Article

# Dance the Night Away: How Automatic TikTok Use Creates Pre-Sleep Cognitive Arousal and Daytime Fatigue

**Kexin Wang** (iD)
College of Communication and International Culture, Zhejiang University, China

**Sebastian Scherr** (iD)
Department of Communication, Texas A&M University, USA

## Abstract

TikTok is one of the most popular apps. TikTok's endless stream of content, the lack time stamps or notifications of ever being "all caught up," and concealing the phone's clock make it easy to lose track of time on TikTok. However, there is a lack of knowledge about how TikTok use may therefore interfere with our circadian rhythms, particularly our sleep hygiene. By focusing on pre-sleep cognitive arousal, this study aimed to close this knowledge gap by investigating the association between automatic TikTok use and daytime fatigue. We also investigated how individual preferences for sensation seeking and delayed gratification moderated this relationship. Within a sample of 1,050 TikTok/Douyin users in China, automatic TikTok use was associated with increased day-time fatigue that was mediated by higher levels of cognitive arousal before sleep. This relationship was aggravated by a preference for sensation seeking, and attenuated by a preference for delayed gratification. Above and beyond these early empirical insights, we also provide an early explanatory framework that is meant to systematize both existing and future knowledge about the use of TikTok.

## Keywords

TikTok, Douyin, automatic use, pre-sleep cognitive arousal, fatigue

**Corresponding author:**
Sebastian Scherr, Department of Communication, Texas A&M University, 202E Bolton Hall, College Station, TX 77843-4234, USA.
Email: scherr@tamu.edu

## Introduction

Media gratification is available at almost any time and in any place (Hofmann et al., 2016), with social media being the number one source of gratification among younger generations (Twenge et al., 2019), especially from online videos (Flayelle et al., 2020). One of the most successful apps in recent years is the short-video app Douyin, the Chinese version of TikTok, launched in mainland China in 2016 by ByteDance. Soon after, in 2017, ByteDance launched a modified version of their app called TikTok, with similar functions, for users outside of China (Oberlo, 2020). TikTok has since become one of the most downloaded mobile video apps. In January 2020, there were 4 billion daily active users of Douyin just in China. Its international version, TikTok, was downloaded 315 million times across over 150 countries in the first quarter of 2020 (Oberlo, 2020).

TikTok is different from other social media video platforms in that it has been designed especially for being used on smartphones, and notifies users constantly about new content that algorithmically fits the users' preferences (Forces, 2018). The TikTok algorithm learns about a user's thematic preferences by monitoring the user's in-app actions including comments, likes, and video views (Chen et al., 2019). TikTok videos are typically short (BoostApps, 2020), which decreases the threshold of "I have time to watch one (more)" and thus facilitates uncontrolled and automatic viewing (Meier et al., 2016). In addition, TikTok is likely to intensify overuse, compared with other social media, as it conceals the phone clock, which prevents users from keeping track of the time. The absence of a timestamp also renders TikTok devoid of time metrics, facilitating users losing hours on the app without even noticing. Concerns have been raised about TikTok being prone to overuse, ultimately compelling the app's developers to implement an "addiction-reduction" feature that encourages a forced stop after 90 min of nonstop use (SafeToNet, 2020). As excessive use of Instagram has been found to affect user fatigue (Sanz-Blas et al., 2019), concerns about the unhealthy overuse of TikTok and its potential interference with and disruption of sleep causing fatigue during the day for its users are common.

Although much of the existing research focuses on social media, TikTok is different from other platforms, rendering findings comparable to only some extent. While other social media are mostly used during the day, for instance, Facebook and Instagram experience highest user-engagement around noon (BusinessofApps, 2020; Sproutsocial, 2020), TikTok can be regarded more as an evening/nighttime app with the app itself warning users about not using it too long or too late in order to maintain a healthy sleep routine (@TikToktips, 2020). Thus, while there are common concerns about the negative consequences of social media night use on the daytime fatigue levels of its users, existing findings cannot fully be generalized to TikTok, or to non-Western countries that have their own social media use idiosyncrasies (Jackson & Wang, 2013).

In order to close this research gap, the present study strove to investigate the impact of automatic TikTok use on daytime fatigue and to identify whether this impact could be explained by experiencing cognitive arousal when people are trying to sleep, as well as examining who may be more suspectable to this impact. The paper contributes to the existing literature in several ways: First, despite the prevalence of TikTok

"overuse" and concerns about its possibly dysfunctional influence on users' sleep patterns, empirical data remain scarce. The present study therefore aimed to explore TikTok's impact on daytime fatigue, for which existing literature about the excessive use of other social media shows a link, but empirical evidence for TikTok specifically is absent. Second, the study is a response to the call to investigate media use habits facilitated by smartphones (Oulasvirta et al., 2012). Third, we introduce and link "pre-sleep cognitive arousal" to both TikTok use and sleep deprivation, following existing lines in sleep research that link media use habits to dysfunctional sleep-related outcomes (Exelmans & Van den Bulck, 2017a). Fourth, we focus on two personality-based antecedents to explore the conceptual boundaries of the media effect to advance our theoretical understanding (Valkenburg & Peter, 2013). We focus on sensation seeking (Perse, 1996) and delaying gratification (Shim et al., 2018), both of which have emerged as highly relevant traits when investigating media effects and the user's self-control in maintaining a balance between immediate media gratification and well-being. Lastly, we test our ideas within a heterogeneous sample from all regions of mainland China.

