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The Chain-Mediating Role of Perceived Stress and Problematic Smartphone Use in the Link Between Critical Thinking and Academic Engagement Among Spanish Adolescents

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Abstract

Because problematic smartphone use (PSU) is rising among adolescents, it is vital to analyze the potential causes and psychosocial consequences affecting this target population. Current theoretical frameworks suggest that specific personal core characteristics might predispose individuals to experience increases in this problematic behavior over time. Additionally, PSU has been conceptualized as a maladaptive coping mechanism to manage negative emotions. The present study aimed at analyzing a personal resource, critical thinking disposition, and a potential negative consequence, reduced academic engagement, and the underlying role of perceived stress and PSU in this association among Spanish adolescents. The sample consisted of 688 adolescents (54% females, 46% males) aged 12 to 18 years from Southern Spain. Participants completed self-report questionnaires to assess critical thinking disposition (VIA-Youth), perceived stress (Perceived Stress Scale), PSU (Smartphone Addiction Scale-Short Version), and academic engagement (Utrecht Work Engagement Scale-Students). We analyzed a serial mediation model using PROCESS (SPSS), in which critical thinking disposition was the independent variable, perceived stress and PSU were the first and second mediators, respectively, and academic engagement was the outcome variable. Our results indicated that lower critical thinking disposition was linked to increased perceived stress, which was associated with higher PSU, resulting in decreased academic engagement. These findings provide empirical support for the pathways model of PSU, the maladaptive coping theories, and the I-PACE model of behavioral addictions. Furthermore, we discuss our results highlighting the important implication of training adolescents to think critically regarding their smartphone usage to reduce their stress levels, to avoid using smartphones as a coping strategy, and hence, to improve their student's attitudes toward school.

Keywords: critical thinking; stress; problematic smartphone use; academic engagement; adolescents; serial mediation

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Introduction

By 2020 there was an estimated global smartphone penetration rate of 78%, which had increased by more than 30% even in the previous five years (Statista, 2021a). Smartphone users are growing in numbers each year, and

reports show that in 2021 there were more than 6.3 billion users (Statista, 2021b). The rapid growth indicates that smartphones are an intrinsic part of everyday lives; thus, it is important to understand the impact this device has on individuals' well-being. Because some of this influence might be detrimental, research efforts about the negative consequences of smartphone usage are increasing (Busch & McCarthy, 2021).

Currently, there is no consensus about the most accepted scientific nomenclature to refer to this phenomenon, as some scholars prefer to use the terms "smartphone addiction" (Lin et al., 2016), "smartphone use disorder" (Montag et al., 2019), or "problematic smartphone use" (Panova & Carbonell, 2018). Problematic smartphone-related behaviors have not yet been included as a mental disorder neither in the ICD-11 (World Health Organization, 2019), or the DSM-5 (American Psychiatric Association, 2013). However, gambling disorder and gaming disorder are Internet-related behavioral addictions that are associated with problematic smartphone use (Derevensky et al., 2019; Elhai et al., 2021), and that have already been acknowledged as mental health disorders or are under consideration for inclusion (American Psychiatric Association, 2013; World Health Organization, 2019). Therefore, several scholars argue that problematic smartphone-related behaviors also merit further research to determine whether or not to consider them as a disorder (for discussions on the matter see Montag et al., 2019). Thus, in this study we opted to use the term problematic smartphone use (PSU) avoiding pathologizing individuals on the basis of their common or productive behavior, but still recognizing that some negative consequences might derive from excessive smartphone use (Elhai et al., 2019; Kardefelt-Winther et al., 2017). Despite the preferred terminology, most researchers consider that PSU refers to an excessively frequent use of the smartphone, leading to the functional impairment of the academic, occupational, or social domains (Billieux et al., 2015).

