A., Aldraiweesh, A.A., Hall, B.J., 2018. Fear of missing out: Testing relationships with negative affectivity, online social engagement, and problematic smartphone use. *Computers in Human Behavior* 89, 289–298.
- Probes, 2016. Snapchat, WhatsApp, and Instagram dominating younger demographic. Retrieved from <https://www.forbes.com/sites/tjmccue/2016/09/27/snapchat-whatsapp-and-instagram-dominating-younger-demographic/#681dd47469fc>.
- Hadar, A., Hadas, I., Lazarovits, A., Alyagon, U., Eliraz, D., Zangen, A., 2017. Answering the missed call: Initial exploration of cognitive and electrophysiological changes associated with smartphone use and abuse. *PLoS One* 12 (7), e0180094. <https://doi.org/10.1371/journal.pone.0180094>.
- Hayes, A.F., 2017. Introduction to mediation, moderation, and conditional process analysis, second edition: A regression-based approach. Guilford Publications, New York.
- Hu, L., Bentler, P., 1995. Evaluating model fit. In: Hoyle, R. (Ed.), *Structural equation modeling concepts, issues, and applications*. Sage Publications Inc., London, pp. 76–99.
- Hu, L., Bentler, P.M., 1999. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal* 6 (1), 1–55.
- Hussain, Z., Griffiths, M.D., Sheffield, D., 2017. An investigation into problematic smartphone use: The role of narcissism, anxiety, and personality factors. *Journal of Behavioral Addictions* 6 (3), 378–386.
- Internal.Psychology.Illinois.edu. In: <https://internal.psychology.illinois.edu/%7Eeediener/SWLS.html> Accessed 12 March 2018.
- Kross, E., Verduyn, P., Demiralp, E., Park, J., Lee, D.S., Lin, N., ... Ybarra, O., 2013. Facebook use predicts declines in subjective well-being in young adults. *PLoS One* 8 (8), e69841. <https://doi.org/10.1371/journal.pone.0069841>.
- Kushlev, K., Proulx, J., Dunn, E.W., 2016. Silence your phones: Smartphone notifications increase inattention and hyperactivity symptoms. In: Paper presented at the Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems. pp. 1011–1020. <https://doi.org/10.1145/2858036.2858359>.
- Kwon, M., Kim, D., Cho, H., Yang, S., 2013. The smartphone addiction scale: Development and validation of a short version for adolescents. *PLoS One* 8 (12), e83558. <https://doi.org/10.1371/journal.pone.0083558>.
- Lachmann, B., Duke, , Saryiska, R., Montag, C., 2017. Who's addicted to the smartphone and/or the Internet?. *Psychology of Popular Media Culture*. <https://doi.org/10.1037/ppm0000172>, (Advance online publication).
- Lachmann, B., Saryiska, R., Kannen, C., Cooper, A., Montag, C., 2016. Life satisfaction and problematic internet use: Evidence for gender specific effects. *Psychiatry Research* 238, 363–367. <https://doi.org/10.1016/j.psychres.2016.02.017>.
- Lachmann, B., Saryiska, R., Kannen, C., Stavrou, M., Montag, C., 2017. Commuting, life-satisfaction and internet addiction. *International Journal of Environmental Research and Public Health* 14 (10), 1176. <https://doi.org/10.3390/ijerph14101176>.
- Lachmann, B., Sandermann, C., Saryiska, R.Y., Luo, R., Melchers, M.C., Becker, B., ... Montag, C., 2018. The role of empathy and life satisfaction in internet and smartphone use disorder. *Frontiers in Psychology* 9, 398. <https://doi.org/10.3389/fpsyg.2018.00398>.
- Lanaj, K., Johnson, R.E., Barnes, C.M., 2014. Beginning the workday yet already depleted? Consequences of late-night smartphone use and sleep. *Organizational Behavior and Human Decision Processes* 124 (1), 11–23. <https://doi.org/10.1016/j.obhdp.2014.01.001>.
- Lin, F., Lei, H., 2017. Structural brain imaging and Internet addiction. In: Montag, C., Reuter, M. (Eds.), *Internet addiction*. Springer, Switzerland, pp. 37–58.