## Automatic TikTok use and fatigue

Watching videos is likely to become an automatic behavior as it is oftentimes habitualized in nature (Exelmans & Van den Bulck, 2017b). While both legacy media (i.e., television) and mobile media use habits are characterized by automaticity and repetition (LaRose, 2010), legacy media habits have been regarded as context-dependent, especially during their formation phase, whereas mobile media use habits can both form and perform without stable contexts due to their ubiquity of use (Naab & Schnauber, 2016; Schnauber-Stockmann & Naab, 2019). Formed habits are sensitive to simple cues that trigger automatic behavioral responses despite other current goals or needs (Wood & Rünger, 2016). Automatic media use can (to some extent) be characterized by mindlessness, resulting from an "overlearned" behavior that not only interferes with daily duties, but also comes with undesired, maladaptive consequences. Such daily interferences can be both reasoned actions (i.e., procrastination: purposefully avoiding cognitively more strenuous activities; Exelmans et al., 2019; Meier et al., 2016), but can also emerge from unawareness, for example, "losing track of time" (Matsakis, 2019). Both automatic social media and TV-use reportedly increase unregulated use (Exelmans & Van den Bulck, 2017b; Schnauber-Stockmann et al., 2018). However, compared with automatic TV viewing, personalized notifications that generally intensify social media use (Hofmann et al., 2016), in combination with the ubiquitous availability of TikTok are likely to boost its automatic use.

One of the most obvious, negative, psychosomatic consequences of automatic media use is fatigue, manifested from a lack of sleep, especially in a media context (Exelmans & Van den Bulck, 2017a). Fatigue is a nonspecific symptom that includes getting tired easily and feeling physically and/or mentally exhausted at night and during the day. Both general media- (Bright et al., 2015; Xiao & Mou, 2019) and specific media use styles (e.g., habitual TV-use; compulsive SNS use) have been linked to fatigue (Dhir et al., 2018; Flayelle et al., 2020). We therefore hypothesized that automatic TikTok use is positively associated with daytime fatigue ($H_1$).

## The mediating role of pre-sleep cognitive arousal

One possible explanation for the association between automatic TikTok viewing and fatigue might be that viewing TikTok videos during the day may interrupt regular sleep patterns during the night. Pre-sleep cognitive arousal refers to the excessive cognitive excitement experienced when people attempt to sleep, "worry about falling asleep, being mentally alert, and can't shut off thought" (Nicassio et al., 1985, p. 265). Sleep quality interventions (compared with social media use) show that relaxation methods such as controlled, slow-paced breathing actually improve subjective sleep quality (Laborde et al., 2019), while media use increases pre-sleep cognitive arousal and affects both the initiation of sleep (Hamilton et al., 2020) and sleep duration (Bhat et al., 2018), thereby increasing daytime fatigue (Exelmans & Scott, 2019; Exelmans & Van den Bulck, 2017a). In fact, Harbard et al. (2016) showed that pre-sleep cognitive arousal mediates the association between what they called "technology-related behaviors" and the time people need to fall asleep (i.e., sleep-onset latency).

More specifically, researchers argue that arousal created by media content consumed before falling asleep exerts an influence on viewers' cognitions before and even while sleeping (Van den Bulck et al., 2016). Two more studies focusing on TV viewing found that pre-sleep cognitive arousal explains why viewers feel increased fatigue during the day, and that TV viewing is responsible for daytime dysfunction (Exelmans & Van den Bulck, 2017a; Exelmans et al., 2019).

However, while most research focuses on traditional legacy video clips or TV episodes (Exelmans & Van den Bulck, 2017a; Flayelle et al., 2020; Shim et al., 2018), research on social media is scarce. There are several arguments why content on TikTok might trigger cognitive arousal even more, especially given that the content is algorithmically prioritized for each user to provide an exciting, visual, and entertaining experience that keeps users on the platform, thus possibly aggravating daytime fatigue. Another reason is that each TikTok video is created with music—mostly catchy pop music—in the background, (Insider, 2020). Since the same music clip loops when playing a TikTok video, viewers are prone to experience "stuck song syndrome," so-called earworms (Beaman & Williams, 2010; Insider, 2020). Earworms have been shown to cause an intrusive, "cognitive itch" (Kellaris, 2008) and can last for hours triggering cognitive arousal. Additionally, TikTok videos are predominantly visually stimulating. Creators use filters and combine these with speed adjustment features to refine the videos, aiming to draw more attention from the viewers within 15 s. Some creators have even been reported to have been severely injured when filming attention-grabbing but dangerous actions, which urged TikTok to issue warning messages to prevent imitation (BBC, 2020). These features might therefore evoke cognitive responses and generate residual excitation for audiences; a prior study reported that exposure to more stimulating media content that enhanced cognitive alertness caused increased sleep-onset latency compared with more tranquil media content (Weaver et al., 2010). Thus, automatic TikTok use may be especially relevant to daytime fatigue when it involves cognitively arousing content that is used for longer durations due to the less reflective nature of automatic TikTok use. Automatic TikTok use is likely to increase the overall time spent on the app and thereby raise the odds of coming across cognitively arousing content that, in turn, can aggravate daytime fatigue.

In sum, automatic media use is prone to increasing cognitive arousal (Harbard et al., 2016), which in turn might have a dysfunctional impact on daytime activities (Exelmans et al., 2019). However, we are not aware of a study that has tested these assumptions for TikTok. As TikTok videos are intrusive and visually engaging, they are likely to facilitate lingering cognitive effects that, in turn, have an impact on daytime fatigue levels. Therefore, we hypothesized that pre-sleep cognitive arousal mediates the relationship between automatic TikTok use and daytime fatigue ($H_2$).

## Potential effects of TikTok on fatigue

### The moderating role of sensation seeking

Sensation seeking has been found to have an impact on both preferences for and responses to media content. For instance, compared with individuals who score low on sensation seeking, "sensation seekers" have been shown to prefer action-adventure TV programs (Perse, 1996) or even violent video games to increase their levels of arousal (Jensen et al., 2011). In addition, people high in sensation seeking are more likely to engage in risky behaviors. Given that TikTok videos typically have a high sensation value (i.e., novel, unpredictable; Wang et al., 2015), high sensation seekers arguably select and respond to media that is congruent with their disposition (Valkenburg & Peter, 2013). Thus, sensation seeking can be conceptualized to moderate between automatic TikTok use, pre-sleep cognitive arousal, and fatigue. It might be that sensation seeking intensifies the direct association between automatic TikTok use and fatigue; for example, people scoring high in sensation seeking might experience more fatigue from habitual viewing because they cannot leave the platform as easily.

