How students' self-control and smartphone-use explain their academic performance

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Abstract

Smartphones cause self-control challenges in people's everyday lives. Supporting this notion, our studies corroborate that trait self-control is negatively associated (1) with students' distraction (via smartphones) during their learning endeavors (Study 1, $N = 446$) and (2) with several aspects of problematic smartphone-use (Study 2, $N = 421$). Study 3 ($N = 106$) investigated whether distinct aspects of smartphone-use also account for the link between students' trait self-control and academic performance. Specifically, we examined (1) smartphone procrastination (i.e., irrational task delays via smartphone), (2) beneficial smartphone habits (placing in a bag [placement habit] or turning the sound off [setting habit]), and (3) the objective amount of smartphone-use (minutes spent on the smartphone [screentime] and times picked up [pickups]). In line with our predictions, students higher in trait self-control showed better academic performance ($\beta = 0.22$). Smartphone procrastination ($\beta = -0.23$) and placement habits ($\beta = 0.21$) were significantly associated with academic performance and both also mediated the self-control-performance-link. Our findings suggest that it is not the objective amount of smartphone-use but the effective handling of smartphones that helps students with higher trait self-control to fare better academically. Implications for future research are discussed from a self-regulatory perspective on smartphone-use.

Keywords: trait self-control, smartphone-use, habits, procrastination, academic performance, mediation

1. Introduction

Beyond basic bodily needs—eating, sleeping, and drinking—media use is one of the most frequent desires people experience on a daily basis (Hofmann, Vohs, et al., 2012). It is hardly surprising anymore that people, on average, check their smartphone 58 times a day (30 times during working hours) and spend about three hours on their phones daily (based on 11,000 users; MacKay, 2019). In more than half of all media use occurrences, it conflicts with important goals such as efficient time use or educational achievement (Reinecke & Hofmann, 2016). Smartphones support people digitally and connect them to friends anytime and anywhere. However, their omnipresence, coupled with the easy accessibility and possibility to (presumably) check for new messages or news (only quickly), make smartphones prominent candidates to interfere with the pursuit of activities that requires prolonged attention and concentration, such as studying.

People are not equally affected by the temptation of smartphones. Empirical research shows that individuals lower in trait self-control—the ability to override impulses and engage in potentially aversive activities (Carver, 2019)—are more likely to respond immediately to mobile notifications (Berger et al., 2018). They are less likely to resist the urge to check the smartphone promptly after receiving a message. In a similar vein, lower self-control has been linked empirically to more problematic smartphone-use, such as losing sleep due to the time spent on the smartphone (Gökçearslan et al., 2016; Van Deursen et al., 2015). These findings are interesting in their own right, but also because they allude to the possibility that people high(er) in trait self-control achieve certain positive life outcomes—such as higher academic achievement (Duckworth & Seligman, 2005)—at least partly because of their lower susceptibility to fall for the momentary allure of smartphones.

In the present study, we pursued two major goals: First, we sought to establish the link between trait self-control and smartphone-use as a study distraction (Study 1), while illuminating which aspects of smartphone-use are problematic (Study 2). Second, we

investigated whether and how smartphone-use can empirically explain the association between trait self-control and academic performance (Study 3). Specifically, we examine how different aspects of smartphone-use—procrastination, habits, and objective amount of use—may improve versus impair students' academic performance.

2. Theoretical and empirical background

2.1. The marshmallow of the Digital Age

Trait self-control can be defined as the “ability to override impulses to act, as well as the ability to make oneself initiate or persist in boring, difficult, or disliked activity” (Carver, 2019, p. 477). Classic studies followed this conceptualization of self-control in, for instance, the seminal ‘Marshmallow Test’ (see Metcalfe & Mischel, 1999; Mischel et al., 1989, for a review). In this paradigm, children were presented with the choice between an immediately available reward (“one marshmallow right away”) versus a larger, but delayed reward (“two marshmallows when I come back”). The experiment induces a classic self-control dilemma and children with higher trait self-control indeed prefer the delayed but larger reward over the smaller, immediate reward. Numerous studies have shown that high trait self-control is associated with positive life outcomes, such as better health behavior, happier relationships, better financial situation, fewer criminal deviations, and less addictive behavior (Daly et al., 2016; de Ridder et al., 2012; Moffitt et al., 2011 for a meta-analysis, see de Ridder et al., 2012). Of special importance for the present research, trait self-control is also robustly associated with better academic performance (Duckworth & Seligman, 2005; Mischel et al., 1989; Véronneau et al., 2014) with some authors claiming that self-control is even more important for academic performance than intelligence (Duckworth & Seligman, 2005). While the benefits of trait self-control are well established, we do not conclusively know *how* individuals higher in self-control attain long-term goals more effectively (Galla & Duckworth, 2015).

In today's Digital Age, the smartphone resembles the well-known 'marshmallow' (Markowitz et al., 2019) causing ubiquitous self-control challenges. Compared to other digital devices, the smartphone is the most accessible device and thus more invasive and disruptive. For students, the smartphone provides an unprecedented number of ways to distract themselves from studying. Studying for exams offers only distal rewards such as a higher grade point average (GPA) at the end of the semester, while the smartphone tempts with immediate rewards in the form of social networking, communication, news or games (Oulasvirta et al., 2012). Building on the link of trait self-control and problematic smartphone-use (e.g., Gökçearslan et al., 2016; Van Deursen et al., 2015), we propose that students' smartphone-use may account for the link of trait self-control and academic performance. In particular, we examine distinct aspects of smartphone-use that may help versus hinder students' academic performance—procrastination, placement and setting habits, as well as objective amount of smartphone-use.