PSU is associated with lower subjective well-being and negative health outcomes (Busch & McCarthy, 2021; Horwood & Anglim, 2019; Sohn et al., 2019). Moreover, PSU has been documented as a public health concern (Van Velthoven et al., 2018; World Health Organization, 2015). One of the reasons might lie in the distinction between generalized and specific Internet-related problems proposed in the cognitive-behavioral model of pathological Internet use (Davis, 2001). The model assumes that individuals with problematic usage of digital technology might have a multidimensional overuse of the Internet (i.e., a generalized pattern) or be dependent on a specific function (i.e., a specific pattern). Because this classification was proposed before smartphones were ubiquitous, recent studies have suggested that PSU could be considered a problematic Internet-related behavior with a generalized pattern (Chen et al., 2020; W. Su et al., 2020). Some researchers suggest that, when investigating behavioral addictions, it is important to specify the content or application being used, because individuals might differ on their usage motives and needs, anticipated rewards, and use expectancies (Brand et al., 2019). This notion has led some scholars to imply that people do not become addicted to smartphones any more than alcoholics become addicted to bottles (Kuss & Griffiths, 2017). However, other researchers argue that specification about the devices should not be discarded altogether because there might be differences in behavioral usage patterns, technological features, or preferred contents or applications (Montag et al., 2019). In addition, network analyses evidence also suggests that specific (e.g., cybersex and gaming addiction) and generalized (e.g., Internet and smartphone addiction) problematic behaviors are independent but interrelated constructs (Baggio et al., 2018). Consequently, research would benefit from some level of detail in the conceptualization of problematic behaviors because the context on which they take place matters for prevention and treatment recommendations (Elhai et al., 2019). In accordance with current DSM and ICD diagnostic criteria for related disorders (i.e., gambling and gaming disorder), it has been proposed that PSU could be synonymous to generalized, unspecified Internet-use disorder, predominantly mobile via a smartphone (Montag et al., 2019), which might be particularly worthy of study because smartphones might be used as a means to enable other behavioral issues, such as problematic social networking, shopping, gambling, or gaming (Kuss & Griffiths, 2017; Montag et al., 2019).

Furthermore, younger generations are the most active adopters of digital technology (Valkenburg & Piotrowski, 2017; World Health Organization, 2015). Accordingly, research suggests that adolescents and youth have an increased vulnerability to PSU (Csibi et al., 2019; Kuss et al., 2018), with most studies showing prevalence rates that range from 10% to 30% (Field, 2020; Sohn et al., 2019). At present, most social interactions with peers occur through social media and smartphones (Crone & Konijn, 2018). Thus, today's youth face traditional developmental tasks in a hybrid reality between offline and (increasingly) online environments (Granic et al., 2020).

Adolescence is considered a period of significant developmental changes, where physical, cognitive, and social-emotional transitions do not often occur synchronously (Valkenburg & Piotrowski, 2017). For instance, adolescents experience an increase in impulsivity and risk-taking behavior (Berman, 2018; Valkenburg & Piotrowski, 2017). Moreover, social relationships play a progressively more important role in adolescents' development and

individuals learn about accepted behaviors from their peer group; thus risk-taking behavior is exacerbated in their presence (Valkenburg & Piotrowski, 2017). Furthermore, neurophysiological developments during this stage are responsible for adolescents' higher levels of experienced and perceived stress (Skinner & Zimmer-Gembeck, 2016). Therefore, youths often find themselves attempting to cope with challenges from numerous stressors, such as home life, academic performance and attendance, romantic relationships, peer pressure, teacher interaction, future uncertainty, school-leisure conflict, financial pressure, and emerging adult responsibilities (Byrne et al., 2007). Finally, more complex cognitive functions such as abstract thought, meta-cognition, and social cognition start to develop in adolescence (Valkenburg & Piotrowski, 2017). Nonetheless, burgeoning emotional states and inexperience affect self-regulation, rational decision-making, and critical thinking (Ellerton, 2019). Consequently, the diversity and magnitude of the transitions that are experienced during adolescence might be part of the explanation for the vulnerability to PSU found in this population.