It might also be that sensation seeking reinforces the indirect association with fatigue, that is, people who score high in sensation seeking experience greater levels of pre-sleep cognitive arousal, which, in turn, relates to higher levels of daily fatigue. One study on the distribution of public service announcements indicated that when media messages have high sensation value (i.e., messages that are novel, unpredictable), high sensation seekers showed greater engagement and increased pleasure than low sensation seekers (Wang et al., 2015). It is thus likely that people's tendency to seek sensation amplifies the cognitive arousal from automatic TikTok viewing, as high sensation seekers would experience more psychological stimulation.

Therefore, we hypothesized that a preference for sensation seeking a) aggravates the direct influence of automatic TikTok use on daytime fatigue, and b) aggravates the indirect effect of automatic TikTok use on daytime fatigue by intensifying pre-sleep cognitive arousal ($H_3$).

### The moderated role of delaying gratification

Delayed gratification is described as "the tendency to forego strong immediate satisfaction for the sake of salient long-term rewards" (Hoerger et al., 2011, p. 725). The ability to delay immediate gratification has repeatedly been shown to be predictive of both physical and mental well-being (Hoerger et al., 2011; Schlam et al., 2013). In a media society,

many sources of immediate media gratification have become particularly hard to resist and may ultimately become a burden in life, partly because using media has become highly habitualized (Hofmann et al., 2016). For instance, habitual TV viewers prefer watching television at night over sleep (Exelmans et al., 2019), and the automatic checking of Facebook has been linked to procrastination behaviors during the day (Meier et al., 2016). As indulging in immediate media gratification relates to an unhealthier life style, delaying gratification thus may work as a buffer to alleviate the negative effects of automatic media use on well-being in the face of a goal conflict.

A goal conflict is the contradiction between the temptations or desire and the potential personal goals (Hofmann et al., 2012). The desire for media use was reported as one of the most intensive desires that stands in conflict with multiple personal goals (i.e., health-related goals such as personal hygiene; time-use goals such as getting things done). Media desires are reportedly experienced most frequently in the evening, peaking at around 22:00 across the week (Hofmann et al., 2012). Automatic TikTok use may contribute to such goal conflicts, for instance, cooling the mind down for a good night's sleep or indulging in the sensational pleasure that TikTok offers. In fact, TikTok is mostly used at night and even warns its users not to use it too late in order to maintain healthy sleep hygiene (@TikToktips, 2020). As such, the tendency to delay gratification is highly relevant to resolving media-related goal conflicts. This notion was further supported by a recent study that argued the tendency to seek immediate gratification fits better than other self-regulatory concepts because immediate gratification becomes the innate affordance of current media (Shim et al., 2018). Specifically, people with higher levels of delayed gratification (i.e., lower levels of immediate gratification) were found to watch TV in a less binging way (Shim et al., 2018). Accordingly, when initiating TikTok use without giving it conscious thought, people differ in their propensity for giving up potential long-term goals for short-term pleasure. As such, automatic TikTok use and delaying gratification were expected to jointly influence pre-sleep cognitive arousal and fatigue.

We argued that the ability to delay gratification would weaken the association between automatic TikTok use and fatigue, because this enables people to apply themselves to long-term goals over immediate media pleasure (Graziano & Tobin, 2013). As a result, people with a higher ability to delay gratification could be conceptualized as experiencing lower levels of daytime fatigue from automatic TikTok, which postpones sleep initiation, because they can stop using the app earlier and delay their gratification until the next day.

Acceptance of delayed gratification might also operate through reducing the strength of the indirect association between automatic TikTok use, pre-sleep cognitive arousal, and daytime fatigue. Delaying gratification requires activation of a "cooling system" that is reflective, strategic, and more rationally oriented; it focuses on long-term goals and at the same time deactivates the "hot" system that is impulsive, reactive, more hedonic-orientated, and focuses on immediate temptations (Mischel & Ayduk, 2002). Notably, the conscious cooling system decreases cognitive arousal, whereas the automatic hot system increases this (Mischel & Ayduk, 2002). It is thus likely that when people have the capacity for higher levels of delayed gratification, they will experience lower levels of cognitive arousal because the cooling system is more dominant than
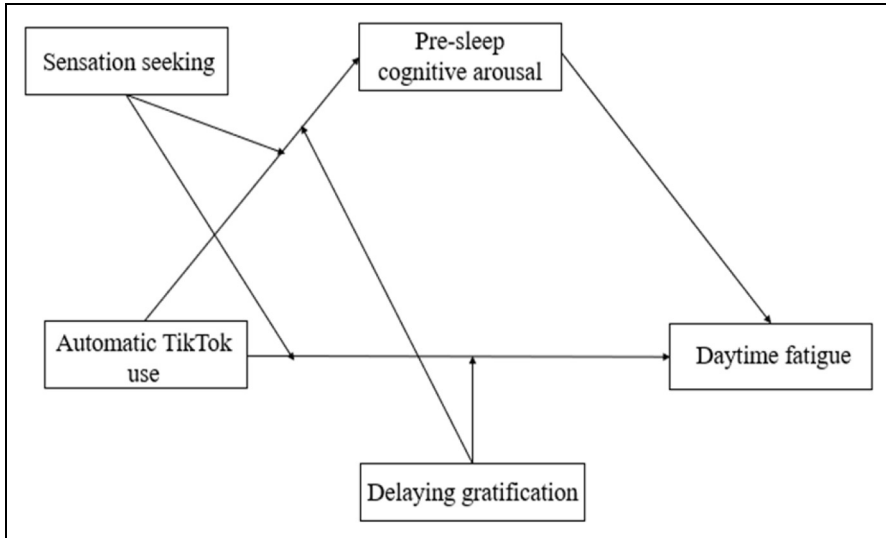
**Figure 1.** Theoretical Moderated-Mediation Model

that of the hot. Taken together, we therefore hypothesized that acceptance of delayed gratification (a) reduces the direct influence of automatic TikTok use on daytime fatigue, and (b) reduces the indirect effect of automatic TikTok use on daytime fatigue by reducing pre-sleep cognitive arousal ($H_4$).