2.2. Smartphones as devices for procrastination

A prominent example of self-control failure in the media context is procrastination (Hofmann et al., 2016). Procrastination is conceptualized as “to voluntarily delay an intended course of action despite expecting to be worse off for the delay” (Steel, 2007, p. 66). Instead of staying focused on an intended, potentially aversive task (e.g., studying for upcoming exams), procrastinators give in to (more) pleasant, immediate temptations. Through its perpetual availability, it is likely that students perceive the smartphone as a potent and frequent temptation during learning endeavors. Although procrastinators experience some short-term positive affect, they typically realize that delaying an intended task is irrational as giving in to immediate temptations falls at the expense of one's own long-term goal (Steel, 2007). As a result, procrastination is empirically associated with unwanted outcomes, such as poorer academic performance ($r = -0.13$, Kim & Seo, 2015; $r = -0.22$ Richardson et al., 2012). Supporting the idea that initiating an intended, but potentially aversive task requires self-

control, research shows a robust negative correlation between procrastination and trait self-control ($r = -0.58$ in the most recent meta-analysis, Steel, 2007). In line with this notion, trait self-control has been linked, for instance, to more procrastination on facebook (Meier et al., 2016). Building on these findings, we expect that students will use their smartphones frequently to procrastinate. Furthermore, students with lower trait self-control should more frequently procrastinate via their smartphones, which may contribute to impaired academic performance relative to students with higher trait self-control who procrastinate less.

2.3. Smartphone habits

Current findings suggest that trait self-control is more than simply resisting temptations. For instance, children try to deal with the self-control dilemma of the Marshmallow Test with a multiplicity of means (Carlson & Beck, 2009): some cover their eyes to not have to look at the tempting marshmallow; others sit on their hands to physically restrain themselves from eating the marshmallow. Interestingly, individuals high in self-control report resisting impulses *less* frequently in their everyday life (Hofmann, Baumeister, et al., 2012; Imhoff et al., 2014). Instead, they seem to be better in forming and maintaining beneficial habits that make effortful inhibition dispensable (Galla & Duckworth, 2015). Habits are characterized as a phenomenon in which behavior is initiated automatically by situational cues; habits are developed through repeated enactment of certain activities under stable conditions (for a review on habits, see Wood, 2017; Wood & Rnger, 2016). For instance, advantageous homework habits (i.e., doing homework frequently in a stable context) explained the effect of trait self-control on students' improved GPA (Galla & Duckworth, 2015). The authors conclude, "that for long-term goals, self-control can be strategically deployed to organize situations and remove temptations that obstruct continued repetition of goal-relevant behavior" (Galla & Duckworth, 2015, p. 522). Accordingly, people high in trait self-control more often report to reduce distractions and temptations in their environment to engage and persist in potentially boring or challenging activities (Hennecke et al., 2019).

Up to date, a few studies have systematically manipulated the placement of smartphones during task engagement (Johannes et al., 2019; Thornton et al., 2014; Ward et al., 2017). For instance, placing one's own smartphone visibly on the table (with notifications switched off) led to higher reported distraction (Johannes et al., 2019). Further, instructing participants to keep all notification alerts on and their smartphones within reach (versus alerts off and smartphones out of reach) also resulted in higher levels of reported distraction (Kushlev et al., 2016). Combining these results with recent findings on the effectiveness of habits, we predict that students with higher trait self-control employ more beneficial smartphone habits while studying. We distinguish between beneficial habits regarding smartphone placement (e.g., placing the smartphone in a bag) and smartphone settings (e.g., turning the sound off). Both habits should lower the chance of distraction and, in turn, facilitate more effective studying and ultimately improve academic performance.

2.4. Amount of smartphone-use

Most students use their smartphones primarily for leisure rather than for school or work purposes (Lepp et al., 2013). Hence, previous research suggests a negative association between the total amount of smartphone-use and academic performance (Baert et al., 2020; Lepp et al., 2015). For instance, students' self-reported estimate of the total amount of time spent on the smartphone was negatively associated with their actual college GPA (Lepp et al., 2015). Researchers even claimed that “a one-standard-deviation increase in their overall smartphone use yields a decrease in their average exam score of about one point (out of 20)” (Baert et al., 2020, p. 21). To our knowledge, all of these previous studies relied on self-reported estimates of smartphone-use. However, there is increasing evidence that individuals are poor estimators of their actual smartphone-use, questioning the validity of self-report measures of smartphone-use (Ellis, 2019). To address these limitations and to complement previous results, we used an objective measure—a monitoring-app—to assess how much time

students factually spent on their smartphones (screentime in minutes) and how many times they picked up their smartphone during the day (pickups).

3. The present research: Anticipated contributions

The present research seeks (1) to further examine the link of trait self-control and smartphone-use and (2) to illuminate our understanding of the association between self-control and academic performance that is explained via distinct aspects of smartphone-use. First, we conducted two correlational studies to investigate our prediction that trait self-control is associated with (a) distractions (particularly via the smartphone; Study 1) while studying and with (b) different aspects of problematic smartphone-use (Study 2). The third study follows up on these correlational findings by investigating whether different aspects of smartphone-use can (c) explain the association between trait self-control and academic performance. Expanding the scope of previous studies, we illuminate both the *how much*—the objective amount of smartphone-use (i.e., screentime, pickups)—but also the *how*—aspects of smartphone-use that may improve (i.e., beneficial habits) versus impair (i.e., smartphone procrastination) academic performance. We opted to conduct the third study in a period of pronounced self-control demands, while students prepared for upcoming exams. In sum, the present research allows us to disentangle the sheer amount of smartphone-use and ways of regulating ones' smartphone-use to explain the effects of trait self-control on academic performance. Methods, data, and analysis scripts for all three studies are publicly available on the Open Science Framework ([URL](#) blinded for peer-review).

4. Study 1

The first correlational study sought to examine (1) the extent to which smartphone-use distracts university students from studying compared to other known sources of distraction and (2) whether students' trait self-control is associated with the extent of distraction (via smartphones) while studying.

4.1. Methods

4.1.1. Participants and procedure

Participants were 454 students (74.9% woman; 0.7% diverse; $M_{\text{age}} = 22.29$, $SD = 3.88$) from Germany ($N = 344$), Switzerland ($N = 81$), and Austria ($N = 29$). They were recruited through an online research participation system at {Institution}, different online platforms (e.g., facebook), and scientific networks. Participants received brief, general information about the study and could access the questionnaire via a URL link. Participants first completed all measures before providing demographic information. They had the chance to win one of two 25€ vouchers for an online store. Participating students from {Institution} additionally received course credit (0.25 hours). Eight participants had to be excluded as their academic degree indicated that they are no students anymore, resulting in a final sample of 446 students. Sensitivity analyses in G*Power (Faul et al., 2007) for a bivariate correlation with $\alpha = .05$ show that the total sample of 446 participants had a 90% chance to detect an effect size of $\rho = -0.15$ and a power of $1 - \beta = 80\%$ to detect an effect of $\rho = -0.13$ (both conventionally small correlation effects, indicating sufficient power).

