



WeChat—Its Problematic Use and Relations with the Big Five Personality Traits and Fear of Missing Out

Cornelia Sindermann¹ · Haibo Yang² · Tour Liu² · Jon D. Elhai³ · Christian Montag^{1,4}

Received: 24 July 2020 / Revised: 25 October 2020 / Accepted: 10 November 2020 / Published online: 11 January 2021
© Springer Nature Switzerland AG 2021

Abstract

Despite the popularity of the WeChat social media platform in China, investigations on its overuse potential as well as personal characteristics being associated with problematic WeChat use are scarce. Against this background, correlations of personality and Fear of Missing Out (FoMO) on rewarding experiences with problematic WeChat use were examined. Moreover, it was tested whether FoMO would mediate the link between personality and problematic WeChat use. A cross-sectional online survey was conducted and revealed a final sample size of $N = 377$ Chinese university students and staff. All participants filled in measures to assess problematic WeChat use, the Big Five personality traits, and FoMO. Results show that problematic WeChat use was positively related to Neuroticism, a link which was fully (cross-sectionally) mediated by FoMO. In conclusion, the present results shed light on the overuse potential of WeChat and individual susceptibility factors.

Keywords WeChat · Problematic WeChat use · WeChat use disorder · Social networks use disorder · Personality · Big Five

Social media is of major importance for today's communication infrastructure enabling individuals around the world to stay in contact with friends, family, and colleagues. Despite many advantages of social media platforms, experts are concerned about negative effects, including debate on a putative pathological overuse of social media. But only little is known about the Chinese social media platform WeChat and its overuse potential. Against this background, the present study took a closer look at WeChat, its functions associated with overuse, and relations to personality variables.

WeChat is a popular multipurpose smartphone application (Montag et al. 2018a) from China. Most of all, it is a messaging

application, hence, a social media platform. As such, it offers functions such as sending and receiving voice and text as well as picture and video messages. In addition, one can, for example, pay merchants and friends via linking one's bank account to the app and can send and receive "red envelopes" or digital monetary gifts (similar to the Chinese tradition). One can also use city services, e.g., to book a transportation or pay utility bills, or play games (Montag et al. 2018a). In addition, WeChat offers the function to follow public accounts. These public accounts can have manifold features enabling a personalized and interactive user experience (Chan 2015). Potentially due to the variety of functions offered by WeChat, it is the most used social messaging app in China (We are social et al. 2019) and the fifth most used social platform worldwide with currently 1.15 billion users (We Are Social et al. 2020). Given the user numbers and importance of WeChat, especially in China, it seems to be of high interest to also investigate a possible pathological overuse of WeChat.

The pathological overuse of WeChat could also be named WeChat Use Disorder (WCUD) in line with "Gaming Disorder" (World Health Organization 2019) and the nomenclature in the I-PACE (Interaction of Person-Affect-Cognition-Execution) model (Brand et al. 2016). Such a putative disorder most likely falls within the category of Online Communication Disorder (Montag et al. 2018b), which is termed Social Networks Use Disorder (SNUD) according to recent discussions (Montag et al. 2019). As such, a possible

✉ Haibo Yang
yanghaibo@tjnu.edu.cn

¹ Department of Molecular Psychology, Institute of Psychology and Education, Ulm University, 89081 Ulm, Germany

² Faculty of Psychology, Academy of Psychology and Behavior, Tianjin Normal University, Tianjin 300387, China

³ Department of Psychology, and Department of Psychiatry, University of Toledo, Toledo, OH, USA

⁴ NeuSCAN Laboratory, Clinical Hospital of the Chengdu Brain Science Institute and Key Laboratory for Neuroinformation, University of Electronic Science and Technology of China, Chengdu, China

SNUD and WCUD can be deemed specific Internet Use Disorders. Researchers emphasize that a SNUD is characterized by a strong concern and urge to use social media and actually spending too much time on social media leading to impairments in other domains of life (Andreassen and Pallesen 2014). Similar to substance-use disorders, putative symptoms of SNUD are salience, tolerance, mood modification, withdrawal, conflict, relapse, and problems/negative effects on daily life (Andreassen 2015; Griffiths et al. 2014). In line with this, research shows that a small proportion of individuals seems to exhibit negative consequences due to the social media use, hence, possibly suffering from something such as SNUD (Andreassen 2015) (see also prevalence estimates (De Cock et al. 2013; Smahel et al. 2020; Wartberg et al. 2020)). However, neither SNUD nor WCUD are officially recognized in the DSM-5 or the ICD-11 (American Psychiatric Association 2013; World Health Organization, 2019). Moreover, it is important to not over-pathologize everyday behavior such as using social media. In line with this, the adoption of symptoms of addiction terminology to SNUD is controversially discussed (Billieux et al. 2015; Kardefelt-Winther et al. 2017). Moreover, also the terminology is debatable: (online) social network site addiction (Andreassen 2015; Andreassen & Pallesen 2014), SNUD (Montag et al. 2019), and problematic social networks use (Rozgonjuk et al., 2020) are exemplary terms having been used in previous works. In line with suggestions of the reviewers, the present study will adopt the terms “problematic social networks use” and “problematic WeChat use” (i) because neither SNUD nor WCUD are official diagnoses, yet, (ii) to not over-pathologize everyday behavior, and (iii) because the present study is implemented on a non-clinical sample. Nevertheless, the term “problematic” is also not without its problems: the term does not make clear whether a position between a healthy and a psychopathological state is described or the end of the spectrum. In this context, it is important to note that Elhai et al. (2020c) mentioned the importance to apply fairness in labeling various types of Internet Use Disorders/problematic use of a technology. For the present work, we follow the suggestions of the reviewers, although “tendencies towards Social Networks Use Disorder/WeChat Use Disorder” can be deemed as an appropriate term in light of the aforementioned reasons, as well. Finally, we define problematic WeChat use as excessive, time-consuming use of WeChat alongside negative consequences on one’s life such as neglecting other domains of life (e.g., school, work, sleep, household, offline friends etc.) and negative effects on well-being (see also symptoms assessed in the questionnaire used (Montag et al., 2018b; Pawlikowski et al., 2013)).