Figure 1 presents our hypothesized model.

## Method

### Sample and procedures

A total of $N = 1,092$ users of the Chinese app Douyin/TikTok were recruited through the sampling services of the China-based company Wenjuanxing (https://www.wjx.cn) who recruited TikTok users from their pool of members. Members who used TikTok and agreed to complete the survey received a small cash bonus for their participation. The cross-sectional survey data allowed us to investigate the relationships between automatic TikTok use, cognitive arousal, and daytime fatigue only at a general level, and to explain the observed, inter-personal variance among the focal variables as well as their associations. Alternative study designs including (intensive) longitudinal, or in situ, momentary assessments would have allowed exploration of intra-individual variance, situational influences, and the dynamics behind the relationships observed here, but with the scarcity of early empirical research, we believe that our exploratory approach is valuable going forward.

The study was approved by the Institutional Review Board of Zhejiang University, and informed consent was obtained from all respondents. Data from 42 participants were deleted due to either a failure to pass the attention check ($n = 31$, 2.84%) or

**Table 1.** Sample Characteristics

|  | *n* (%) |
|---|---|
| Gender |  |
| Female, *n* (%) | 576 (54.9) |
| Male | 474 (45.1) |
| Age group |  |
| 18–25 years | 333 (31.7) |
| 26–33 years | 459 (43.8) |
| 34–41 years | 185 (17.6) |
| 42–49 years | 46 (4.4) |
| ⩾50 years | 27 (2.5) |
| Education |  |
| Less than a high school diploma | 1 (0.1) |
| High school degree | 20 (1.9) |
| Associate degree | 153 (14.6) |
| Bachelor's degree | 789 (75.1) |
| Master's degree | 82 (7.8) |
| Doctorate degree | 5 (0.5) |
| Total *N* | 1,050 |

being duplicate cases from the same IP address ($n = 11$, 1.01%), leaving a total of 1,050 cases for the final analysis. The final sample had a mean age of 29.66 ($SD = 7.78$), with almost a third being young adults (18- to 25-years old, 31.7%), and 576 participants being women (54.9%). Compared with all Douyin/TikTok users in China (QuestMobile, 2020), our sample contained fewer women (54.9% vs. 57% among Douyin/TikTok users overall), no users under 18 years (0% vs. 10% among Douyin/TikTok users), and fewer users over 40 years (7% vs. 26% among Douyin/TikTok users). Almost 98% ($n = 1,029$) of participants had obtained an associate or higher degree. Table 1 presents the sample characteristics.

## Measures

The survey was administered in Chinese. We used backward-translation techniques to translate the English scales into Mandarin. Two researchers were involved in the translation and first translated half of the items of each scale into Mandarin, then discussed any ensuing issues until these were resolved and then translated the second half of the items. This was done to establish a fixed terminology for the scales. Special attention was paid to adjusting the Chinese wording to contemporary Chinese and adult expressions reflective of Chinese adults' everyday lives.

*Daytime fatigue.* The Fatigue Assessment Scale was used to measure the experience of daily fatigue during the past month (Michielsen et al., 2003). On a 5-point scale ranging from *never* ($= 1$) to *always* ($= 5$), respondents indicated their agreement on 10 items about how they usually feel during the day, for instance, "I don't do much

during a day." An average score was created to represent daily fatigue after recoding the reversed items. The internal consistency of the scale was satisfactory ($M = 2.54$, $SD = 0.75$; Cronbach's $\alpha = 0.89$; McDonald's omega $\omega = 0.89$).

*Automatic TikTok use.* The automatic TikTok use scale was adapted from the Self-Report Behavioural Automaticity Index (Gardner et al., 2012) using four items geared toward the use of TikTok. On a 7-point scale *(completely disagree* = 1 to *completely agree* = 7), respondents rated the extent to which they agreed with the following descriptions: "Viewing TikTok is something I do... (1) automatically, (2) without having to consciously remember, and (3) without thinking, (4) I start viewing TikTok before I realize I am viewing it." From these responses, an average score was created where higher scores denote that a respondent has stronger automatic TikTok use. The internal consistency of the scale was satisfactory ($M = 3.40$, $SD = 0.98$; Cronbach's $\alpha = 0.86$; McDonald's omega $\omega = 0.86$).

*Pre-sleep cognitive arousal.* We extracted the cognitive subscale of the Pre-sleep Arousal Scale to access the mental arousal experiences when trying to sleep (Nicassio et al., 1985). On a 5-point scale ranging from *not at all* ( = 1) to *extremely* ( = 5), respondents indicated their agreement on four items. For instance, "Thoughts keep running through your head." The mean score of these responses was calculated as a new variable. A higher score indicates higher cognitive arousal before sleep. The internal consistency of the scale was satisfactory ($M = 2.59$, $SD = 0.87$; Cronbach's $\alpha = 0.89$; McDonald's omega was $\omega = 0.89$).

*Sensation seeking.* The trait sensation seeking was assessed using the Brief Measurement of Sensation Seeking Scale (Stephenson et al., 2003). On a 5-point scale ranging from *strongly disagree* ( = 1) to *strongly agree* ( = 5), respondents indicated their agreement on four descriptions, for instance, "I like new and exciting experiences, even if I have to break the rules." Items were averaged to obtain a score for sensation seeking. Higher scores indicated higher levels of sensation seeking. The internal consistency of the scale was satisfactory ($M = 2.79$, $SD = 0.88$; Cronbach's $\alpha = 0.82$; McDonald's omega $\omega = 0.83$).

