Resisting problematic smartphone use: Distracter resistance strengthens grit's protective effect against problematic smartphone use

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ABSTRACT

Recent studies suggest that grit serves as a protective trait against maladaptive smartphone use. However, little is known about possible boundary conditions, such as cognitive abilities, that could modulate the relations. Evidence suggests that the cognitive functions that underlie goal-maintenance abilities—specifically, inhibition—could moderate the relations of the two subfactors of grit (i.e., grit-consistency and grit-perseverance) with problematic smartphone use. Hence, we investigated the moderating roles of two core aspects of inhibition: prepotent response inhibition and resistance to distracter interference. Testing college students ($N = 237$, $M_{age} = 21.8$ years, 73.4% female), we found that only resistance to distracter interference, but not prepotent response inhibition, significantly moderated the link between grit-perseverance and problematic smartphone use. However, neither facet of inhibition moderated the associations between grit-consistency and problematic smartphone use. These results underscore the importance of cognitive inhibition for resisting task-irrelevant distracters and strengthening the protective role of grit-perseverance against problematic smartphone use.

KEYWORDS

Grit, Resistance to distracter interference, Response inhibition, Smartphone use

1. Introduction

Problematic smartphone use is an increasing concern because of its wide-ranging maladaptive consequences; these include emotional health problems, loss of control, and physical health issues (Busch & McCarthy, 2021). Problematic smartphone use refers to the impaired ability to regulate one's smartphone use, evidenced by symptoms of excessive dependency such as lack of tolerance, withdrawal, escape, craving, etc. (Thomée, 2018). Recent studies have highlighted grit—trait-level perseverance and passion for long-term goals (Duckworth & Quinn, 2009)—as a possible protective trait against problematic smartphone use (Kim, Kwak, & Kim, 2021). Gritty individuals tenaciously pursue their dominant superordinate goals despite setbacks (Duckworth & Gross, 2014) and tend to have greater resilience and hardiness (Georgoulas-Sherry & Kelly, 2019). Given this, it is plausible that gritty people have healthier coping abilities to manage negative events, and thus are less likely to resort to problematic smartphone use for compensatory coping (Kardefelt-Winther, 2014; Khoo & Yang, 2021). Furthermore, studies have shown that gritty individuals are less easily distracted by smartphones due to their enhanced ability for sustained attention (Kalia, Thomas, Osowski, & Drew, 2018), which would in turn contribute to fewer problematic smartphone use behaviors.

However, the relation between grit and problematic smartphone use remains inconclusive for two reasons. First, previous studies failed to differentiate the two subfactors of grit—consistency in interest and perseverance of effort—in examining their relations to problematic smartphone use (e.g., Maddi et al., 2013), despite recent findings that these subfactors have differential relations to behavioral outcomes (e.g., Credé, Tynan, & Harms, 2017). Second, considering the vital associations of inhibition—which underlies goal-maintenance abilities—with problematic smartphone use (e.g., Toh, Ng, Yang, & Yang, 2021), less is known about how such cognitive factors may qualify the relation between grit and problematic smartphone use. In view of these gaps in knowledge, we sought to investigate the moderating role of inhibition, a critical cognitive-control ability, in the relation between the two grit subfactors and problematic smartphone use.

1.1. Grit and problematic smartphone use

Although past studies have demonstrated that grit negatively relates to technological addictions (Borzikowsky & Bernhardt, 2018; Kim et al., 2021; Maddi et al., 2013), they lack theoretical integration. The Interaction of Person-Affect-Cognition-Execution (I-PACE; Brand, Young, Laier, Wölfling, & Potenza, 2016, Brand et al., 2019) model and the

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compensatory internet use model (Kardefelt-Winther, 2014) elucidate the relation between grit and problematic smartphone use. The I-PACE model describes the psychological and neurobiological processes that underlie the development and maintenance of addictive technology use, such as smartphone use, online shopping, or social networking. Specifically, the revised I-PACE model illustrates how technology can be misused for gratification or coping. Similarly, the compensatory internet use model posits that problematic smartphone use develops to fulfill compensatory needs to relieve individuals of negative emotions.