In line with findings on problematic social networks use, also problematic WeChat use has been negatively associated

with variables such as mental and social health (Xue et al. 2018) and positively with depression and anxiety (Hou et al. 2019). For general associations between problematic social networks use, including problematic WeChat use, and depression/anxiety in Chinese samples, see Hussain et al. (2020).

According to the prominent I-PACE model, personal factors such as stable personality traits are important predisposing factors for tendencies towards specific Internet Use Disorders (as the authors name it) and, hence, putatively also problematic WeChat use (Brand et al. 2016). One of the most prominent personality taxonomies is that personality can be described on the basis of five broad dimensions (Fiske 1949; Tupes and Christal 1992). Based on this taxonomy, the Big Five of personality emerged. As stated in the light of the Big Five, the five factors can be labeled Openness (to Experience), Conscientiousness, Extraversion, Agreeableness, and Neuroticism (Costa and McCrae 1992; Rammstedt and Danner 2017). Putative associations between the Big Five and problematic social networks use have been examined in many empirical studies, oftentimes in Western samples and several times specific to problematic Facebook use. Results of these studies are not perfectly homogeneous. However, across several studies, the protective roles of high scores in Conscientiousness and low scores in Neuroticism have been emphasized (Blackwell et al. 2017; Marino et al. 2018; Sindermann et al. 2020; Wilson et al. 2010). While Conscientiousness describes how diligent, reliable, and efficient one is working and how orderly one is, Neuroticism describes the tendency to being depressed, emotionally unstable, and nervous and to worry (Rammstedt and Danner 2017). Studies on the associations between problematic WeChat use and the Big Five are scarce. One study reports positive associations between all Big Five factors except Neuroticism, which exhibited a non-significant association with problematic WeChat use (Xue et al., 2018). Another related study found positive associations of Extraversion and Agreeableness with use intensity of WeChat (Chen and Li 2019).

Additionally, Fear of Missing Out (FoMO) on rewarding experiences has gained increasing attention in research especially on social media use/problematic social networks use in recent years. FoMO is defined as “pervasive apprehension that others might be having rewarding experiences from which one is absent, FoMO is characterized by the desire to stay continually connected with what others are doing” (Przybylski et al. 2013, p. 1841). Importantly, FoMO must be understood as a predisposition prevalent to a certain degree in every person rather than a psychological or medical disorder. As such, FoMO has been positively associated with problematic social networks use and social network intensity previously (Blackwell et al. 2017; Fuster et al. 2017; Oberst et al. 2017; Stead and Bibby 2017). This positive association is most likely explained

by high scores in FoMO being associated with the urge to repeatedly check upon what friends are doing/experiencing. This desire can be followed via repeatedly/continuously checking social media to keep track. Given the many social functions of WeChat, it is plausible to assume that FoMO is also positively associated with problematic WeChat use. For a recent overview on FoMO research, see the work by Elhai, Yang, and Montag (2020d).

The actual nature of FoMO and whether it is a trait or a state is not definitively clarified. According to Przybylski et al. (2013), FoMO can be seen as a mediating variable between individual differences and social media engagement. In line with this, several other authors conceptualize FoMO as a mediating variable between motivational variables and social media engagement (Alt 2015), between need for popularity/need to belong and Facebook use (Beyens et al. 2016), between fear of negative and positive evaluation and problematic smartphone use (Wolniewicz et al. 2018), and between life satisfaction and problematic smartphone, WhatsApp, and Facebook use (Sha et al. 2019). Therefore, the present study further aimed at investigating a putative (cross-sectional) mediating effect of FoMO in the relation between personality and problematic WeChat use.

In conclusion the study had two major aims: (i) Examining the associations between the Big Five, FoMO, and problematic WeChat use: we expected Conscientiousness to be negatively associated with problematic WeChat use and Neuroticism and FoMO to be positively associated with problematic WeChat use; (ii) testing whether FoMO would (cross-sectionally) mediate the relation between the aforementioned personality traits and problematic WeChat use. Additionally, we report exploratory investigations on associations between WeChat activities and problematic WeChat use in the [Supplementary Material](#).

Materials and Methods

Procedure

The study was implemented online on the platform www.wjx.cn and data collection was implemented at Tianjin Normal University in Tianjin, China. In detail, the subjects were senior university students, graduate students, doctoral students, and some university staff. The students were recruited through the elective course “Academic Essay Writing” and staff was recruited through random invitation. Invitation links were sent via mobile phones to a total of 479 potential subjects. $N=444$ finished participation during November 2019. Every participant received a reward of 8–12 RMB (Chinese renminbi yuan; 1 RMB = 0.15 USD (2020.10.19)). Participation was allowed from the age of 18 and voluntary. Before participation, individuals had to give informed

electronic consent. The study was approved by the local ethics committee of Tianjin Normal University, Tianjin, China. All questionnaires were administered in Chinese language.

Sample

Initially, we aimed at recruiting at least $N=280$ individuals as correlations were found to stabilize at around $N=252$ individuals when level of confidence is set at 80%, width of corridor stability is set to .10, and expected correlations are around .10 (and after data cleaning, $N=250$ individuals was the expected sample size) (Schönbrodt & Perugini 2013). However, response rate was high and a total of $N=444$ individuals participated in the present study. After data cleaning (see [Supplementary Material](#)), the final sample comprised $N=377$ ($n=91$ men, $n=286$ women) participants. The mean age of this sample was $M=21.64$ years ($SD=5.31$) with a range from 18 to 56 years.

Measures

Problematic WeChat Use

Problematic WeChat use was assessed by means of a reformulated version of the 12-item short Internet Addiction Test (Pawlikowski et al. 2013). Specifically, the term “Internet” was replaced by “WeChat”. This reformulated version in Chinese language has already been used in Montag et al. (2018b). The items are answered on a 5-point Likert scale ranging from 1 = “never” to 5 = “very often” and a mean score across all items was built. The internal consistency estimate (Cronbach’s alpha) was $\alpha=0.93$ in the present sample.