- Lin, Y.H., Lin, Y.C., Lee, Y.H., Lin, P.H., Lin, S.H., Chang, L.R., ... Kuo, T.B., 2015. Time distortion associated with smartphone addiction: Identifying smartphone addiction via a mobile application (app). *Journal of Psychiatric Research* 65, 139–145.
- Marketing Land, 2016. Nearly 80 percent of social media time now spent on mobile devices. Retrieved from <http://marketingland.com/facebook-usage-accounts-1-5-minutes-spent-mobile-171561>.
- Miles, J., Shevlin, M., 2001. Applying regression and correlation: A guide for students and researchers. Sage.
- Montag, C., 2017. *Homo Digitalis: Smartphones, soziale Netzwerke und das Gehirn*. Springer-Verlag.
- Montag, C., Becker, B., Gan, C., 2018. The multi-purpose application WeChat: A review on recent research. *Frontiers in Psychology* 9, 2247.
- Montag, C., Bey, K., Sha, P., Li, M., Chen, Y.F., Liu, W.Y., ... Reuter, M., 2015. Is it meaningful to distinguish between generalized and specific Internet addiction? Evidence from a cross-cultural study from Germany, Sweden, Taiwan and China. *Asia-Pacific Psychiatry* 7 (1), 20–26. <https://doi.org/10.1111/appy.12122>.
- Montag, C., Błazkiewicz, K., Lachmann, B., Saryiska, R., Andone, I., Trendafilov, B., Markowetz, A., 2015. Recorded behavior as a valuable resource for diagnostics in mobile phone addiction: Evidence from psychoinformatics. *Behavioral Science* 5 (4), 434–442.
- Montag, C., Błazkiewicz, K., Saryiska, R., Lachmann, B., Andone, I., Trendafilov, B., ... Markowetz, A., 2015. Smartphone usage in the 21st century: Who is active on WhatsApp?. *BMC Research Notes* 8 (1), 331. <https://doi.org/10.1186/s13104-015-1280-z>.
- Montag, C., Duke, , Reuter, M., 2017. A short summary of neuroscientific findings on Internet addiction. *Internet Addiction* Springer, Cham, 209–218.
- Montag, C., Reuter, M., 2017. Molecular genetics, personality, and Internet addiction revisited. *Internet Addiction* Springer, Cham, 141–160. https://doi.org/10.1007/978-3-319-46276-9_9.

- Montag, C., Sindermann, C., Becker, B., Panksepp, J., 2016. An affective neuroscience framework for the molecular study of Internet addiction. *Frontiers in Psychology* 7, 1906 <https://doi.org/10.3389/fpsyg.2016.01906>.
- Montag, C., Zhao, Z., Sindermann, C., Xu, L., Fu, M., Li, J., ... Dai, J., 2018. Internet communication disorder and the structure of the human brain: Initial insights on WeChat addiction. *Scientific Reports* 8 (1), 2155. <https://doi.org/10.1038/s41598-018-19904-y>.
- Müller, M., Brand, M., Mies, J., Lachmann, B., Sariyska, R.Y., Montag, C., 2017. The 2D:4D marker and different forms of Internet Use Disorder. *Frontiers in Psychiatry* 8, <https://doi.org/10.3389/fpsyg.2017.00213>.
- Oberst, U., Wegmann, E., Stodt, B., Brand, M., Chamarro, A., 2017. Negative consequences from heavy social networking in adolescents: The mediating role of fear of missing out. *Journal of Adolescence* 55, 51–60. <https://doi.org/10.1016/j.adolescence.2016.12.008>.
- Pontes, H.M., Szabo, A., Griffiths, M.D., 2015. The impact of Internet-based specific activities on the perceptions of Internet addiction, quality of life, and excessive usage: A cross-sectional study. *Addictive Behaviors Reports* 1, 19–25.
- Pontes, H.M., Taylor, M., Stavropoulos, V., 2018. Beyond “Facebook addiction”: The role of cognitive-related factors and psychiatric distress in social networking site addiction. *Cyberpsychology, Behavior and Social Networking* 21 (4), 240–247.