In favor of this, past studies have shown that problematic smartphone use for escapism is intensified when individuals have difficulty coping with stress (Wang, Wang, Gaskin, & Wang, 2015). Given that grittier individuals tend to more effectively manage negative events by reframing them or limiting attention to stressors and focusing on long-term goals (Blalock, Young, & Kleiman, 2015), they may have a lower tendency to seek external sources such as smartphones for gratification or coping purposes. In other words, grittier individuals could be less susceptible to an addictive compensatory use of smartphones, since they are more resilient against stressors (Blalock et al., 2015) and negative emotions (Credé et al., 2017; Disabato, Goodman, & Kashdan, 2019).

Notably, grit was originally theorized to be a higher-order factor with two subcomponents: consistency in interest (grit-consistency—the tendency to sustain interest over time) and perseverance of effort (grit-perseverance—the tendency to work hard despite setbacks; Duckworth & Quinn, 2009). However, recent findings are mixed regarding the factor structure of grit (Disabato et al., 2019). An increasing number of studies present evidence in favor of the bifactor model and suggest that the two facets of grit are differentially related to behavioral outcomes (Bowman, Hill, Denson, & Bronkema, 2015; Disabato et al., 2019). Specifically, the grit-perseverance factor has shown greater predictive power than the grit-consistency factor in academic performance and cognitive ability (Bowman et al., 2015; Kalia et al., 2018). Importantly, meta-analytic findings indicate that combining perseverance and consistency scores for an overall grit score appears to significantly reduce its predictability (Credé et al., 2017). In view of these findings, studies that examine the relation between grit and technological addictions, including problematic smartphone use, have reported inconsistent findings depending on how grit was indexed. For instance, Kim et al. (2021) found that the overall grit score and its two subscale scores negatively predicted problematic smartphone use. However, Borzikowsky and Bernhardt (2018) found that grit predicted lower online gaming addiction when it was modeled as a higher-order factor, but not when it was modeled as two separate subfactors. Given this inconsistency and strong meta-analytic evidence suggesting the separation of grit-perseverance from grit-consistency (Credé et al., 2017), it is crucial that we examine whether the two subfactors of grit independently predict problematic smartphone use.

1.2. Inhibition as a moderator

Inhibition is the cognitive ability to ignore and suppress irrelevant information (Friedman & Miyake, 2004). According to the revised I-PACE model (Brand et al., 2019), a diminished level of inhibition is a vulnerability factor in both early and later developmental stages of addictive behavior, such as problematic smartphone use. Specifically, inhibition could moderate the link between responses to stress and engagement in addictive behavior. Given that an individual's predisposing traits (e.g., grit) influence one's experience of stress (Blalock et al., 2015) and susceptibility to engage in addictive behavior to alleviate the stress, it is conceivable that inhibition moderates the link between grit and addictive behaviors such as problematic smartphone use. Furthermore, inhibition plays an instrumental role in goal-directed behaviors (e.g., Berkman, Falk, & Lieberman, 2012) and adaptive coping (e.g., Cohen, Mor, & Henik, 2015; Toh & Yang, 2020), which would further alleviate or curb gritty individuals' tendency to develop problematic smartphone use as a maladaptive coping habit. Below, we elaborate on two major conceptual and empirical contexts that lend support to this notion.