*Delaying gratification.* Using the 10-item short-form Delaying Gratification Inventory (Hoerger et al., 2011), respondents rated themselves from *strongly disagree* ( = 1) to *strongly agree* ( = 5) on the descriptors (e.g., "I have given up physical pleasure or comfort to reach my goals"). After recoding the reversed items, a mean score was calculated as the indicator of the tendency to delay gratification. The internal consistency of the scale was satisfactory ($M = 3.44$, $SD = 0.51$; Cronbach's $\alpha = 0.77$; McDonald's omega $\omega = 0.71$).

*Control variables.* We included several control variables in all the models. We followed Michielsen et al. (2003) who suggested controlling for gender, age, workload, health condition, sleep quality, and exercise habits when modeling daytime fatigue; controlling for working conditions, perceived physical health, and exercise levels was suggested for

assessing the association between media use, sleep-related issues, and daytime dysfunction (see Exelmans & Van den Bulck, 2017a). Therefore, all our models controlled for gender (male = 1, female = 2), age (by years), average work hours, average sleep hours, health status, and exercise levels. Health status was measured by asking respondents to rate their self-perceived health condition ranging from *poor* (= 1) to *excellent* (= 5) (Jenkinson et al., 1993). Exercise level was assessed by asking respondent to rate how long, on average, they exercise every day, from *not at all* (= 1) to *more than 1 h* (= 5).

*Analytical approach.* Descriptive statistics and zero-order correlations were conducted using SPSS 24.0. For the mediation analysis, we used the PROCESS macro for SPSS (Hayes, 2017), specifically Model 4 with bootstrapping, using daytime fatigue as the dependent variable, automatic TikTok use as the independent variable, pre-sleep cognitive arousal as the mediator, and all control variables as the covariates. The PROCESS macro uses bootstrapping to estimate direct and indirect effects. Moderated-mediation analysis was performed using Model 10 with sensation seeking and delaying gratification as the two moderators.

## Results

### Preliminary analysis

Table 2 presents the descriptive statistics and bivariate correlations among the variables. Automatic TikTok use was positively related to pre-sleep cognitive arousal ($r = 0.31$, $p < 0.001$) and daytime fatigue ($r = 0.20$, $p < 0.001$). Additionally, pre-sleep cognitive arousal was positively related to sensation seeking ($r = 0.21$, $p < 0.001$) and daytime fatigue ($r = 0.56$, $p < 0.001$), whereas it was negatively related to delaying gratification ($r = -0.28$, $p < 0.001$). These correlations provided some initial evidence for the mediating chain among automatic TikTok use, pre-sleep cognitive arousal, and daytime fatigue.

### Direct and (indirect) mediation analysis

$H_1$ proposed the direct positive association between automatic TikTok use and daytime fatigue and $H_2$ proposed the indirect association via pre-sleep cognitive arousal. The results showed that automatic TikTok use was positively related to daytime fatigue (*total effect* = 0.16, $SE = 0.02$, $p < 0.001$, 95% CI [0.126, 0.203]). $H_1$ was thus supported. The results for mediation analysis showed that automatic TikTok use was positively related to pre-sleep cognitive arousal ($b = 0.27$, $SE = 0.03$, $p < 0.001$, 95% CI [0.221, 0.320]). The mediation relationship was confirmed by 5,000 bootstrap samples: indirect effect = 0.10, bootstrap $SE = 0.01$, 95% CI [0.078, 0.122]. Pre-sleep cognitive arousal thus partly mediated the association between automatic TikTok use and daytime fatigue (see Table 3 for complete results). Therefore, $H_2$ was supported.

**Table 2.** Mean, Standard Deviation, and Zero-order Correlations (N = 1,050)

| Variable | M | SD | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Gender | — | — | — | | | | | | | | | |
| 2. Age | 29.66 | 7.78 | −0.14** | — | | | | | | | | |
| 3. Work hours | 3.24 | 0.84 | −0.13*** | 0.18*** | — | | | | | | | |
| 4. Sleep hours | 3.73 | 0.75 | 0.07* | −0.13*** | −0.06* | — | | | | | | |
| 5. Health status | 3.72 | 0.68 | −0.07* | 0.06* | 0.01 | 0.15*** | — | | | | | |
| 6. Exercise level | 2.88 | 0.96 | −0.09** | 0.27*** | 0.09** | 0.08* | 0.36*** | — | | | | |
| 7. Automatic TikTok use | 3.40 | 0.98 | 0.08* | 0.02 | 0.08** | −0.08** | 0.01 | 0.04 | — | | | |
| 8. Pre-sleep cognitive arousal | 2.59 | 0.88 | 0.05 | −0.18*** | −0.02 | −0.14*** | −0.24*** | −0.13*** | 0.31*** | — | | |
| 9. Sensation seeking | 2.79 | 0.88 | −0.07* | −0.14*** | −0.03 | −0.01 | 0.09** | 0.10*** | 0.18*** | 0.21*** | — | |
| 10. Delaying gratification | 3.63 | 0.58 | −0.08** | 0.20*** | 0.10** | 0.06* | 0.33*** | 0.38*** | −0.12*** | −0.31*** | −0.03 | — |
| 11. Daytime fatigue | 2.54 | 0.75 | −0.05 | −0.27*** | −0.10** | −0.13*** | −0.42*** | −0.36*** | 0.20*** | 0.56*** | 0.07* | −0.58*** |