- Przybylski, A.K., Murayama, K., Dehaan, C.R., Gladwell, V., 2013. Motivational, emotional, and behavioral correlates of fear of missing out. *Computers in Human Behavior* 29 (4), 1841–1848. <https://doi.org/10.1016/j.chb.2013.02.014>.
- Rosseel, Y., 2012. Lavaan: An R package for structural equation modeling. *Journal of Statistical Software* 48 (2), 1–36.
- Salehan, M., Negahban, A., 2013. Social networking on smartphones: When mobile phones become addictive. *Computers in Human Behavior* 29 (6), 2632–2639. <https://doi.org/10.1016/j.chb.2013.07.003>.
- Samaha, M., Hawi, N.S., 2016. Relationships among smartphone addiction, stress, academic performance, and satisfaction with life. *Computers in Human Behavior* 57, 321–325. <https://doi.org/10.1016/j.chb.2015.12.045>.
- Sariyska, R., Reuter, M., Bey, K., Sha, P., Li, M., Chen, Y., ... Montag, C., 2014. Self-esteem, personality and internet addiction: A cross-cultural comparison study. *Personality and Individual Differences* 61, 28–33. <https://doi.org/10.1016/j.paid.2014.01.001>.
- Solomon, S.R., Sawilowsky, S.S., 2009. Impact of rank-based normalizing transformations on the accuracy of test scores. *Journal of Modern Applied Statistical Methods* 8 (2), 448–462. <https://doi.org/10.22237/jmasm/1257034080>.
- Soror, A.A., Hammer, B.L., Steelman, Z.R., Davis, F.D., Limayem, M.M., 2015. Good habits gone bad: Explaining negative consequences associated with the use of mobile phones from a dual-systems perspective. *Information Systems Journal* 25 (4), 403–427. <https://doi.org/10.1111/isj.12065>.
- Spitzer, M., 2015. Smartphones, Angst und Stress. *Nervenheilkunde* 34 (8), 591–600.
- Statista, 2018a. Prognose zur Anzahl der Smartphone-Nutzer weltweit von 2012 bis 2020 (in Milliarden). Retrieved from <https://de.statista.com/statistik/daten/studie/309656/umfrage/prognose-zur-anzahl-der-smartphone-nutzer-weltweit/>.
- Statista, 2018b. Most popular mobile messaging apps in the United States as of July 2018, by monthly active users (in millions). Retrieved October 24, 2018 from <https://www.statista.com/statistics/350461/mobile-messenger-app-usage-usa/>.
- Tromholt, M., 2016. The Facebook experiment: Quitting Facebook leads to higher levels of well-being. *Cyberpsychology, Behavior and Social Networking* 19 (11), 661–666.
- Valenzuela, S., Park, N., Kee, K.F., 2009. Is there social capital in a social network site?: Facebook use and college students' life satisfaction, trust, and participation. *Journal of Computer-Mediated Communication* 14 (4), 875–901. <https://doi.org/10.1111/j.1083-6101.2009.01474.x>.
- Ward, A.F., Duke, K., Gneezy, A., Bos, M.W., 2017. Brain drain: The mere presence of one's own smartphone reduces available cognitive capacity. *Journal of the Association for Consumer Research* 2 (2), 140–154. <https://doi.org/10.1086/691462>.
- Wegmann, E., Brand, M., 2016. Internet-communication disorder: It's a matter of social aspects, coping, and internet-use expectancies. *Frontiers in Psychology* 7, 1747 <https://doi.org/10.3389/fpsyg.2016.01747>.
- Wegmann, E., Oberst, U., Stodt, B., Brand, M., 2017. Online-specific fear of missing out and Internet-use expectancies contribute to symptoms of Internet-communication disorder. *Addictive Behaviors Reports* 5, 33–42. <https://doi.org/10.1016/j.abrep.2017.04.001>.
- World Health Organization, Beta Draft, 2018. Retrieved October 24, 2018 from <https://icd.who.int/dev11/1-m/en#/http%3a%2f%2fwww.who.int%2fid%2fentity%2f499894965>.