First, it is plausible that inhibition provides cognitive resources for gritty individuals to pursue their superordinate goals by suppressing automatic/dominant or goal-irrelevant distractors (Kalia et al., 2018). Accordingly, gritty people with stronger inhibition may be better at achieving their goals despite setbacks and experience fewer negative outcomes (e.g., goal failures), which often render individuals more prone to problematic smartphone use for compensatory gratification or coping (Brand et al., 2019; Kardefelt-Winther, 2014). In support of this, studies have shown that individuals with stronger inhibition abilities are less susceptible to problematic smartphone use (e.g., Chen, Liang, Mai, Zhong, & Qu, 2016; Choi et al., 2021). Relatedly, neuroimaging evidence suggests that grit and inhibition work together for goal-maintenance purposes. Specifically, inhibition and grit recruit related neural regions in the prefrontal cortex, including the dorsolateral prefrontal cortex (DLPFC) and the right dorsomedial prefrontal cortex (DMPFC; Aron, Robbins, & Poldrack, 2004; Wang et al., 2017). Importantly, the DMPFC and DLPFC work together to support the cognitive control required for goal maintenance and achievement, with the former responsible for monitoring performance and the latter supporting the adjustment of behaviors (Taren, Venkatraman, & Huettel, 2011). Thus, grit and inhibition likely tap into interrelated neural mechanisms that strengthen individuals' successful pursuit of goals, which thereby alleviates problematic smartphone use.

Second, stronger inhibitory abilities have been suggested to facilitate adaptive coping, which correspondingly curtails compensatory use of problematic smartphone use. For example, Cohen et al. (2015) found that participants who practiced inhibition were better able to inhibit irrelevant emotional information and used dysfunctional coping strategies less often. Relatedly, Toh and Yang (2020) found that individuals with stronger inhibition and reappraisal abilities had greater life satisfaction. Therefore, it is conceivable that grittier individuals who have stronger inhibition would cope better with stressors and be less likely to rely on smartphones to regulate negative emotions.

Notably, inhibition can be further differentiated into (a) prepotent response inhibition (hereafter *response inhibition*)—the ability to deliberately suppress dominant automatic responses—and (b) resistance to distracter interference (hereafter *distracter resistance*)—the ability to resist or resolve task-irrelevant interference stemming from the external environment ((Friedman & Miyake, 2004). Past studies, however, often focused on only limited aspects of inhibition. For instance, Chen et al. (2016) only assessed response inhibition in relation to problematic smartphone use, while Choi et al. (2021) focused on distracter resistance. Kalia et al. (2018) only examined the relation between distracter resistance abilities and grit. Given that these studies focused on a single aspect of inhibition in relation to grit and problematic smartphone use, it is vital that we consider the moderating roles of both response inhibition and distracter resistance in the relation between grit and problematic smartphone use.

We first hypothesized that both factors of grit would negatively predict problematic smartphone use. Second, we hypothesized that the negative link between grit and problematic smartphone use would be strengthened by inhibition abilities, such that grittier individuals with stronger response inhibition and distractor resistance would be less susceptible to problematic smartphone use.

2. Method

2.1. Participants

Two hundred and fifty-one students from a local university in Singapore were recruited for this study in exchange for course credit or a monetary reward ($30). Participants completed the tasks and questionnaires over two sessions. Due to technical errors, six participants' flanker or Stroop data were not recorded, and 12 participants did not

return for the second session. The final sample contained 237 participants (M_{age} = 21.8 years, 73.4% female; see Table S1 in Supplementary Materials) who were mostly from middle-income families with household income ranged between S$7500 and S$9999.

According to a post hoc power analysis, our sample has 99.8% power to detect a small moderation effect size (i.e., f^2 = 0.10; Faul, Erdfelder, Lang, & Buchner, 2007). Since we use a subset of a larger dataset, only the variables of interest for this study were reported; note that there was no experimental manipulation that might affect participants' responses or inhibition task performance.

2.2. Measures

2.2.1. Grit

We assessed grit using the short Grit scale (1 = *Not at all like me*; 5 = *Very much like me*; Duckworth & Quinn, 2009), which has two subscales: grit-consistency (4 items, M = 3.18, SD = 0.89, α = 0.836; e.g., "I often set a goal but later choose to pursue a different one") and grit-perseverance (4 items, M = 3.41, SD = 0.80, α =0.759; e.g., "Setbacks don't discourage me"). Higher scores indicate stronger grit-consistency and grit-perseverance.