Theory

The present study aimed to investigate the correlates of PSU by testing a path linking what could be possible causes and consequences, based on different theoretical frameworks. First, an integrative approach to Internet-related disorders is the interaction person-affect-cognition-execution or I-PACE model (Brand et al., 2019). The theory proposes that addictive behaviors are a consequence of the interaction between predisposing personal core characteristics, affective and cognitive responses to triggers, and the decision to engage in specific (i.e., problematic) behaviors. Regarding the present study, the I-PACE model highlights the importance of considering personal characteristics as potential predisposing factors of PSU.

Second, the pathways model of PSU suggests that there are distinct routes to this phenomenon: (a) an excessive reassurance pathway that is associated with a dependent or addictive usage of the smartphone; (b) an impulsive pathway that may lead to addictive, antisocial, and/or dangerous use of the device; and (c) an extraversion pathway that may be associated with a risky usage of smartphones (Billieux et al., 2015; Canale et al., 2021; Pivetta et al., 2019). The pathways model is relevant to the present research as it provides orientation about potential individual differences that might be at the core of PSU. For instance, Canale et al. (2021) suggested that individuals coursing the first pathway (a) are driven to obtain reassurance about social relationships, which relates to a poor attachment style; those whose PSU is better explained by pathway (b) are prompted by the lack of planning and a sense of urgency; and the PSU of people with high sensation-seeking behavior is better described by pathway (c).

Finally, several theoretical approaches serve as a reference to propose PSU as a maladaptive coping mechanism. To illustrate, compensatory Internet use theory (CIUT) suggests that many people might attempt to reduce the negative emotions experienced after a stressful event by overusing the Internet (Kardefelt-Winther, 2014). Furthermore, the components model of behavioral addictions (i.e*.,* the mood-modification component) assumes that individuals might repeat a specific behavior (e.g., engaging in an excessive or problematic manner with the smartphone) to produce a reliable shift in their emotional state as a coping strategy and to feel better (Griffiths, 2019). Built on the general notion that problematic Internet usage might be a coping mechanism for some, Elhai et al. (2019) suggested that, although people might attempt other adaptive or maladaptive ways of coping with stressful events, the availability and portability of smartphones make them the most obvious choice for many to alleviate negative feelings. The proposal of PSU as a coping mechanism is relevant to this research because it highlights that, while dysfunctional, the strategy might be relatively common for some adolescents who do not know how to properly manage stress levels.

Furthermore, one of the core features of problematic behaviors is that they lead to functional impairment and negative consequences (Elhai et al., 2019; Griffiths, 2019). Consistent with this notion, if PSU is thought of as a maladaptive coping strategy, then it should result in adverse emotional, physical, social, or academic outcomes (for a review of some of the consequences of PSU see Busch & McCarthy, 2021). Byrne et al. (2007) found that academic stressors exhibit the greatest frequency during adolescence; thus it is possible to say tentatively that negative educational consequences deriving from PSU might be among the most notorious effects for this population.

The Present Study

Due to the increasing concerns regarding PSU in adolescents and the gaps on research addressing this issue in this population, the present study aimed at investigating a possible predisposing factor and a potential negative consequence of using smartphones to cope with stress.