*Note.* $^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

**Table 3.** Mediation Analysis of the Influence of Automatic TikTok use, Pre-sleep Cognitive Arousal (*M*), and Daytime Fatigue (*Y*) (*N* = 1,050)

| Variables | B | SE | t | p |
|---|---|---|---|---|
| Automatic TikTok use (*X*) → Pre-sleep cognitive arousal (*M*) | 0.27*** | 0.03 | 10.78 | <0.001 |
| *Indirect effect* Automatic TikTok use (*X*) → Daytime fatigue (*Y*) via | | | Lower 95% CI | Upper 95% CI |
| Pre-sleep cognitive arousal (*M*) | 0.10*** | 0.01 | 0.078 | 0.122 |
| *Direct effect* | | | Lower 95% CI | Upper 95% CI |
| Automatic TikTok use (*X*) → Daytime fatigue (*Y*) | 0.06*** | 0.02 | 0.029 | 0.101 |
| *Total effect* | | | | |
| Automatic TikTok use (*X*) → Daytime fatigue (*Y*) | 0.16*** | 0.02 | 0.125 | 0.203 |

*Note.* Significance testing for indirect effects based on 95% confidence intervals (CIs) using a 5,000 bootstrap sample according to Hayes (2017). *SE*: standard error. All models were controlled for age, gender, average sleep hours, average working hours, exercise level, and health status.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

## Moderation and moderated-mediation analysis

$H_{3a}$ proposed the moderating role of sensation seeking on the direct association between automatic TikTok use and daytime fatigue. $H_{3b}$ proposed its moderating role in the indirect association via pre-sleep cognitive arousal. The results for $H_{3a}$ showed that the interaction effect of automatic TikTok use and sensation seeking on daytime fatigue was not significant ($b = 0.02$, $SE = 0.02$, $p = .160$). $H_{3a}$ was thus not supported.

The results for $H_{3b}$ showed that automatic TikTok use and sensation seeking interacted to affect pre-sleep cognitive arousal ($b = 0.08$, $SE = 0.03$, $p = 0.002$). Pre-sleep cognitive arousal then significantly affected daytime fatigue ($b = 0.32$, $SE = 0.02$, $p < 0.001$). The moderated mediation was confirmed by 5,000 bootstrap samples, index = 0.02, bootstrap $SE = 0.01$, 95% CI [0.01, 0.04]. H3b was thus supported (see Table 4 for the complete results). The moderation analysis, depicted in Figure 2, shows a significantly stronger relationship between automatic TikTok use and pre-sleep cognitive arousal at higher levels of sensation seeking.

$H_{4a}$ proposed the moderating role of delaying gratification on the direct relationship between automatic TikTok use and daytime fatigue, and $H_{4b}$ proposed its indirect moderating effect via pre-sleep cognitive arousal. The results for $H_{4a}$ (Table 4) showed that the interaction effect of automatic TikTok use and sensation seeking on daytime fatigue was not significant ($b = -0.06$, $SE = 0.03$, $p = 0.064$). $H_{4a}$ was thus not supported.

The results for $H_{4b}$ showed that automatic TikTok use and delaying gratification interacted to affect pre-sleep cognitive arousal ($b = -0.13$, $SE = 0.05$, $p = 0.006$). Pre-sleep cognitive arousal then significantly affected daytime fatigue ($b = 0.32$, $SE = 0.02$, $p < 0.001$, 95% CI [0.27, 0.36]). This moderated mediation was confirmed by 5,000 bootstrap samples, index = −0.04, bootstrap $SE = 0.01$, 95% CI [−0.07, −0.01]). $H_{4b}$ was thus

**Table 4.** Moderated-Mediation Analysis of the Influence of Automatic TikTok Use (X), Pre-sleep Cognitive Arousal (M), and Fatigue (Y) Moderated by Sensation Seeking and Delaying Gratification (N = 1,050)

|  | B | SE | t | p |
|---|---|---|---|---|
| Automatic TikTok use (X) → Pre-sleep cognitive arousal (M) | | | | |
| Automatic TikTok use (X) | 0.44** | 0.17 | 2.53 | 0.012 |
| Sensation seeking | −0.11 | 0.09 | −1.17 | 0.241 |
| Interaction 1 (automatic TikTok use × sensation seeking) | 0.08** | 0.03 | 3.04 | 0.002 |
| Delaying gratification | 0.15 | 0.17 | 0.871 | 0.384 |
| Interaction 2 (automatic TikTok use × delaying gratification) | −0.12** | 0.05 | −2.71 | 0.007 |
| X/M → Daytime fatigue (Y) | | | | |
| Automatic TikTok use (X) | 0.17 | 0.12 | 1.48 | 0.141 |
| Sensation seeking | −0.09 | 0.06 | −1.45 | 0.147 |
| Delaying gratification | −0.29* | 0.11 | −2.59 | 0.010 |
| Pre-sleep cognitive arousal (M) | 0.32*** | 0.02 | 15.51 | <0.001 |
| Interaction 1 (automatic TikTok use × sensation seeking) | 0.02 | 0.02 | 1.36 | 0.171 |
| Interaction 2 (automatic TikTok use × delaying gratification) | −0.05 | 0.03 | −1.77 | 0.077 |

*Note.* Significance testing for indirect effects based on 95% confidence intervals (CIs) using 5000 bootstrap sample according to Hayes (2017). *SE*: standard error. All models controlled for age, gender, average sleep hours, average working hours, exercise level, and health condition.
*p < 0.05, **p < 0.01, ***p < 0.001.

supported. As illustrated in Figure 3, the association between automatic TikTok use and pre-sleep cognitive arousal was significantly weaker at higher levels of delayed gratification.

## Discussion

Research has increasingly focused on how people maintain the balance between the immediate gratification from media use and the potential cost to a healthy daily routine (Hofmann et al., 2016). Recently, the highly popular app TikTok (Douyin) has been criticized for making it hard for users to stop using the app, which indicates that TikTok use could easily become automatic. The present study investigated the mediating role of pre-sleep cognitive arousal and the moderating role of sensation seeking and delaying gratification when investigating the association between automatic TikTok use and daytime fatigue.