42-Item Big Five Short-Scale

The Big Five personality traits were assessed by administering the 42-item Big Five short-scale (Olaru et al. 2015) in the Chinese language (Sindermann et al. 2018). Items are answered on a 7-point Likert scale ranging from 1 = “very strongly disagree” to 7 = “very strongly agree”. In addition to the broad Big Five factors, two to three subscales per factor can be computed. However, the present study will focus on the broad Big Five factors for which mean scores across all items of the respective scale were built (after recoding responses to some items). Internal consistency estimates of the scales as measured by Cronbach’s alpha were $\alpha=0.76$, $\alpha=0.76$, $\alpha=0.62$, $\alpha=0.83$, and $\alpha=0.86$ for Openness (to Experience), Conscientiousness, Extraversion, Agreeableness, and Neuroticism, respectively.

Fear of Missing Out Scale

To assess Fear of Missing Out (FoMO), we used the Chinese version of the Fear of Missing Out scale (Przybylski et al.

2013; Xie et al. 2018). Responses to the 10 items of the scale are given on a 5-point Likert scale ranging from 1 = “Not at all true of me” to 5 = “Extremely true of me”. A mean score across all items was built. The internal consistency estimate (Cronbach’s alpha) was $\alpha = 0.85$ in the present sample.

Statistical Analysis

The R version 3.5.2 (R Core Team 2018) and R studio version 1.1.463 (RStudio Team 2015) were used for data cleaning and analysis. The scales assessing problematic WeChat use, FoMO, and each of the Big Five exhibited skewness and kurtosis of less than ± 1 . Therefore, an approximate normal distribution was assumed according to Miles and Shevlin (2001) [the only negligible exceptions were the kurtosis of Extraversion being 1.17 in the total sample and 1.14 in women and the kurtosis of the FoMO scale being 1.10 in men]. Accordingly, parametric tests were used.

First, descriptive statistics of all variables of interest were calculated using the *describe* function in the *psych* package (Revelle 2018). Next, gender differences and associations with age were computed by *t* tests (Welch’s *t* tests whenever necessary; *t.test* function in R base) and Pearson correlations (*rcorr* function in Hmisc package (Harrell & with contributions from Charles Dupont and many others 2019)). Cohen’s *d* was computed as effect size of gender differences using the *cohensD* function in the *lsr* package (Navarro 2015). Gender differences and associations with age were of interest because previous literature suggests that both variables are related with a variety of social media use variables (Graziani 2019; Montag, Blaszkiwicz, Sariyska, et al. 2015b; Sindermann et al. 2020).

Aim I In order to examine associations of problematic WeChat use scores with the Big Five and FoMO, zero-order bivariate Pearson correlations were calculated; *p*-values were corrected for multiple testing by the Holm method using the *rcorr.adjust* function of the *RcmdrMisc* package (Fox et al. 2020).

Aim II One mediation model was computed based on the correlations. In detail, Neuroticism was included as independent variable, FoMO as a mediating variable, and problematic WeChat use as dependent variable. The effects of age and gender were partialled out (i.e., removed) in each association. For this, the *mediate* function of the *psych* package was used (Revelle 2018).

Results

Descriptive Statistics, Gender Differences, and Associations with Age

In the total sample, scores on problematic WeChat use ranged from 1.08 to 5.00, with a mean of $M = 2.69$ ($SD = 0.86$) (see

Table 1). A histogram of the problematic WeChat use scores is presented in Fig. 1. Of interest, 135 (35.81%) individuals showed a score of higher than 3.00, the cutoff score for possible pathological overuse (Pawlikowski et al., 2013).

More descriptive statistics for the total sample and split by gender are presented in Table 1. As can be seen in this table, there were several significant gender differences found in the present sample.

Significant positive associations with age were found for problematic WeChat use scores ($r = .23$, $p < .001$).

Aim I: Zero-Order Bivariate Correlations of Problematic WeChat Use with Other Study Variables

The zero-order bivariate correlations between all study variables are presented in Supplementary Table 2.

Of the Big Five, only Neuroticism was significantly associated with problematic WeChat use scores after Holm correction ($r = 0.26$, $p < .001$). Moreover, FoMO was significantly associated with problematic WeChat use scores after Holm correction ($r = 0.51$, $p < .001$). Neuroticism and FoMO were also significantly associated ($r = 0.44$, $p < .001$) after Holm correction.

Aim II: Mediation Model

Given the results from the aforementioned correlation analyses, only the following model was calculated: Neuroticism as the independent variable, FoMO as mediating variable, and problematic WeChat use as dependent variable. Effects of age and gender were partialled out in the model (see Fig. 2).

The mediation model shows that the association between Neuroticism and problematic WeChat use was completely mediated by FoMO. Most importantly, this can be seen in the indirect effect, whose coefficient lies within the confidence interval, which does not include 0. Moreover, as seen in Fig. 2, only the total effect (c) but not the direct effect (c’) of Neuroticism on problematic WeChat use is significant.

Discussion

The present study aimed at further investigating problematic WeChat use. Specifically, the present research endeavor followed two major aims: (i) investigating the associations between the Big Five, FoMO, and problematic WeChat use to examine susceptibility factors; (ii) testing whether FoMO would (cross-sectionally) mediate the relation between personality and problematic WeChat use. Furthermore, we present exploratory investigations on which of the various WeChat activities are related to problematic WeChat use scores to examine which ones contribute to problematic WeChat use in the [Supplementary Material](#).