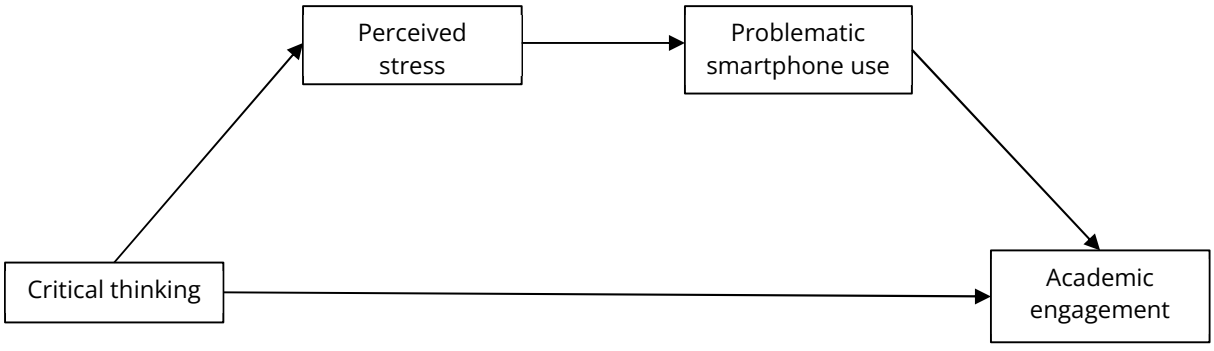
First, because the cognitive changes during adolescence might affect rational decision-making (Ellerton, 2019) and stress levels (Skinner & Zimmer-Gembeck, 2016), in our study we posited that low critical thinking would be associated with elevated levels of perceived stress (**H1**). Critical thinking refers to a purposeful, self-regulatory process of reasonable and reflective thinking that results in decision-making (Ennis, 2018; Facione, 1990). It is a personal resource composed of abilities (e.g., interpretation, analysis, evaluation, inference, explanation, and self-regulation) and dispositions (e.g., open-mindedness, using credible sources of information, changing position in the face of evidence, taking into account the total situation; Ennis, 2018; Facione, 1990). Based on the I-PACE model, critical thinking could be a personal core characteristic that might be a predisposition towards PSU. Meanwhile, perceived stress is defined as the experience of life as unpredictable, uncontrollable, or overloaded (Cohen & Williamson, 1988). Critical thinking might be negatively associated with stress levels, as it may allow individuals to question stress-inducing stimuli (Escolà-Gascón et al., 2021). In addition, previous studies have empirically supported this correlation (Escolà-Gascón et al., 2021; Kim et al., 2015; M. R. Su & Shum, 2019).

Second, the relation between stress and PSU is well-established in the scientific literature (Chiu, 2014; Q.-Q. Liu et al., 2018; Samaha & Hawi, 2016; Wang et al., 2020; H. Yang et al., 2021). Thus, in accordance with the proposal that suggests PSU might be a coping mechanism (Elhai et al., 2019; Griffiths, 2019; Kardefelt-Winther, 2014), we postulated that increased levels of perceived stress are related to greater PSU (**H2**).

Third, one of the main aspects for considering PSU as a problematic or addictive behavior is that it ought to have negative consequences (Elhai et al., 2019; Griffiths, 2019). Therefore, since the academic context is among the most important during adolescence (Bronfenbrenner, 1979; Byrne et al., 2007), in the present study we posited that higher levels of PSU are associated with lower levels of student engagement (**H3**). Academic engagement is a positive and fulfilling mental state that is characterized by vigor, absorption, and dedication in the educational setting (Schaufeli et al., 2002). To the best of our knowledge, no prior research has explored the association between PSU and academic engagement. Nonetheless, some studies have found that higher PSU is associated with increased school conflict (Hong et al., 2012; Mahapatra, 2019), academic procrastination (Z. Yang et al., 2019a, 2019b), and diminished classroom connectedness (Soomro et al., 2019). Therefore, there is some preliminary evidence to suggest that negative academic attitudes, such as diminished academic engagement, might be among the consequences of PSU.

Finally, in accordance with the I-PACE (Brand et al., 2019) and pathways models (Billieux et al., 2015; Canale et al., 2021) that propose an integrative framework for the development of PSU, starting from personal characteristics and ending in negative consequences, we propose that perceived stress and PSU will serially mediate the linkage between critical thinking and academic engagement among adolescents. That is, lower levels of critical thinking are related to higher levels of perceived stress, which are associated with greater PSU and, consequently, decreased student engagement (**H4**). The proposed model is presented in Figure 1.

Figure 1. *The Proposed Serial Mediation Model.*



Methods

Procedure

Secondary education schools in the Málaga province (Spain) were contacted via telephone to invite them to participate in the present investigation. Thirteen schools were reached, and five of them agreed to participate (one private and four public). The main reason for refusal was the lack of time to complete the questionnaires during class hours. The administration of the schools signed an informed consent. Furthermore, the parents or legal guardians of the adolescents were also asked for their consent: in four schools the consent was given passively (i.e., they were informed of the research process and unless they refused, all adolescents were asked to participate), and in one school the consent was given actively (i.e., they had to sign and return the consent form for the adolescent to participate in the study). All the students who had a fluent understanding of the Spanish language agreed to participate.