4.1.2. Measures

Trait self-control. Participants completed the German version of the trait self-control short-scale (Bertrams & Dickhäuser, 2009; Tangney et al., 2004). The 13 items (e.g., “I am good at resisting temptation”; Cronbach’s $\alpha = .85$) were assessed on a 7-point Likert scale ranging from 1 (*does not apply at all*) to 7 (*applies fully*).

Distractions while studying. To assess distractions while studying, we generated a list of potential sources of distractions. Specifically, the first author and three university students with different academic majors (i.e., psychology, law, cognitive science) independently generated lists of potential sources of distractions while studying. Based on these lists, the first author identified conceptual overlap and inter-individual agreement to generate a comprehensive list of 17 sources of study distractions (Table 1). Following the question “How much do the following things keep you from studying?”, participants rated all

options (e.g., “reading and responding to private messages (e.g., texts, WhatsApp).”, “fatigue and exhaustion.”, “food and drink.”, “lack of enthusiasm for class topic (e.g., feeling unexcited, lack of motivation).”, etc.) on a 7-point Likert scale from 1 (*does not distract me at all*) to 7 (*distracts me a lot*). For the overall correlation with trait self-control, we averaged these items ($\alpha = .72$).

Distracting devices while studying. Additionally, participants rated to what extent different digital devices (i.e., smartphone, laptop, tablet, or television; Table 1) distract them from studying using sliders, ranging from 0 (*never distracts me*) to 100 (*distracts me constantly*).

4.2. Results

Distractions from studying. First, we examined how much each of the 17 different sources of distraction affected our student participants. On average, participants reported the following sources as most distracting: (1) private messages ($M = 5.15$, $SD = 1.44$), (2) fatigue and exhaustion ($M = 4.98$, $SD = 1.49$), (3) lack of enthusiasm for class topic ($M = 4.85$, $SD = 1.62$), and (4) social media ($M = 4.47$, $SD = 1.84$). In line with our predictions, trait self-control was significantly and negatively correlated with all of these sources of distraction: (1) $r = -.24$, $CI_{95}[-.33, -.15]$, (2) $r = -.22$, $CI_{95}[-.31, -.13]$, (3) $r = -.42$, $CI_{95}[-.49, -.34]$, and (4) $r = -.28$, $CI_{95}[-.36, -.19]$ (all $ps < .001$), showing that lower trait self-control was associated with more pronounced distractions. According to common effect size conventions (Cohen, 1988) these correlations can be interpreted as small (item 1, 2, and 4) and medium effects (item 3). For prevalence, descriptive statistics, and correlations with trait self-control of all items, see Table 1. Trait self-control was significantly related to participants’ averaged study distraction scores ($r = -.47$, $CI_{95}[-.54, -.39]$, $p < .001$).

Distracting devices while studying. The smartphone ($M = 69.79$, $SD = 24.81$) was the device that distracted participants the most, and significantly more so than laptops ($M = 56.14$, $SD = 26.45$), $t(445) = 9.03$, $p < .001$, TVs ($M = 35.62$, $SD = 30.88$), $t(445) = 19.72$, $p < .001$.

.001, and tablets ($M = 13.84$, $SD = 23.72$), $t(445) = 33.27$, $p < .001$. When correcting for inflated type-I errors due to multiple testing (following the conservative Bonferroni correction method; Streiner & Norman, 2011), these differences remained statistically significant (with $\alpha_{\text{adjusted}} = \alpha / \text{number of tests} = 0.0125$). Trait self-control correlated significantly with the degree to which students reported to be distracted by their smartphone ($r = -.27$, $CI_{95}[-.35, -.18]$, $p < .001$).

Table 1

Study 1: Descriptive statistics and correlations with trait self-control.

“How much do the following things keep you from studying?” ^a	<i>M</i>	<i>SD</i>	<i>r</i>	<i>CI</i> ₉₅
1. Reading and responding to private messages (e.g., texts, WhatsApp)	5.15	1.44	-.24**	[-.33, -.15]
2. Fatigue and exhaustion	4.98	1.49	-.22**	[-.31, -.13]
3. Lack of enthusiasm for class topic (e.g., feeling unexcited, lack of motivation)	4.85	1.62	-.42**	[-.49, -.34]
4. Social media (e.g., Instagram, Facebook, Twitter)	4.47	1.84	-.28**	[-.36, -.19]
5. Food and drink	4.43	1.56	-.15**	[-.24, -.06]
6. Appointments (e.g., going out for coffee, dates, relaxing on the couch)	4.29	1.53	-.28**	[-.36, -.19]
7. Movies or TV shows (e.g., streaming, Netflix, AmazonPrime)	4.02	1.99	-.29**	[-.37, -.20]
8. Chores (e.g., cleaning, household, laundry, shopping)	3.90	1.55	-.10*	[-.19, -.01]
9. Reading and responding to Emails	3.67	1.61	.00	[-.09, .09]
10. Organizational matters (e.g., rent, insurance, exam registration)	3.43	1.58	-.06	[-.15, .03]
11. Online entertainment (e.g., browsing, 9GAG, ESPN, sports pages)	3.33	1.96	-.38**	[-.46, -.30]
12. Anxiety or concerns (e.g., about failing)	3.33	1.93	-.34**	[-.42, -.26]
13. News (e.g., CNN, NY Times)	2.78	1.57	-.10*	[-.19, -.01]
14. Making calls	2.39	1.42	-.09	[-.18, 0.00]
15. Television (e.g., Fox, CNN, ESPN, HGTV)	2.37	1.71	-.04	[-.13, .05]
16. Online shopping (e.g., Amazon, eBay, Craigslist)	2.32	1.48	-.13**	[-.22, -.04]
17. Gaming (e.g., computer games, consoles)	1.88	1.57	-.19**	[-.28, -.10]
<i>Average of all items</i>	<i>3.62</i>	<i>0.70</i>	-.47**	[-.54, -.39]
“Which devices most often keep you from studying?” ^b	<i>M</i>	<i>SD</i>	<i>r</i>	<i>CI</i> ₉₅
1. Smartphone	69.79	24.81	-.27**	[-.35, -.18]
2. Laptop	56.14	26.45	-.27**	[-.35, -.18]
3. TV	35.62	30.88	-.23**	[-.32, -.14]
4. Tablet	13.84	23.72	-.11*	[-.20, -.02]