Table 1 Descriptive statistics and gender differences

	Total sample (<i>N</i> = 377)	Men (<i>n</i> = 91)	Women (<i>n</i> = 286)	Gender differences (<i>t</i> test and Cohen’s <i>d</i>)
Problematic WeChat use	2.69 (0.86)	3.00 (0.86)	2.58 (0.84)	$t(375) = 4.13, p < 0.001, d = 0.50$
Openness	4.53 (0.83)	4.75 (0.93)	4.46 (0.78)	$t(132.48) = 2.68, p = 0.008, d = 0.35$
Conscientiousness	4.76 (0.86)	4.67 (0.99)	4.78 (0.81)	$t(375) = -1.13, p = 0.261, d = 0.14$
Extraversion	4.20 (0.66)	4.30 (0.57)	4.17 (0.69)	$t(375) = 1.63, p = 0.105, d = 0.20$
Agreeableness	4.93 (0.78)	4.85 (0.93)	4.96 (0.73)	$t(127.17) = -1.02, p = 0.309, d = 0.14$
Neuroticism	4.60 (0.95)	4.58 (0.87)	4.61 (0.98)	$t(375) = -0.23, p = 0.819, d = 0.03$
Fear of Missing Out	3.02 (0.71)	3.18 (0.74)	2.96 (0.69)	$t(375) = 2.62, p = 0.009, d = 0.31$

First of all, the present sample showed a rather high mean value of $M = 2.69$ ($SD = 0.86$) in the scale assessing problematic WeChat use and nearly 36% of the sample showed a score

which might indicate an actual pathological overuse of WeChat (Pawlikowski et al. 2013). Therefore, the overuse potential of WeChat is underlined by the present findings.

Fig. 1 Histogram of scores on problematic WeChat use. The *x*-axis shows the problematic WeChat use scores (possible range: 1–5). The *y*-axis shows the number of participants reaching the respective score

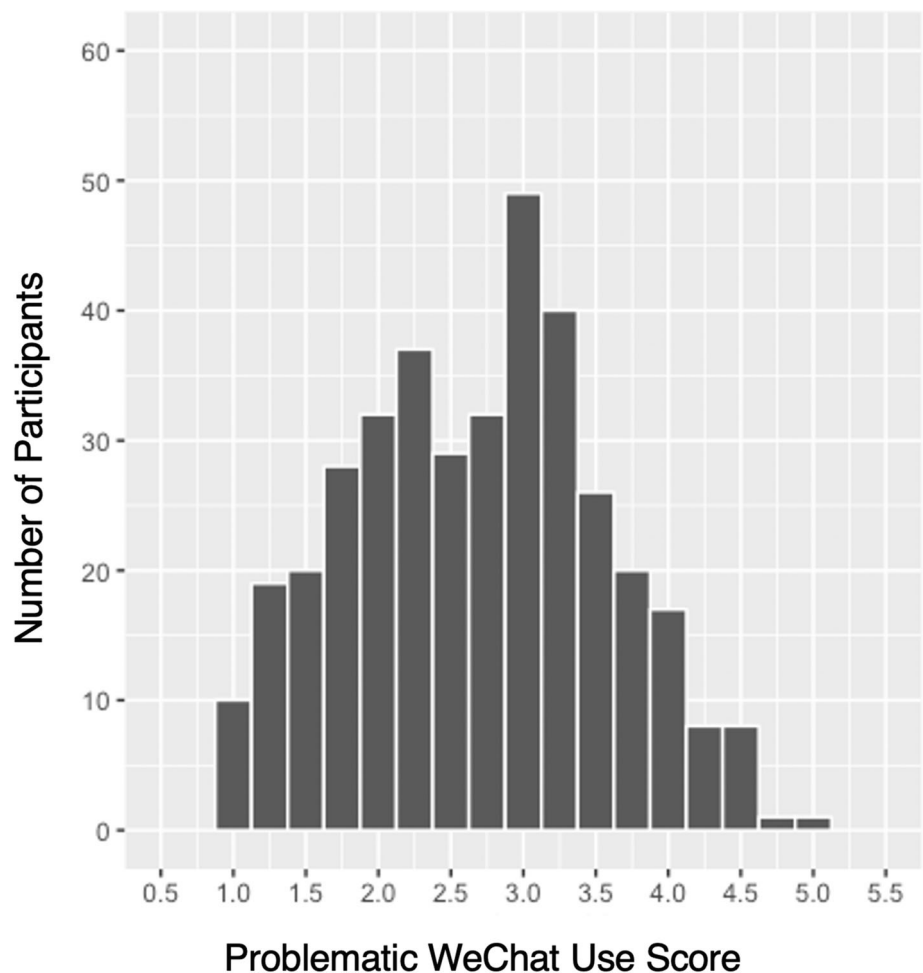
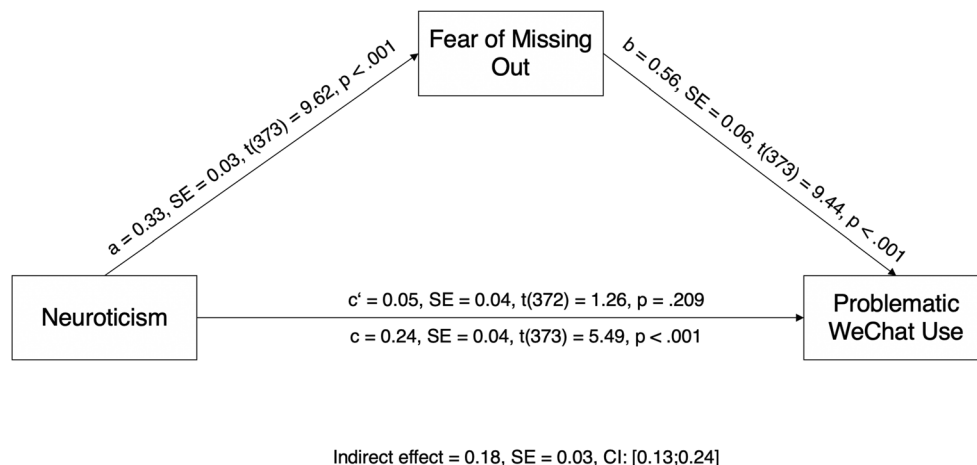


Fig. 2 Mediation model of the effects of Neuroticism on problematic WeChat use via FoMO



Nevertheless, it must be acknowledged that problematic WeChat use (and also problematic social networks use) is not an official diagnosis, yet. Therefore, also the cutoff is debatable.