2.2.2. Problematic smartphone use

Problematic smartphone use was assessed using a 10-item scale (M = 3.01, SD = 0.89, α =0.835; e.g., "Missing planned work due to smartphone use"; 1 = *Strongly disagree*; 6 = *Strongly agree*; Kwon, Kim, Cho, & Yang, 2013). Higher scores indicate more problematic use.

2.2.3. Response inhibition

We used the Stroop task to assess response inhibition (Friedman & Miyake, 2004). Participants had to identify the ink color of color words that appeared on screen in either a congruent (e.g., RED in red) or incongruent (e.g., RED in blue) color (Stroop, 1992). In each trial, participants reported the ink color of the target word as fast and accurately as possible by pressing one of the four corresponding keys. Participants completed 10 practice trials and three blocks of 72 trials, each consisting of 36 congruent and 36 incongruent trials. The dependent measure was reverse-coded adjusted bin scores, which incorporated both accuracy and reaction time (RT) scores (Vandierendonck, 2017; see Section S1 in Supplementary Materials for details); higher values denote better performance (M = −19.70, SD = 120.24, α = 0.978).

2.2.4. Distracter resistance

The Eriksen flanker task was used to assess distracter resistance (Friedman & Miyake, 2004). Participants had to identify a target letter (G or H) surrounded by either incongruent (e.g., HHHGHHH) or congruent (e.g., GGGGGGG) flankers by pressing the "G" or "H" key, respectively (Eriksen & Eriksen, 1974). There were 85 trials of each type (i.e., congruent and incongruent); 30 vigilance trials—in which participants had to press the spacebar when there was a gap between the alphabets (e.g., GGG GG); and 10 practice trials. The trials were intermixed in a fixed random order. The dependent measure was reverse-coded adjusted bin scores; higher values indicate better performance (M = -13.51, SD = 80.39, α =0.677).

2.2.5. Covariates

Participants' age, sex, and nonverbal fluid intelligence served as covariates (for details, see Table S1). Past studies have shown that intelligence is associated with inhibition (Unsworth et al., 2009), and thus should be controlled for. Participants' nonverbal fluid intelligence was assessed using nine questions from Raven's Progressive Matrices (Raven, Raven, & Court, 2000). More accurate responses indicated higher intelligence.

2.3. Procedure

The study was held over two sessions. Participants completed the two inhibition tasks and fluid intelligence task in the first lab session, in which they responded to computerized tasks that took about 20 min in total. One week later, participants received a survey link and responded to questionnaires online—demographic information, personality traits (i.e., grit) and problematic smartphone-use tendencies. All procedures were approved by the university's institutional review board, and informed consent was obtained from all participants before the study began.

3. Results

The Shapiro-Wilk test was used to test the normality assumption. Problematic smartphone use, our outcome variable, was normally distributed (see Table S1 in Supplementary Materials). Our analyses of kurtosis and skewness also confirmed the normality of its distribution (i.e., ± 2; George & Mallery, 2010; see Table S1 for details). No evidence of multicollinearity was found. Thus, we examined the moderating role of inhibition between subfactors of grit and problematic smartphone use, using the PROCESS macro (Hayes, 2013), which estimated 95% bootstrap confidence intervals (CIs) for interaction effects based on 5000 bootstrapped samples. Age, sex, and fluid intelligence were included as covariates.

We found that only distracter resistance assessed by the flanker task significantly moderated the relation between grit-perseverance and problematic smartphone use (b = −0.002, SE = 0.009, p = .032), but not the link between grit-consistency and problematic smartphone use (b = −0.001, SE = 0.001, p = .552). Further probing by simple slope analyses (see Fig. 1) revealed that grit-perseverance predicted problematic smartphone use more strongly in individuals at the mean (b = −0.209, SE = 0.069, p = .003) or 1 SD above the mean bin scores of distracter resistance (b = −0.369, SE = 0.101, p < .001), but not in those with weaker abilities (1 SD below the mean of bin scores; b = −0.049, SE = 0.101, p = .624).