### Direct and indirect association between automatic TikTok use and daytime fatigue

In accordance with our expectations (H₁), automatic TikTok use was positively related to daytime fatigue. This finding is in line with previous research on the automatic use of other media (Aalbers et al., 2019; Exelmans et al., 2019). These studies attempted to explain why automatic media use can induce fatigue. Habitual TV viewers have reported
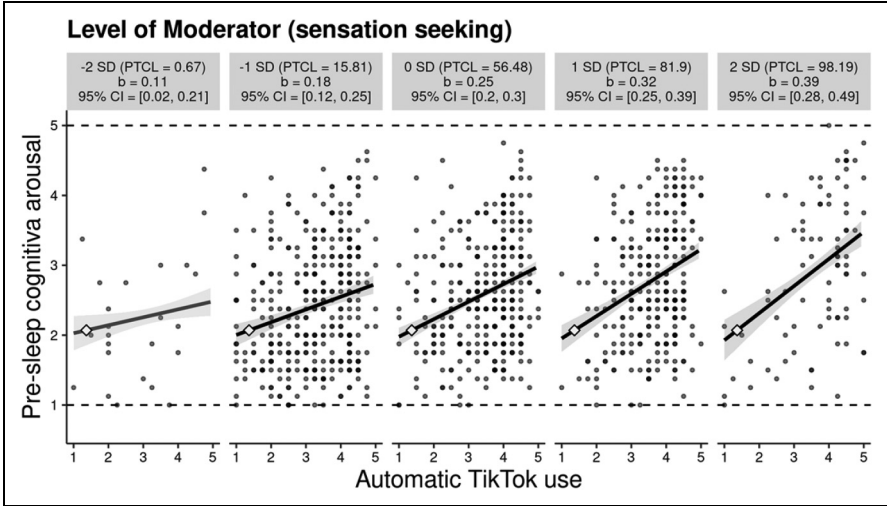
**Figure 2.** The Moderating Role of Sensation Seeking in the Relationship between Automatic TikTok Use and Pre-sleep Cognitive Arousal

*Note.* The small multiples illustrate the interaction across the range from 2 *SD*s below to 2 *SD*s above the mean of sensation seeking (McCabe et al., 2018). Each graphic shows the computed 95% confidence region (shaded area), the observed data (gray circles), and the maximum and minimum values of the outcome (dashed horizontal lines). CI = confidence interval; PTCL = percentile.

high levels of fatigue as a result of increased stress from procrastinating in the face of other important tasks (Exelmans et al., 2019). Social media users have reported experiencing high levels of fatigue from automatically scrolling, possibly due to experiencing high levels of information overload (Aalbers et al., 2019).

We proposed pre-sleep cognitive arousal as an additional explanation and tested its mediating effect between automatic TikTok use and daytime fatigue. Such a mediating effect was indeed observed, both supportive of hypothesis $H_2$ and in line with a prior study suggesting that the disturbance caused by media content is still at play in the absence of sensory instigation (Van den Bulck et al., 2016): Specifically, the chronic effect of media exposure may infiltrate the cognitive system without conscious control. Automatic TikTok use may simply raise the odds of people coming across arousing content, which is relatively popular on the platform (BBC, 2020), and may lead to more overall time spent on TikTok, thereby aggravating daytime fatigue. Moreover, in the case of TikTok, videos are algorithmically prioritized for users, aiming to attract and keep their attention, which may both increase and retain levels of cognitive arousal at night, and in turn, burden the mind. This finding might also relate to involuntary retrieval theory and the phenomenon of "earworms" because of the continuous loop feature in the background music in TikTok videos. Repeated and recent exposure to specific content can form memory episodes (e.g., a song), and these memory episodes are found to be easily and automatically retrieved when the mind is in low attention states (Williamson et al., 2012), for instance, when people are trying to sleep. Consequently, this intrusive arousal can be
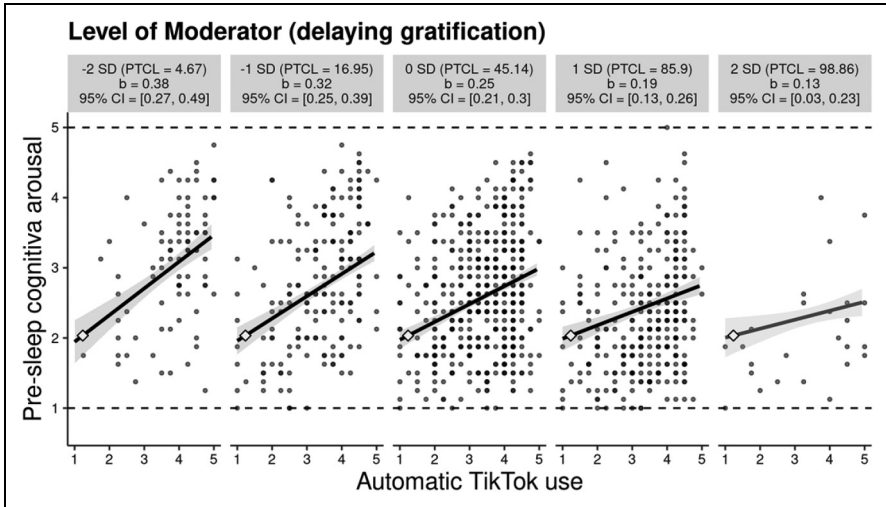
**Figure 3.** The Moderating Role of Delaying Gratification in the Relationship between Automatic TikTok Use and Pre-sleep Cognitive Arousal
*Note.* The small multiples illustrate the interaction across the range from 2 *SD*s below to 2 *SD*s above the mean of delaying gratification (McCabe et al., 2018). Each graphic shows the computed 95% confidence region (shaded area), the observed data (gray circles), and the maximum and minimum values of the outcome (dashed horizontal lines). CI = confidence interval; PTCL = percentile.

unpleasant or distressing before sleep onset, which in turn may aggravate fatigue the next day. Future research might specifically consider auditory arousal, as this might be relevant with respect to inducing dysfunctional outcomes from TikTok use.