Moreover, problematic WeChat use was positively related to Neuroticism of the Big Five and FoMO. The positive association of FoMO with problematic WeChat use is in line with previous literature on problematic social networks use (Blackwell et al. 2017; Fuster et al. 2017; Oberst et al. 2017; Stead and Bibby 2017). The association with Neuroticism is partly in line with previous literature, which mostly reports positive associations of problematic social networks use with Neuroticism and negative associations with Conscientiousness (but also heterogeneous results in previous literature exist) (Blackwell et al. 2017; Marino et al. 2018; Sindermann et al. 2020; Wilson et al. 2010). Interestingly, both Neuroticism and Conscientiousness are also related to other “addictive tendencies” such as alcohol involvement (including problems due to alcohol use) (Malouff et al. 2007) and smoking and drug use (Terracciano et al. 2008). Finally, higher Neuroticism and lower Conscientiousness also play some role in predicting problematic use of the smartphone (Lachmann et al. 2017; Marengo et al. 2020; Peterka-Bonetta et al. 2019), which is known to be driven by social media apps (Sha et al. 2019). However, and as mentioned above, an association between problematic WeChat use and Conscientiousness was not evident in the present study.

We found that FoMO fully mediated the relationship between Neuroticism and problematic WeChat use. As already mentioned in the “Introduction” section, high scores in Neuroticism are associated with the tendency to being depressed, emotionally unstable, and nervous and to worry (Rammstedt and Danner 2017). As such, higher scores in Neuroticism are associated with a higher likelihood to suffer from mental disorders such as major depression, likely due to shared genetic underpinnings (Adams et al., 2019; Lahey, 2009). Therefore, the present results are in line with findings showing that FoMO mediates the relation between depression

and problematic smartphone use tendencies (Elhai et al. 2020a), but also see the non-significant association in Elhai et al. (2020b). In this regard, it is important to note that problematic smartphone use (also coined Smartphone Use Disorder) can be seen as a mobile version of Internet Use Disorder (as the authors name it) (Montag et al. 2019) and that WeChat is an Internet-based smartphone application (which can also be used on a desktop computer). Therefore, problematic smartphone and WeChat use are likely to be positively associated. In light of the I-PACE model (Brand et al. 2016), the mediation effect found in the present work indicates that Neuroticism is a predisposing factor potentially causing negative emotionality. FoMO, in turn, might be seen as a cognitive/affective response to these emotions ultimately leading to problematic WeChat use.

When interpreting the results, however, one needs to take into account some limitations of the present study. First, the present study is cross-sectional, disallowing definite causal conclusions. Additionally, the present sample consists mostly of young female students which is due to the recruitment strategy. Because most of the students asked to participate were studying music and literature, the proportion of females participating in the survey is relatively high. This makes the present sample non-representative of the general Chinese (adult) population and limits generalizability of the present findings. Finally, we used self-report questionnaires to assess all variables of interest. Self-report measures clearly have several disadvantages. For example, previous research shows that individuals are not accurate in estimating smartphone use variables (e.g., number of incoming calls) (Lin et al. 2015; Montag et al. 2015a; Rozgonjuk & Elhai 2019). To overcome this problem, future studies could track the actual time users spend on WeChat using certain functions via methods of Psychoinformatics (if possible) (Montag et al. 2016; Yarkoni 2012). Nevertheless, we deem it important to assess tendencies towards problematic use of, for example, WeChat via self-report because these behaviors

not only rely on the time spent online, but also on the negative effects an individual experiences due to his/her use of social media such as WeChat (see, e.g., the debate on Internet Use Disorder (Pontes et al. 2015)).

In conclusion, we found that Neuroticism was positively linked to problematic WeChat use via FoMO. These results expand previous literature on problematic social networks use which was mostly conducted on social media platforms owned by Facebook Inc. and help to understand tendencies towards pathological overuse tendencies of the Chinese WeChat application in more detail.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s41347-020-00179-y>.

Author's Contributions Cornelia Sindenmann: Conceptualization, data curation, formal analysis, methodology, project administration, validation, visualization, writing—original draft

Haibo Yang: Conceptualization, investigation, project administration, writing—review and editing

Tour Liu: Data curation, formal analysis, investigation, project administration, writing—review and editing.

Jon D. Elhai: Conceptualization, writing—review and editing

Christian Montag: Conceptualization, project administration, writing—review and editing

All authors have read and agreed upon the final version of the manuscript and its submission.

Funding This research is supported by Tianjin Philosophy and Social Science Project(TJXX15–002).

For reasons of transparency, CM mentions that he has received (to Ulm University and earlier University of Bonn) grants from agencies such as the German Research Foundation (DFG). CM has performed grant reviews for several agencies; has edited journal sections and articles; has given academic lectures in clinical or scientific venues or companies; and has generated books or book chapters for publishers of mental health texts. For some of these activities, he received royalties, but never from the gaming or social media industry. CM mentions that he is part of a discussion circle (Digitalität und Verantwortung: <https://about.fb.com/de/news/h/gespraechskreis-digitalitaet-und-verantwortung/>) debating ethical questions linked to social media, digitalization, and society/democracy at Facebook. In this context, he receives no salary for his activities. Finally, he mentions that he currently functions as independent scientist on the scientific advisory board of the Nymphenburg group. This activity is financially compensated.

Dr. Elhai notes that he receives royalties for several books published on posttraumatic stress disorder (PTSD); is a paid, full-time faculty member at University of Toledo; is a paid, visiting scientist at Tianjin Normal University; occasionally serves as a paid, expert witness on PTSD legal cases; and receives grant research funding from the U.S. National Institutes of Health.