Notes. $N = 446$. Items are ordered in descending order of the mean; ^a from 1 = *does not distract me at all* to 7 = *distracts me a lot*; ^b from 0 = *never distracts me* to 100 = *distracts me constantly*; M = mean; SD = standard deviation; r = correlation with trait self-control; CI_{95} = corresponding 95% confidence intervals; Items with absolute correlations of $r > .25$ are formatted in bold. * $p < .05$; ** $p < .01$

4.3. Discussion of Study 1

Study 1 supports our prediction that lower trait self-control is linked to higher levels of self-reported distraction (via the smartphone) while studying. Compared to other digital devices the smartphone is perceived as most distracting. The study further shows that private messages (item 1) as well as social media use (item 4) belong to the most prevalent distractions while studying as identified by students. Both sources of distraction showed significant correlations with trait self-control. Building on Study 1, we next examined which aspects of their smartphone-use are perceived to be most problematic by students and how these aspects might also be linked to self-control.

5. Study 2

Study 2 sought to examine (1) which aspects of using their smartphones students perceive as more versus less problematic, and (2) whether (and to what extent) students' trait self-control is associated with these aspects of problematic smartphone-use.

5.1. Methods

5.1.1. Participants and procedure

Participants were 431 students (70.5% woman; 0.7% diverse; $M_{\text{age}} = 22.20$, $SD = 3.82$) from Germany ($N = 308$), Switzerland ($N = 89$), and Austria ($N = 34$). The procedure (recruitment, instructions, and compensation) was similar to Study 1. Ten participants had to be excluded as their academic degree indicated that they are no students anymore, resulting in a final sample of 421 students. Sensitivity analyses in G*Power (Faul et al., 2007) for a bivariate correlation with $\alpha = .05$ show that the total sample of 421 participants had a 90% chance to detect an effect size of $\rho = -0.16$ and a power of $1 - \beta = 80\%$ to detect an effect of at least $\rho = -0.14$ (both conventionally small correlation effects, indicating sufficient power).

5.1.2. Measures

Trait self-control. Participants again completed the same German trait self-control scale as used in Study 1 (Bertrams & Dickhäuser, 2009; $\alpha = .83$).

Problematic smartphone-use. To capture participants' self-reported 'problematic' smartphone-use, we engaged in an exploratory, literature-based approach. In contrast to existing scales, the focus of this questionnaire was on the subjective perception of problematic aspects of smartphone-use. Again, the first author and three university students with different academic majors (i.e., psychology, law, cognitive science) independently generated lists of potential problematic aspects of smartphone-use. Based on these lists, the first author again identified conceptual overlap and inter-individual agreement to generate a comprehensive list of 20 problematic aspects of smartphone use (Table 2; e.g., "I feel stressed because I can be reached all the time", "I use my smartphone to actively keep myself from more pressing things", "My performance [in school, college, or at work] has declined as a result of the time I spend on my smartphone"). Following the question "What do you think is a negative side effect of using your smartphone?", participants rated all options on a 7-point Likert scale ranging from 1 (*does not apply at all*) to 7 (*applies fully*). For an overall correlation with trait self-control, we averaged these items ($\alpha = .86$).

5.2. Results

Problematic smartphone-use. Participants reported the following aspects as most problematic in their smartphone-use: (1) "I am increasingly dependent on my smartphone to gather information on the internet (e.g., bus or train schedule)" ($M = 5.66$, $SD = 1.35$), (2) "I waste an unnecessary amount of time on my smartphone" ($M = 5.12$, $SD = 1.59$), (3) "I am uncomfortable with doing nothing and often reach for my smartphone when resting" ($M = 4.78$, $SD = 1.71$), and (4) "I use my smartphone to actively keep myself from more pressing things" ($M = 4.50$, $SD = 1.65$). In line with our predictions, participants trait self-control was negatively and significantly correlated with these items: (1) $r = -.11$, $CI_{95}[-.20, -.02]$, (2) $r = -.35$, $CI_{95}[-.43, -.26]$, (3) $r = -.22$, $CI_{95}[-.31, -.13]$, and (4) $r = -.38$, $CI_{95}[-.46, -.30]$ (all $ps < .031$). According to common effect size conventions (Cohen, 1988), these correlations can be interpreted as small (item 1 and 3) and medium effects (item 2 and 4). Prevalence, descriptive

statistics, and correlations with trait self-control are listed in Table 2. In line with our expectations, trait self-control was significantly related to participants' averaged scores of problematic smartphone-use ($r = -.41$, $CI_{95}[-.49, -.33]$, $p < .001$).

Table 2

Study 2: Descriptive statistics and correlations with trait self-control of all items.