### The moderating role of sensation seeking and delaying gratification

Our third research question related to whether people differ in vulnerability to the negative impact of automatic use. Specific focus was given to the moderating role of sensation seeking and delaying gratification in direct and indirect associations between automatic TikTok use and daytime fatigue.

Contrary to the prediction, the results suggested that sensation seeking and delaying gratification did not moderate the direct association between automatic TikTok use and daytime fatigue. However, in line with our expectations, both sensation seeking and delaying gratification did interact with automatic TikTok use to affect pre-sleep cognitive arousal and, in turn, affected daytime fatigue. Specifically, people with higher levels of sensation seeking and lower levels of delaying gratification appeared to experience higher levels of pre-sleep arousal and reported higher levels of daytime fatigue. These findings indicate that individual differences in sensation seeking and/or delaying gratification do not necessarily facilitate or alleviate daytime fatigue by simply using TikTok, but they might when TikTok affects the onset of sleep, which might then translate into daytime fatigue.

It is possible that TikTok videos are especially attractive to high sensation seekers who are excited by novel experiences and therefore possibly drawn to media congruent with their personal preferences, as outlined, for example, by the media practice model (Steele & Brown, 1995). Future studies might take a more in-depth look into the role of the background music (e.g., energetic vs. soothing) or in how far the content of the videos resonates with users. It might be expected that videos with energetic background music and risky or dangerous activities contribute to the appeal of TikTok, especially for high sensation seekers. At the same time, users who are willing to delay their immediate media rewards seem to suffer less daytime fatigue than those who cannot resist the instant gratification that TikTok offers. One reason for the decreased fatigue in those who postponed immediate gratification was the lower mental arousal reported before "lights out," which supported regular sleep onset and a higher sleep quality.

Our findings both stress the importance of sensation seeking in identifying automatic viewers who are more at risk from the unhealthy effects of TikTok use, and highlight how delaying gratification and resisting immediate media temptations can bolster individual well-being.

## Implications

The findings have several important implications: Theoretically, integrating media use patterns, media response states, and dispositional antecedents will provide a more comprehensive understanding of the media effects for the relatively new and trendy, but hardly investigated, TikTok platform. This also responds to the call for more integrative conceptual work in the domain of media effects (Valkenburg & Peter, 2013).

The study's practical implication calls for greater awareness of automatic media use and its dysfunctional impacts. From a behavioral perspective, aiming to control automatic use seems advisable to increase well-being, for example, increasing individuals' awareness of the negative impacts of such apps. For instance, relocating the TikTok app to a folder that is separate from the most accessed part of the smartphone screen, or turning off the app's notifications may be valuable techniques. Prior research on media use has identified that viewing a logo or receiving notifications from an app can promote mindless scrolling, particularly with entertainment apps (Van Koningsbruggen et al., 2017). Since the association between automatic use and daytime fatigue was mediated by pre-sleep cognitive arousal, interventions aimed at reducing arousal could also be considered. For instance, practicing meditation is effective for decreasing arousal (Cincotta et al., 2011) and reducing automatic responses to external stimuli (Wenk-Sormaz, 2005). Additionally, turning down the volume of background music may help to reduce the arousal caused by highly energetic, repetitive music that might trigger earworms and cause an unrested mind, especially before bedtime (Jakubowski et al., 2017).

## Limitations

Our findings should be interpreted in light of several limitations. First, we relied on retrospective, self-report data. In order to capture the ubiquitous and volatile nature of mobile media use, future studies could use intensive longitudinal and/or mobile experience sampling approaches that would be complementary to the self-report, retrospective measures

presented here (see e.g., Naab et al., 2019). Second, although the conceptualized model in our study is theoretically and empirically sound, the cross-sectional nature of our research design prevents us from making casual inferences or ruling out alternative models. For instance, while automatic TikTok use was modeled as the cause of fatigue, the association was found to be highly reciprocal. Other researchers have indicated that the outcomes of media use might also influence media use (Valkenburg & Peter, 2013). For example, a recent study proposed that fatigue may cause automatic scrolling in social media use (Aalbers et al., 2019). Longitudinal and experimental designs are needed to investigate the temporal order of these relationships in more detail. Third, although we assumed that TikTok content was predominantly stimulating (e.g., visually engaging) and therefore facilitated pre-sleep cognitive arousal from automatic use, we did not empirically investigate how specific content features heightened or alleviated pre-sleep cognitive arousal. Future studies should distinguish between such different content features, their structures, and the genres of TikTok videos when investigating cognitive effects. Finally, although efforts were made to collect a large-scale, heterogeneous (nonstudent) sample, our sample deviated from all Douyin/TikTok users in China as it did not include children or adolescents under the age of 18, or users over 40; women were also under-represented in the sample. Future research might therefore aim to replicate and extend our findings within different samples.

## Conclusion

This study highlighted the importance of being aware of automatic social media use, especially on new, trendy platforms such as TikTok, and shed light on their dysfunctional potentials that can have an impact on individual well-being. By investigating TikTok, we found that unconscious media consumption may be tiring our minds by hindering us from getting good quality, healthy sleep after lights out. Users should be mindful about their social media use and try to be restrained when facing ubiquitous and unlimited media temptations, especially before bedtime.

### ORCID iDs

Kexin Wang  https://orcid.org/0000-0002-5601-8774
Sebastian Scherr  https://orcid.org/0000-0003-4730-1575

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## Author biographies

**Kexin Wang (PhD, Tsinghua University)** is an assistant professor at College of Media and International Culture at Zhejiang University. Her research interests focus on the relationships between media use and well-being.

**Sebastian Scherr (PhD, University of Munich)** is an assistant professor of Health Communication at the Department of Communication at Texas A&M University. His research interests focus on individual and structural susceptibility factors for media effects in the domains of health and political communication, with a special emphasis on mental health, suicide prevention, and empirical methods.