In contrast, response inhibition, assessed by the Stroop task, interacted with neither grit-perseverance (b = −0.0003, SE = 0.001, p = .575) nor grit-consistency (b = 0.0002, SE = 0.001, p = .666) to influence problematic smartphone use. Despite recent findings that grit-perseverance has greater predictive power than grit-consistency in psychological or behavioral outcomes, our findings indicate that both subfactors similarly predict problematic smartphone use. In all moderation analyses, grit-perseverance and grit-consistency negatively

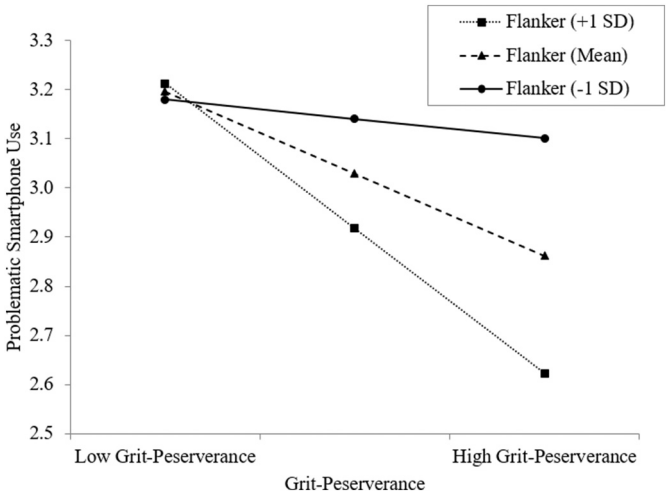

Fig. 1. Problematic smartphone use as a function of grit-perseverance and flanker performance.

predicted problematic smartphone use, *ps* < 0.005.

4. Discussion

Our study highlights several notable findings. First, they corroborate the revised I-PACE and compensatory internet use models (Brand et al., 2019; Kardefelt-Winther, 2014) in that grit, as a predisposed trait, buffers against an individual's tendency toward problematic smartphone use. According to the revised I-PACE model, less gritty individuals could experience more frequent and stronger affective and cognitive responses to negative triggers (e.g., goal failures). This, in turn, likely stimulates and habituates their proneness toward problematic smartphone use as a tool for mental disengagement or momentary relief from negative affect (Kardefelt-Winther, 2014). Forming an addictive smartphone-use response to negative triggers, less gritty individuals would then easily lose control over their smartphone use and more likely experience negative consequences in daily life (e.g., missing planned work), manifesting more apparent problematic smartphone use behaviors.

Importantly, our study demonstrates that gritty individuals' resilience against problematic smartphone use is further enhanced by stronger inhibition; in particular, an ability to ignore goal-irrelevant stimuli. While previous studies have shown that response inhibition, the ability to withhold prepotent responses, is protective against problematic smartphone use (Liebherr, Schubert, Antons, Montag, & Brand, 2020), our study shows that only distracter resistance (assessed by the flanker task)—and not response inhibition (assessed by the Stroop task)—modulates the link between grit-perseverance and problematic smartphone use. According to Stahl et al. (2014), the fundamental difference between individuals' distracter resistance and response inhibition is parallel to the difference between proactive stopping (e.g., preparing to selectively stop an upcoming response tendency) and reactive stopping (e.g., stopping an already ongoing response when instructed by a cue), respectively. Given that grit entails maintaining long-term commitment to superordinate goals (Duckworth & Gross, 2014), gritty individuals could greatly benefit from their distracter-resistance abilities to proactively suppress rival goals or setbacks to achieve goal success, and thereby reduce their need for maladaptive coping habits (e.g., problematic smartphone use). Moreover, gritty individuals with stronger distracter-resistance abilities would conceivably be better at shielding their attention from distracting smartphones and regulating their smartphone use. In line with this notion, studies have found that poorer performance on a flanker task was related to more problematic smartphone use (Choi et al., 2021). On the other hand, since grit engenders the need to exercise proactive defense against rival goals, reactive abilities to withhold prepotent responses may be less relevant. In line with this notion, previous findings have suggested that response inhibition has only weak associations with self-control (Duckworth & Kern, 2011), which is closely related to grit (Duckworth & Gross, 2014). Furthermore, Johannes, Veling, Verwijmeren, & Buijzen (2018) found that response inhibition, assessed by a stop-signal task, has no association with individuals' distractibility by smartphones, which is a key characteristic of problematic smartphone use. Our findings support the notion that grittier individuals with stronger resistance to distracters would be less susceptible to problematic smartphone use.