Compliance with Ethical Standards

Competing Interests On behalf of all authors, the corresponding author states that there is no conflict of interest.

Adherence with Ethical Standards Before participation, individuals had to give informed electronic consent. The study was approved by the local ethics committee of Tianjin Normal University in Tianjin, China.

References

- Adams, M. J., Howard, D. M., Luciano, M., Clarke, T.-K., Davies, G., Hill, W. D., Team, 23andMe Research, Consortium, M. D. D. W. G. of the P. G. Smith, D., Deary, I. J., Porteous, D. J., & McIntosh, A. M. (2019). Genetic stratification of depression by neuroticism: Revisiting a diagnostic tradition. *Psychological Medicine*, 1–10. <https://doi.org/10.1017/S0033291719002629>.
- Alt, D. (2015). College students' academic motivation, media engagement and fear of missing out. *Computers in Human Behavior*, 49, 111–119. <https://doi.org/10.1016/j.chb.2015.02.057>.
- American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (DSM-5)* (5th ed.).
- Andreassen, C. S. (2015). Online social network site addiction: A comprehensive review. *Current Addiction Reports*, 2(2), 175–184. <https://doi.org/10.1007/s40429-015-0056-9>.
- Andreassen, C. S., & Pallesen, S. (2014). Social network site addiction—An overview. *Current Pharmaceutical Design*, 20(25), 4053–4061.
- Beyens, I., Frison, E., & Eggermont, S. (2016). “I don’t want to miss a thing”: Adolescents’ fear of missing out and its relationship to adolescents’ social needs, Facebook use, and Facebook related stress. *Computers in Human Behavior*, 64, 1–8. <https://doi.org/10.1016/j.chb.2016.05.083>.
- Billieux, J., Schimmenti, A., Khazaal, Y., Maurage, P., & Heeren, A. (2015). Are we overpathologizing everyday life? A tenable blueprint for behavioral addiction research. *Journal of Behavioral Addictions*, 4(3), 119–123. <https://doi.org/10.1556/2006.4.2015.009>.
- Blackwell, D., Leaman, C., Tramosch, 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., Wöfling, 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>.
- Chan, C. (2015). When one app rules them all: The case of WeChat and mobile in China. *Andreessen Horowitz*. <https://a16z.com/2015/08/06/wechat-china-mobile-first/>
- Chen, W., & Li, Y. (2019). The influence of personality, loneliness and FoMO on the use of WeChat friend circle. *Future Communication*, 26(6), 94–102.
- Costa, P. T., & McCrae, R. R. (1992). *Revised NEO Personality Inventory (NEO-PI-R) and NEO Five-Factor Inventory (NEO-FFI) professional manual*. Lutz: Psychological Assessment Resources.
- De Cock, R., Vangeel, J., Klein, A., Minotte, P., Rosas, O., & Meerkerk, G.-J. (2013). Compulsive use of social networking sites in Belgium: Prevalence, profile, and the role of attitude towards work and school. *Cyberpsychology, Behavior and Social Networking*, 17(3), 166–171. <https://doi.org/10.1089/cyber.2013.0029>.
- Elhai, J. D., Gallinari, E. F., Rozgonjuk, D., & Yang, H. (2020a). Depression, anxiety and fear of missing out as correlates of social, non-social and problematic smartphone use. *Addictive Behaviors*, 105, 106335. <https://doi.org/10.1016/j.addbeh.2020.106335>.
- Elhai, J. D., Yang, H., Fang, J., Bai, X., & Hall, B. J. (2020b). Depression and anxiety symptoms are related to problematic smartphone use severity in Chinese young adults: Fear of missing out as a mediator. *Addictive Behaviors*, 101, 105962. <https://doi.org/10.1016/j.addbeh.2019.04.020>.
- Elhai, J. D., Yang, H., & Levine, J. C. (2020c). Applying fairness in labeling various types of internet use disorders: Commentary on