"What do you think is a negative side effect of using your smartphone?" ^a	<i>M</i>	<i>SD</i>	<i>r</i>	<i>CI</i> ₉₅
1. I am increasingly dependent on my smartphone to gather information on the internet (e.g. bus or train schedules).	5.66	1.35	-.11*	[-.20, -.02]
2. I waste an unnecessary amount of time on my smartphone.	5.12	1.59	-.35**	[-.43, -.26]
3. I am uncomfortable with doing nothing and often reach for my smartphone when resting.	4.78	1.71	-.22**	[-.31, -.13]
4. I use my smartphone to actively keep myself from more pressing things.	4.50	1.65	-.38**	[-.46, -.30]
5. In the evening, I often spend time on my smartphone and end up falling asleep late.	4.44	1.89	-.24**	[-.33, -.15]
6. I feel the need to constantly check for news, to be up to speed.	4.14	1.68	-.21**	[-.30, -.12]
7. I feel stressed because I can be reached all the time.	3.98	1.90	-.09	[-.18, .01]
8. When I'm on my smartphone, sometimes moments pass by without me actually noticing.	3.86	1.60	-.17**	[-.26, -.08]
9. I am often interrupted in my current activity and have to start over again (e.g. because my smartphone vibrates when a message arrives).	3.82	1.67	-.23**	[-.32, -.14]
10. I feel under pressure because I think people expect me to answer messages immediately.	3.69	1.92	-.16**	[-.25, -.07]
11. I am jittery and can't concentrate on one thing for long.	3.55	1.69	-.46**	[-.53, -.38]
12. I compare myself to (at times strongly) idealized presentations on the internet (e.g. vacation blogs, beauty, nutrition).	3.44	1.93	-.12*	[-.21, -.03]
13. When I'm picking up my smartphone, e.g. to enter an appointment, I get distracted by pop-up notifications and forget my initial objective.	3.36	1.86	-.15**	[-.24, -.06]
14. My attention and my field of view are restricted when I'm using my smartphone, so that I'm presenting a risk for accidents in traffic.	3.35	1.86	-.18**	[-.27, -.09]
15. My performance (in school, college, or at work) has declined as a result of the time I spend on the smartphone.	3.14	1.67	-.38**	[-.46, -.30]
16. Because of my smartphone-use I am bothered by fatigue, headaches and poor posture.	2.81	1.60	-.27**	[-.36, -.18]
17. I catch myself checking for news or messages on my smartphone while I'm in traffic (e.g. in the car or on the bike).	2.80	1.91	-.16**	[-.25, -.07]
18. My „real-life“ social interactions suffer because I'm often busy on my smartphone and then, e.g. I don't listen carefully.	2.47	1.36	-.14**	[-.23, -.05]
19. I criticize others faster because I don't have to look into their faces while doing so.	2.05	1.35	-.21**	[-.30, -.12]
20. I get angry looks because my smartphone rings or vibrates at inappropriate moments (e.g. in a lecture, in the cinema).	1.62	1.11	-.08	[-.17, .02]
Average of all items	3.63	0.87	-.41**	[-.49, -.33]

Notes. *N* = 421. Items are ordered in descending order of the mean; ^a from 1 = *does not apply at all* to 7 = *applies fully*; *M* = mean; *SD* = standard deviation; *r* = correlation with trait self-control; *CI*₉₅ = corresponding 95% confidence intervals; Items with absolute correlations of $r > .25$ are formatted in bold. * $p < .05$; ** $p < .01$

5.3. Discussion of Study 2

Study 2 supports our prediction that lower trait self-control is associated with a higher proclivity to report problematic aspects of smartphone-use. Specifically, items reflecting the amount of smartphone-use (item 2), as well as smartphone procrastination (item 4) belong to the most problematic aspects of smartphone-use as identified by students, and both aspects are significantly and moderately correlated with trait self-control. Study 3 seeks to replicate the link of trait self-control and smartphone-use and to extend this link to students' academic performance.

6. Study 3

The correlational studies 1 and 2 established the predicted link of trait self-control and (a) students' study distractions (via smartphone), as well as (b) several aspects of problematic smartphone-use. Specifically, students' frequently reported smartphone procrastination and the amount of smartphone-use as problematic aspects, both of which were also related to students' trait self-control. In a next step, we sought to build on these findings from Study 1 and Study 2 and examined the consequences of self-control and smartphone-use on students' academic performance. Therefore, Study 3 seeks to replicate these correlational findings and to further investigate whether (and how) smartphone-use can explain the association between trait self-control and academic performance. Specifically, we examined different aspects of smartphone-use that should foster (i.e., beneficial habits) versus hinder (i.e., objective amount of smartphone-use and procrastination) academic performance.

6.1. Methods

6.1.1. Participants and procedure

Participants were 106 students of the University of {Institution} (70.8% woman; $M_{\text{age}} = 21.51$, $SD = 2.65$) which were recruited through the local online research participation

system at {Institution}¹. Participants first received an online questionnaire at the beginning of the semester's preparation period (mid-January). In this questionnaire, they were instructed to install a monitoring-app on their smartphone (i.e., 'RealizD' or 'Moment'). One participant used an older generation of smartphones and was not able to install a monitoring-app. Hence, smartphone-use data are missing for this participant. Three weeks after the installation of the monitoring-app, we arranged appointments with each participant to read out the smartphone-use data from their monitoring-apps. At the end of the semester (early April), participants received a second online questionnaire and were granted course credit (6.25 hours) or money (20€). Upon participants' consent, we received their official academic records from the university's central examination office. For a schematic representation of study procedure and the temporal order of data assessment, please see Figure 1.² We only included participants who took part in each phase of the study and for whom all data were available—both questionnaires and consent to receive students' academic records.

Figure 1. Schematic representation of study procedure and data assessment in Study 3. CW = calendar week. The exam period spans from calendar weeks 7–13.

¹ Participants were recruited to participate in an intervention study aimed at promoting self-control of their smartphone-use while studying (4-hour face-to-face training; results of this pre-registered intervention study are available on the Open Science Framework [\[URL\]](#) blinded for peer-review]). Participants were randomly assigned to an intervention group and a waiting control group. Please note that the intervention did not show any systematic effects on smartphone-use, nor on academic performance. For the present research question, we focus on the link of trait self-control and smartphone-use on academic performance.

² At the University of {Institution}, there are three different forms of examination—written exams, term papers, and so-called ‘combined scientific projects’. The most prevalent form of examination are written exams and term papers, both of which are completed or handed in during the exam period that immediately followed the smartphone-app monitoring phase (see Figure 1). These two forms of examination make up 93% of all exams. The combined scientific project consists of a test (also written at the end of the semester) and a presentation during the semester. Given the academic importance of the study weeks preceding the exam period, we measured the objective amount of smartphone-use in this preceding period via monitoring-app (calendar weeks 3–6). The second questionnaire measures self-reported mediators also directly referring to this period (“Please think of an ordinary day of studying for your exams”).