Our second notable finding is that the moderating effect of distracter resistance was specific to only grit-perseverance, but not grit-consistency. These findings corroborate previous findings that only grit-perseverance was associated with performance on a variant flanker task (Kalia et al., 2018), despite the fact that both subfactors were negatively related to problematic smartphone use. This could be because a lack of grit-perseverance engenders greater stressors and negative emotions (e.g., being discouraged by setbacks) than a lack of consistency in interest (e.g., being derailed from a current project by a new interest). Consistent with this notion, one prior study showed that individuals with weaker grit-perseverance, but not grit-consistency, experienced lower life satisfaction (Disabato et al., 2019). Further, given that poorer distracter resistance abilities are associated with poorer adaptive coping, e.g., greater rumination (Cohen et al., 2015), it is conceivable that individuals with poorer grit-perseverance and distracter resistance would more maladaptively rely on smartphones for compensatory gratification or coping. Further, considering that stronger distracter resistance promotes individuals' goal-directed behaviors (Veling & van Knippenberg, 2006) and facilitates achievement of long-term goals, individuals with higher grit-perseverance and distracter resistance may experience fewer instances of stressors (e.g., goal failures) or a lesser extent of negative emotions, and thus they are less likely to seek compensatory coping through problematic smartphone use.

Our study is not without limitations. First, the use of a single task to assess each inhibition limited our ability to eliminate task-impurity issues for the constructs. Such issues arise because no executive function task can purely measure its intended construct due to the inclusion of task-specific measurement errors (cf. Miyake et al., 2000). For instance, the Stroop task assesses not only response inhibition, but also reading or color perception. Therefore, future studies should employ multiple inhibition tasks to extract a latent variable. Second, our study design is correlational and cross-sectional in nature, which restricts causal inferences. Given the possibility of a bidirectional relationship, such that problematic smartphone use negatively influences daily productivity (Duke & Montag, 2017) and, in the longer run, impacts one's grit, longitudinal or more extensive studies are needed to shed light on this aspect. Third, our sample consisted of only young adults. Thus, future studies should employ more representative samples to ensure the generalizability of findings to other age groups.

Our study contributes novel evidence to research that links grit and problematic smartphone use. Importantly, our findings elucidate the importance of distracter resistance, a core aspect of cognitive control, in attenuating the relation between individual differences in grit and maladaptive smartphone use. Our findings hold practical implications for developing intervention strategies for smartphone addiction. In addition to strengthening one's psychological resilience (i.e., grit), it is important to promote cognitive exercises that directly benefit distracter resistance (e.g., Cohen et al., 2015) to increase the effectiveness of interventions for problematic smartphone use.

CRediT authorship contribution statement

Shuna Shiann Khoo: Conceptualization, Project administration, Investigation, Data curation, Formal analysis, Writing – original draft, Writing – review & editing. **Hwajin Yang:** Conceptualization, Formal analysis, Supervision, Writing – review & editing, Funding acquisition.

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Appendix A. Supplementary data

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