- how to overcome taxonomical problems in the study of internet use disorders and what to do with “smartphone addiction”? *Journal of Behavioral Addictions*, 1(aop), 71. <https://doi.org/10.1556/2006.2020.00071>.
- Elhai, J. D., Yang, H., & Montag, C. (2020d). Fear of missing out (FOMO): Overview, theoretical underpinnings, and literature review on relations with severity of negative affectivity and problematic technology use. *Brazilian Journal of Psychiatry*. <https://doi.org/10.1590/1516-4446-2020-0870>.
- Fiske, D. W. (1949). Consistency of the factorial structures of personality ratings from different sources. *The Journal of Abnormal and Social Psychology*, 44(3), 329–344. <https://doi.org/10.1037/h0057198>.
- Fox, J., Muenchen, R., & Putler, D. (2020). *RcmdrMisc: R commander miscellaneous functions* (2.7-0) [Computer software]. <https://cran.r-project.org/web/packages/RcmdrMisc/RcmdrMisc.pdf>
- Fuster, H., Chamorro, A., & Oberst, U. (2017). Fear of missing out, online social networking and mobile phone addiction: A latent profile approach. *Aloma: Revista de Psicologia, Ciències de l'Educació i de l'Esport*, 35(1), 1 <http://www.revistaaloma.net/index.php/aloma/article/view/310>.
- Graziani, T. (2019, April 14). WeChat official account report 2019 reveals importance of cross-promotion & social shopping. *WalktheChat*. <https://walkthechat.com/wechat-official-account-report-2019-reveals-importance-of-cross-promotion-social-shopping/>
- Griffiths, M. D., Kuss, D. J., & Demetrovics, Z. (2014). Social networking addiction: An overview of preliminary findings. In *Behavioral Addictions* (pp. 119–141). Amsterdam: Elsevier Academic Press. <https://doi.org/10.1016/B978-0-12-407724-9.00006-9>.
- Harrell, F. E. Jr., & with contributions from Charles Dupont and many others. (2019). *Hmisc: Harrell miscellaneous* (4.2-0) [Computer software]. <https://CRAN.R-project.org/package=Hmisc>
- Hou, X.-L., Wang, H.-Z., Hu, T.-Q., Gentile, D. A., Gaskin, J., & Wang, J.-L. (2019). The relationship between perceived stress and problematic social networking site use among Chinese college students. *Journal of Behavioral Addictions*, 8(2), 306–317. <https://doi.org/10.1556/2006.8.2019.26>.
- Hussain, Z., Wegmann, E., Yang, H., & Montag, C. (2020). Social Networks Use Disorder and associations with depression and anxiety symptoms: A systematic review of recent research in China. *Frontiers in Psychology*, 11. <https://doi.org/10.3389/fpsyg.2020.00211>.
- Kardefelt-Winther, D., Heeren, A., Schimmenti, A., van Rooij, A., Maurage, P., Carras, M., Edman, J., Blaszczynski, A., Khazaal, Y., & Billieux, J. (2017). How can we conceptualize behavioural addiction without pathologizing common behaviours? *Addiction*, 112(10), 1709–1715. <https://doi.org/10.1111/add.13763>.
- Lachmann, B., Duke, È., Sariyska, R., & Montag, C. (2017). Who's addicted to the smartphone and/or the Internet? *Psychology of Popular Media Culture*, 8(3), 182–189. <https://doi.org/10.1037/ppm0000172>.
- Lahey, B. B. (2009). Public health significance of neuroticism. *The American Psychologist*, 64(4), 241–256. <https://doi.org/10.1037/a0015309>.
- Lin, Y.-H., Lin, Y.-C., Lee, Y.-H., Lin, P.-H., Lin, S.-H., Chang, L.-R., Tseng, H.-W., Yen, L.-Y., Yang, C. C. H., & Kuo, T. B. J. (2015). Time distortion associated with smartphone addiction: Identifying smartphone addiction via a mobile application (app). *Journal of Psychiatric Research*, 65, 139–145. <https://doi.org/10.1016/j.jpsychires.2015.04.003>.
- Malouff, J. M., Thorsteinsson, E. B., Rooke, S. E., & Schutte, N. S. (2007). Alcohol involvement and the five-factor model of personality: A meta-analysis. *Journal of Drug Education*, 37(3), 277–294. <https://doi.org/10.2190/DE.37.3.d>.
- Marengo, D., Sindermann, C., Häckel, D., Settanni, M., Elhai, J. D., & Montag, C. (2020). The association between the Big Five personality traits and smartphone use disorder: A meta-analysis. *Journal of Behavioral Addictions*, 9(3), 534–550. <https://doi.org/10.1556/2006.2020.00069>.
- Marino, C., Gini, G., Vieno, A., & Spada, M. M. (2018). A comprehensive meta-analysis on problematic Facebook use. *Computers in Human Behavior*, 83, 262–277. <https://doi.org/10.1016/j.chb.2018.02.009>.
- Miles, J., & Shevlin, M. (2001). *Applying regression and correlation: A guide for students and researchers*. Thousand Oaks: SAGE Publications.
- Montag, C., Becker, B., & Gan, C. (2018a). The multipurpose application WeChat: A review on recent research. *Frontiers in Psychology*, 9. <https://doi.org/10.3389/fpsyg.2018.02247>.
- Montag, C., Błazskiewicz, K., Lachmann, B., Sariyska, R., Andone, I., Trendafilov, B., & Markowetz, A. (2015a). Recorded behavior as a valuable resource for diagnostics in mobile phone addiction: Evidence from psychoinformatics. *Behavioral Science*, 5(4), 434–442. <https://doi.org/10.3390/bs5040434>.
- Montag, C., Błazskiewicz, K., Sariyska, R., Lachmann, B., Andone, I., Trendafilov, B., Eibes, M., & Markowetz, A. (2015b). 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, È., & Markowetz, A. (2016). Toward psychoinformatics: Computer science meets psychology. *Computational and Mathematical Methods in Medicine*, 2016, 2983685–2983610. <https://doi.org/10.1155/2016/2983685>.
- Montag, C., Wegmann, E., Sariyska, R., Demetrovics, Z., & Brand, M. (2019). How to overcome taxonomical problems in the study of Internet use disorders and what to do with “smartphone addiction”? *Journal of Behavioral Addictions*, 1–7. <https://doi.org/10.1556/2006.8.2019.59>.
- Montag, C., Zhao, Z., Sindermann, C., Xu, L., Fu, M., Li, J., Zheng, X., Li, K., Kendrick, K. M., Dai, J., & Becker, B. (2018b). 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>.
- Navarro, D. J. (2015). Learning statistics with R: A tutorial for psychology students and other beginners (Version 0.5). <http://ua.edu.au/ccs/teaching/lr>
- Oberst, U., Wegmann, E., Stodt, B., Brand, M., & Chamorro, 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>.
- Olaru, G., Witthöft, M., & Wilhelm, O. (2015). Methods matter: Testing competing models for designing short-scale big-five assessments. *Journal of Research in Personality*, 59, 56–68. <https://doi.org/10.1016/j.jrp.2015.09.001>.