Sensitivity analyses in G*Power (Faul et al., 2007) for a multiple regression with 5 predictors with $\alpha = .05$ show that the total sample of 106 participants has a 90% chance to detect an effect size of $f^2 = 0.16$ and a power of $1-\beta = 80\%$ to detect an effect of at least $f^2 = 0.13$. For a mediation analysis with medium path sizes ($\beta = 0.39$; see Richardson et al., 2012; Steel, 2007) and a bias-corrected bootstrap procedure striving for a power of $1-\beta = 80\%$ we needed at least 71 participants (Fritz & MacKinnon, 2007). Thus, the final sample of $N = 106$ should be sufficient to investigate the proposed mediating effects.

6.1.2 Measures

Trait self-control. In a first questionnaire at the beginning of the preparation period (i.e., pre-exams, calendar week [CW] 3, Figure 1), participants completed the same German trait self-control scale as used in Study 1 and 2 (Bertrams & Dickhäuser, 2009; $\alpha = .88$).

Mediator 1: Procrastination. In a second questionnaire (Figure 1; CW 14), we assessed all relevant, self-reported mediators. Participants were instructed to “please think of an ordinary day of studying for your exams”. Participants’ proclivity to procrastinate with their smartphone was assessed with the Procrastination Scale (Tuckman, 1991), which has been used successfully in previous media research (Meier et al., 2016; Reinecke et al., 2014). Items were translated to German and adapted to measure smartphone-use as procrastinating behavior. Specifically, participants rated four items (“I used my smartphone although I had more important things to do”, “I used my smartphone while procrastinating upcoming work”, “I used my smartphone although I knew that I had an important task to complete.”, “I used my smartphone although I had planned to get something done.”; $\alpha = .95$) on a 7-point Likert scale from 1 (*does not apply at all*) to 7 (*applies fully*).

Mediator 2: Placement habits. We assessed participants’ placement habits of their smartphone during ‘an ordinary day of studying’ with five items (While studying I placed my smartphone: “...on the table with the screen upwards.”; “...on the table with the screen downwards.”; “...in my pants/pocket”; “...in my bag/backpack.”; “...in another room.”) on a

5-point Likert scale ranging from 1 (*almost never*) to 5 (*always*). The first three items were recoded given that they do not effectively reduce smartphone distractions (Johannes et al., 2019; Thornton et al., 2014; Ward et al., 2017). We averaged all five items into one scale ($\alpha = .52^3$), so that higher scores reflected more beneficial placement habits that prevent students from being distracted by their smartphones.

Mediator 3: Setting habits. Following the same instruction as above, we assessed smartphone setting habits with four items (While studying I: "...turned off the sound of my smartphone."; "...turned off the vibration of my smartphone."; "...put my smartphone on flight / do-not-disturb mode"; "...switched off my smartphone.") on a 5-point Likert scale from 1 (*almost never*) to 5 (*always*). We averaged the four items into a single scale ($\alpha = .50^4$), so that higher scores again reflected more beneficial placement habits that prevent participants from being distracted by their smartphones.

Mediators 4 and 5: Objective amount of smartphone-use. Participants installed a monitoring-app on their smartphones ('RealizD' for Android [$N = 48$], or 'Moment – Screen time Tracker' for iOS [$N = 57$]). For a total of 24 days, the app objectively tracked the amount of time students spent on their smartphone (screentime) and the number of times they picked up (and unlocked) their smartphone (pickups per day). The monitoring app was installed after completing the first questionnaire and data was read out four weeks later. For each participant, we calculated the average amount of screentime per day (in minutes; $\alpha = .95$) and the number of pickups per day ($\alpha = .97$). On average, participants spent 117.82 minutes ($SD =$

³ We conducted an exploratory factor analysis using the principle component extraction method to examine the structure of this self-developed scale. The Scree plot indicated a one-factor solution (eigenvalue of the first factor = 1.75), with uniform factor loadings ranging from .422 to .689. To account for different amounts of information that each item contributes to the overall scale, we additionally created an optimally-weighted scale by extracting factor scores (Coefficient H [Hancock & Mueller, 2001; maximal reliability] = .60). Using the optimally-weighted factor score led to the same pattern of mediation results as reported in the text.

⁴ Again, we conducted an exploratory factor analysis using the principle component extraction method to examine the structure of this self-developed scale. The Scree plot indicated a one-factor solution (eigenvalue of the first factor = 1.71), with uniform factor loadings ranging from .395 to .793. Creating an optimally-weighted scale by extracting factor scores (Coefficient $H = .71$), led to the same pattern of mediation results as reported in the text.

56.58) on their smartphones and picked it up 60.61 times ($SD = 30.06$) per day. For the amount of smartphone-use, we decided prior to data collection to exclude outliers exceeding > 2.5 SDs of the sample mean and daily smartphone-use outlier scores that exceeded > 2.5 SDs for a respective individual.

Academic performance. As the main dependent variable, we attained participants' objective academic performance, their grade point average (GPA), from the university's central examination office three months after the end of the baseline monitoring period. For better interpretation, we reversed the German grading scale (1 = *excellent* to 6 = *insufficient*) so that higher scores reflected better academic performance (1 = *insufficient* to 6 = *excellent*).

Control variable: study time. Again referring to an ordinary day of studying, participants' were asked to indicate the time they had spent on three different study activities (studying alone, studying in a group, writing term papers) on a 11-point scale (1 = [*almost never*]; 2 = *up to 15 minutes*, 3 = *up to one hour*, 4 = *1-2h*, 5 = *2-3h*, 6 = *3-4h*, 7 = *4-5h*, 8 = *5-6h*, 9 = *6-7h*, 10 = *7-8h*, 11 = *more than 8 hours*). Data were recoded into an index of minutes and summed up to an overall index of study time.

6.2. Results

Trait self-control and academic performance. In line with our predictions and supporting previous research (e.g., Duckworth & Seligman, 2005), a single linear regression showed that participants' trait self-control significantly predicted their academic performance (GPA; $\beta = 0.22$, $CI_{95}[0.03, 0.41]$, $p = .025$).

Smartphone-use and academic performance. In a multiple regression analysis, we contrasted the *how much* and the *how* of participants' smartphone-use and their respective impact on students' academic performance. Specifically, we examined whether and to what extent smartphone procrastination, placement habits, and setting habits, as well as absolute screentime and pickups explained students' academic performance. The multiple regression analysis with a simultaneous entry of all predictors (Table 3; Model 1) shows that participants

with increasingly higher procrastination scores showed increasingly worse academic performance ($\beta = -0.23$, $CI_{95}[-0.43, -0.03]$, $p = .028$), whereas participants with more beneficial smartphone placement habits performed significantly better academically ($\beta = 0.21$, $CI_{95}[0.01, 0.41]$, $p = .041$). Smartphone setting habits, absolute screentime, and number of pickups did not show significant effects on academic performance (beyond the impact of procrastination and placement habits). Model 1 explained 13.5% of variance in academic performance which can be interpreted as a small-to-moderate effect (Ferguson, 2009).

As a robustness check, we conducted the same multiple regression analyses while additionally controlling for students' self-reported study time (as a sixth predictor; Table 3, Model 2). Again, smartphone procrastination was positively associated with academic performance ($\beta = -0.22$, $CI_{95}[-0.43, -0.02]$, $p = .031$), and placement habits were marginally significant ($\beta = 0.20$, $CI_{95}[-0.01, 0.40]$, $p = .055$). Self-reported study time did not show a significant association with academic performance. Model 2 explained only slightly more variance ($\Delta R^2 = 0.5\%$) than Model 1 (14.0%; small-to-moderate effect; Ferguson, 2009).

Table 3

Study 3: Multiple regression analyses of smartphone-use measures on academic performance.

	Model 1				Model 2			
	β	CI_{95}	t	p	β	CI_{95}	t	p
Procrastination	-0.23*	[-0.43, -0.03]	-2.23	.028	-0.22*	[-0.43, -0.02]	-2.19	.031
Placement habits	0.21*	[0.01, 0.41]	2.07	.041	0.20 [†]	[-0.01, 0.40]	1.94	.055
Setting habits	-0.03	[-0.23, 0.17]	-0.28	.782	-0.03	[-0.23, 0.17]	-0.27	.790
Screentime (min)	-0.03	[-0.25, 0.20]	-0.22	.827	-0.04	[-0.27, 0.19]	-0.31	.757
Pickups (counts)	0.19	[-0.02, 0.41]	1.78	.078	0.18	[-0.04, 0.40]	1.62	.108
Study time					0.07	[-0.12, 0.27]	0.76	.452
R^2	0.135				0.140			

Notes. $N = 104$; standardized regression coefficients. In Model 1, we simultaneously entered all smartphone measures to predict students' academic performance in a multiple regression. In Model 2, we controlled for students' self-reported study time to validate the robustness of Model 1. * $p < .05$, [†] $p < .06$

Mediation analysis. In a subsequent multiple mediation analysis, we sought to illuminate whether students' smartphone-use that already predicted their academic performance in the multiple regression—i.e., procrastination and placement habits—could also explain the link of trait self-control on academic performance. We ran bootstrapping procedures with 5,000 iterations (Process macro; Hayes, 2013; Model 4) with trait self-control as the independent variable, academic performance as the dependent variable, and procrastination and placement habits as competing mediators (Figure 2). Results revealed that the total indirect effect was significant ($\beta = 0.12$; BC CI₉₅[0.02, 0.22]) and accounted for the majority (53.22%) of the total effect. Comparing the relative impact of the two mediators showed that smartphone procrastination ($\beta = 0.09$, BC CI₉₅[-0.01, 0.18]) accounted for a higher share of the total effect with 39.36% compared to placement habits ($\beta = 0.03$, BC CI₉₅[-0.01, 0.08]) with 13.81%. The contrast for this descriptive difference of indirect effects, however, was not significant (BC CI₉₅[-0.06, 0.16]). Finally, when accounting for both mediators, the direct effect of trait self-control on academic performance was no longer significant ($b = 0.10$, CI₉₅[-0.11, 0.31], $p = .342$).

Figure 2. Multiple mediation model: The model shows that the effect of trait self-control on academic performance is mediated by procrastination and placement habits. Path coefficients are weights for the a- and b-paths.⁵

6.3. Discussion of Study 3

⁵ Please note that when including all five smartphone measures as competing mediators in this mediation model, we found a similar pattern in that smartphone procrastination and placement habits were the most influential mediators. For reasons of simplicity and higher test power, we only included the smartphone measures that predicted academic performance in the multiple regression analysis in this mediation model. Further, we found the same significant indirect effect as reported here, when we additionally entered (a) students' study time or (b) the condition (intervention vs. waiting control group) as covariate in this model. Neither study time ($p = .371$) nor condition ($p = .717$) significantly affected academic performance.

Study 3 provides empirical support for the expected impact of students' trait self-control on their academic performance. Further, we investigated whether (and how) smartphone-use can illuminate this effect. Among different aspects that might foster (i.e., beneficial habits) versus hinder (i.e., procrastination and objective amount of use) students' academic performance, smartphone procrastination explained most of the total effect from self-control on academic performance. Students higher in trait self-control used their smartphone less often to procrastinate, which—in turn—led to better academic performance. In addition, beneficial placement habits also accounted for a considerable share of the self-control-academic performance link. Students higher in trait self-control more frequently placed their smartphone out of reach while studying, which facilitated their academic performance. Interestingly, the objective amount of smartphone-use (i.e., screentime and pickups) showed only negligible effects (as did beneficial setting habits). In sum, the indirect effects provide support for our prediction that smartphone-use can explain the association between trait self-control and academic performance. Even when taking students' study time into account (see Footnote 5), smartphone procrastination and placement habits remained influential mediators. Interestingly, the *how* of smartphone-use, at least in the present data, was more influential than the *how much* of smartphone-use (and studying).

7. General Discussion

Previous research suggests that the smartphone provides students with manifold ways to distract themselves from studying. Yet, it is largely unknown how students with high versus low trait self-control deal with these self-regulatory challenges that smartphones present. In two high-powered, correlational studies, we showed that trait self-control is indeed linked to (a) students' distraction (via their smartphones) during learning endeavors and (b) different problematic aspects of smartphone-use. The aims of the third study were twofold: first, to replicate this link of self-control and smartphone use and, second, to expand the previous studies by investigating the consequences of trait self-control and smartphone-use on

students' academic performance. The findings show that students with higher self-control used their smartphone less frequently to procrastinate; in turn, this led to better academic performance. Further, they more often regulated their smartphone-use with beneficial placement habits (placing their phones in a bag rather than on the table while studying), which was also associated with better academic performance. In contrast, neither the objective amount of smartphone-use (i.e., screentime, pickups), nor setting habits showed a significant association with academic performance.