- Pawlikowski, M., Altstötter-Gleich, C., & Brand, M. (2013). Validation and psychometric properties of a short version of Young's Internet Addiction Test. *Computers in Human Behavior*, 29(3), 1212–1223. <https://doi.org/10.1016/j.chb.2012.10.014>.
- Peterka-Bonetta, J., Sindermann, C., Elhai, J. D., & Montag, C. (2019). Personality associations with smartphone and Internet use disorder: A comparison study including links to impulsivity and social anxiety. *Frontiers in Public Health*, 7. <https://doi.org/10.3389/fpubh.2019.00127>.
- Pontes, H. M., Kuss, D. J., & Griffiths, M. D. (2015). Clinical psychology of Internet addiction: A review of its conceptualization, prevalence, neuronal processes, and implications for treatment. *Neuroscience and Biobehavioral Reviews*, 2015(4), 11–23. <https://doi.org/10.2147/NAN.S60982>.
- 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>.
- R Core Team. (2018). *R: A language and environment for statistical computing*. Vienna: R Foundation for Statistical Computing <https://www.R-project.org/>.
- Rammstedt, B., & Danner, D. (2017). Die Facettenstruktur des Big Five Inventory (BFI). *Diagnostica*, 63, 70–84. <https://doi.org/10.1026/0012-1924/a000161>.
- Revelle, W. (2018). *Psych: Procedures for personality and psychological research*. Evanston: Northwestern University <https://CRAN.R-project.org/package=psych>.
- Rozgonjuk, D., & Elhai, J. D. (2019). Emotion regulation in relation to smartphone use: Process smartphone use mediates the association between expressive suppression and problematic smartphone use. *Current Psychology*. <https://doi.org/10.1007/s12144-019-00271-4>.
- Rozgonjuk, D., Sindermann, C., Elhai, J. D., Christensen, A. P., & Montag, C. (2020). Associations between symptoms of problematic smartphone, Facebook, WhatsApp, and Instagram use: An item-level exploratory graph analysis perspective. *Journal of Behavioral Addictions*, 9(3), 686–697. <https://doi.org/10.1556/2006.2020.00036>.
- RStudio Team. (2015). *RStudio: Integrated development for R*. Vienna: R. RStudio, Inc <http://www.rstudio.com/>.
- Schönbrodt, F. D., & Perugini, M. (2013). At what sample size do correlations stabilize? *Journal of Research in Personality*, 47(5), 609–612. <https://doi.org/10.1016/j.jrp.2013.05.009>.
- Sha, P., Sariyska, R., Riedl, R., Lachmann, B., & Montag, C. (2019). Linking Internet communication and smartphone use disorder by taking a closer look at the Facebook and WhatsApp applications. *Addictive Behaviors Reports*, 9, 100148. <https://doi.org/10.1016/j.abrep.2018.100148>.
- Sindermann, C., Duke, É., & Montag, C. (2020). Personality associations with Facebook use and tendencies towards Facebook use disorder. *Addictive Behaviors Reports*, 11, 100264. <https://doi.org/10.1016/j.abrep.2020.100264>.
- Sindermann, C., Luo, R., Zhao, Z., Li, Q., Li, M., Kendrick, K. M., Panksepp, J., & Montag, C. (2018). High ANGER and low agreeableness predict vengefulness in German and Chinese participants. *Personality and Individual Differences*, 121, 184–192. <https://doi.org/10.1016/j.paid.2017.09.004>.
- Smahel, D., MacHáková, H., Mascheroni, G., Dedkova, L., Staksrud, E., Olafsson, K., Livingstone, S., & Hasebrink, U. (2020). *EU Kids Online 2020: Survey results from 19 countries [monograph]*. London: London School of Economics and Political Science <http://www.lse.ac.uk/media-and-communications/research/research-projects/eu-kids-online>.
- Stead, H., & Bibby, P. A. (2017). Personality, fear of missing out and problematic internet use and their relationship to subjective well-being. *Computers in Human Behavior*, 76, 534–540. <https://doi.org/10.1016/j.chb.2017.08.016>.
- Terracciano, A., Löckenhoff, C. E., Crum, R. M., Bienvenu, O. J., & Costa, P. T. (2008). Five-factor model personality profiles of drug users. *BMC Psychiatry*, 8(1), 22. <https://doi.org/10.1186/1471-244X-8-22>.
- Tupes, E. C., & Christal, R. E. (1992). Recurrent personality factors based on trait ratings. *Journal of Personality*, 60(2), 225–251. <https://doi.org/10.1111/j.1467-6494.1992.tb00973.x>.
- Wartberg, L., Kriston, L., & Thomasius, R. (2020). Internet gaming disorder and problematic social media use in a representative sample of German adolescents: Prevalence estimates, comorbid depressive symptoms and related psychosocial aspects. *Computers in Human Behavior*, 103, 31–36. <https://doi.org/10.1016/j.chb.2019.09.014>.
- We are social, Hootsuite, & Datareportal. (2019). Digital 2019: Global digital overview. DataReportal – Digital 2019: Global Digital Insights. <https://datareportal.com/reports/digital-2019-global-digital-overview>
- We Are Social, Hootsuite, & Datareportal. (2020). Digital 2020: Global digital overview. **DataReportal – Global Digital Insights**. <https://datareportal.com/reports/digital-2020-global-digital-overview>
- Wilson, K., Fornasier, S., & White, K. M. (2010). Psychological predictors of young adults' use of social networking sites. *Cyberpsychology, Behavior and Social Networking*, 13(2), 173–177. <https://doi.org/10.1089/cyber.2009.0094>.
- Wolniewicz, C. A., Tiarniyu, M. F., Weeks, J. W., & Elhai, J. D. (2018). Problematic smartphone use and relations with negative affect, fear of missing out, and fear of negative and positive evaluation. *Psychiatry Research*, 262, 618–623. <https://doi.org/10.1016/j.psychres.2017.09.058>.
- World Health Organization. (2019). *ICD-11: International classification of diseases*. <https://icd.who.int/en/>
- Xie, X., Wang, Y., Wang, P., Zhao, F., & Lei, L. (2018). Basic psychological needs satisfaction and fear of missing out: Friend support moderated the mediating effect of individual relative deprivation. *Psychiatry Research*, 268, 223–228. <https://doi.org/10.1016/j.psychres.2018.07.025>.
- Xue, Y., Dong, Y., Luo, M., Mo, D., Dong, W., Zhang, Z., & Liang, H. (2018). Investigating the impact of mobile SNS addiction on individual's self-rated health. *Internet Research*, 28(2), 278–292. <https://doi.org/10.1108/IntR-05-2017-0198>.
- Yarkoni, T. (2012). Psychoinformatics: New horizons at the interface of the psychological and computing sciences. *Current Directions in Psychological Science*, 21, 391–397. <https://doi.org/10.1177/0963721412457362>.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.