Previous studies investigating the relationship of smartphone-use and academic performance found that the self-reported amount of smartphone-use was negatively correlated with students' GPA (e.g., Baert et al., 2020; Lepp et al., 2015). The present study does not replicate this direct link from daily smartphone-use on academic performance when measuring total amount of smartphone-use objectively via a monitoring-app. In contrast, the potentially more valid indicator of objectively-tracked smartphone-use (Ellis, 2019) suggests that it is less a matter of *how much* but rather a matter of *how* students are using their smartphones during a learning period.

The present approach of objectively measuring the absolute amount of smartphone-use via monitoring-apps complements previous findings. Nonetheless, we wish to highlight two reasons why counting minutes (screentime) and number of pickups may not sufficiently describe (and fully capture) students' smartphone behavior. First, *what* students use their smartphones for likely matters immensely. Smartphones can facilitate productivity in that they enable information seeking anytime and anywhere. Measuring the overall quantity of daily smartphone-use—whether subjectively or objectively—does not reflect the quality of this smartphone-use. Interestingly, individuals who report to use their smartphones for information-seeking have higher levels of trait self-control than individuals who use it for entertainment (Servidio, 2019). Future studies could use monitoring-apps that distinguish between learning versus leisure activity (e.g., apps for entertainment versus information-

seeking) to account for this qualitative difference. Second, based on the definition of self-control (Carver, 2019; Tangney et al., 2004), one could argue that there is only a need to regulate smartphone-use when it actually conflicts with long-term goals. After several hours of studying effectively during the day, using the smartphone for leisure activities in the evening should no longer conflict with study obligations. Simply quantifying daily smartphone-use, however, does not account for whether (or not) students' smartphone-use actually conflicted with learning endeavors. By disentangling the objective amount of smartphone-use and ways of regulating one's smartphone-use, the present research establishes first evidence that especially the irrational delay via the smartphone—the qualitative *how* of smartphone-use—rather than the *how much* can account for effects on academic performance and explain why students higher in self-control fare better academically. A very recent discussion on the conceptualization of problematic smartphone use indeed states that, “it is currently unclear whether ‘problematic use’ ought to be defined by use quantity, patterns of use, or by the negative consequences of the use” (Harris et al., 2020, p. 2). Contributing to this discussion (see also Davidson et al., 2020), the present studies suggest that the pattern of use (e.g., smartphone procrastination) is relatively more influential than the quantity—at least when it comes to academic outcomes. In a similar vein, research has shown that the objective amount of smartphone-use is not robustly associated with individuals' well-being (Johannes et al., 2020; Orben & Przybylski, 2019).

Additionally, beneficial habits regarding the smartphone placement also explained why higher trait self-control was linked to better academic performance, while beneficial setting habits did not play a significant role. According to the self-control literature, beneficial habits are particularly effective as they prevent an intrapsychic conflict before it even occurs (Duckworth et al., 2016). By placing the smartphone out of reach and sight, students may have been less likely to experience a conflict between their long-term goal of academic success and the immediate reward of smartphone-use. This may have also undermined the

phenomenon that the mere visibility of a smartphone and incoming notifications increase distraction (Johannes et al., 2019; Thornton et al., 2014; Ward et al., 2017). In contrast, setting habits were not as beneficial as anticipated. Future research may examine a counterintuitive notion—that is, whether turning off the sound might potentially lead to an *increase* of smartphone-use as a student might be especially tempted to check for incoming messages (given that no more signals arrive and important messages might be missed).

We wish to transparently highlight a relevant limitation, in that the present design does not allow us to determine statistically whether significant mediators reflect a true cause within a theoretical explanation (Fiedler et al., 2011). Hence, we urge caution to draw strong causal inferences about the relations between self-control, smartphone measures, and academic performance (without experimental mediation evidence; Fiedler et al., 2011; Spencer et al., 2005). Nonetheless, our self-regulatory perspective on smartphone-use offers avenues for future research. Researchers could further examine whether individuals can rely on established self-control strategies—such as specific goal-setting (Latham & Locke, 1991, 2007) or implementation intentions (Gollwitzer, 1999)—to prevent procrastination via the smartphone and to foster beneficial smartphone habits. For instance, by conducting intervention studies with random assignment (Fiedler et al., 2011) aiming at an improvement of individuals self-control via such strategies, future research could provide more insights on the causality of the link between self-control, smartphone-use, and academic performance.

Future research could also put more emphasis on the processes that occur during self-control challenges in a learning period. In the present research, we relied on retrospective self-report measures at the end of the learning period. A novel, complementary approach could be an experience sampling or diary study to attain daily data on conflicts between smartphone-use and long-term goals. Here, it would be interesting to also investigate psychological and situational antecedents of smartphone-use while studying. Procrastinated tasks are often perceived as more strenuous, stressful, or boring (Pychyl et al., 2000), and the smartphone

might often function as a more pleasant alternative that is close at hand. For now, however, we do not yet know whether it is the rewarding aspect of smartphone-use (through social networking, communication, news or games; e.g., Oulasvirta et al., 2012) or rather the escape from a boring, demanding, or potentially stressful task (e.g., Dora et al., 2020; Steel, 2007) that leads individuals with lower trait self-control to their smartphones and away from their long-term goals. Future research should systematically assess the characteristics of both intended and alternative activities to better understand the motivational processes underlying procrastinating behavior.

8. Conclusion

The present research illuminates our understanding of the behavioral means by which university students' deal with self-regulatory challenges presented by their smartphones. The results from three studies extend previous research by showing that the link of trait self-control and academic performance can be explained by *how* students use their smartphones. Specifically, our results suggest that not the objective amount of smartphone-use but the way how students regulate their smartphone-use (avoiding procrastination and fostering beneficial habits) is associated with their academic performance. The present work seeks to offer stimulating insights and impulses for future research that aims to address the ubiquitous conflict of smartphones and long-term goals in people's everyday lives.

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