Data collection was held in the schools during regular class hours in the presence of a teacher, from January to February of 2021. Due to the COVID-19 pandemic restrictions, researchers were not admitted to the centers. Therefore, a video of the instructions and ethical considerations was sent to the schools, in which the adolescents were informed of the objectives of the study and they were guaranteed of the anonymity, confidentiality, and voluntary participation in the study (World Medical Association, 2013). The questionnaires were completed in an online (four schools) and paper (one school) format, over a duration of approximately 45 minutes.

Participants

The sample of this study was composed of 688 adolescents (54% females, 46% males) within the ages of 12 and 18 years (M = 14.23, SD = 1.76). It is worth noting that based on the adolescent population of the province of Málaga (n = 188,067), a sample of 599 is required to make statistical inferences with a 95% confidence interval and a 4% sample error (National Institute for Statistics, 2021). Regarding school course, 26.4% of the participants were in the first year of compulsory secondary education, 23.7% in the second year, 12.4% in the third year, and 15.5% in the fourth year. Additionally, 12% attended the first year of Baccalaureate and 10% the second year.

Instruments

Critical Thinking

The Spanish version of the subscale of judgment/open-mindedness on the Values-In-Action-Youth questionnaire (VIA-Y; Giménez Hernández et al., 2010; Park & Peterson, 2006) was used to assess critical thinking disposition. The scale assesses the adolescent's perceptions about their ability to make decisions based on critical judgment and their disposition to gather all the relevant information of a situation before arriving at conclusions. It is composed of eight items (e.g., *I make decisions only when I have all of the facts*) that are answered on a scale ranging from 1 (*very much like me*) to 5 (*not like me at all*), so higher scores indicate better critical thinking disposition. Evidence of the concurrent and predictive validity of the Spanish version of the VIA-Y is found in Giménez Hernández et al. (2010). In our study, the reliability of the scale was adequate (α = .69, Ω = .70, AVE = .34, CR = .76).

Perceived Stress

The Spanish short version of the Perceived Stress Scale (PSS4; Cohen & Williamson, 1988; Herrero & Meneses, 2006) was used to measure this construct. The PSS4 assesses the extent to which individuals perceive life as uncontrollable, overloaded, or unpredictable (e.g., *How often have you felt difficulties were piling up so high that you could not overcome them?*). It is composed of four items that are answered on a scale ranging from 1 (*never*) to 5 (*always*); thus, higher scores suggest worse levels of perceived stress. Evidence for the factorial and predictive validity of the PSS4 is found in the work of Cohen and Williamson (1988). In our sample, the reliability of the PSS4 was acceptable (α = .60, Ω = .62, AVE = .39, CR = .61).

Problematic Smartphone Use (PSU)

The Spanish short version of the Smartphone Addiction Scale (SAS-SV; Kwon et al., 2013; Lopez-Fernandez, 2017) was used to assess PSU. The SAS-SV contains 10 items that are answered on a scale from 1 (*strongly disagree*) to 6 (*strongly agree*). An example item is *I have my smartphone in my mind even when I am not using it*, so higher scores indicate higher PSU. The validity of the SAS-SV in Spanish samples is supported in López-Fernández (2017). The reliability of the scale in our study was satisfactory (α = .87, Ω = .86, AVE = .35, CR = .81).

Academic Engagement

This construct was assessed using the Spanish short version of the Utrecht Work Engagement Scale for Students (UWES-9S; Carmona-Halty et al., 2019; Schaufeli et al., 2002). The UWES-9S measures the levels of vigor, absorption, and dedication that students experience with regard to their academic activities. It is composed of nine items (e.g., *my studies inspire me*) that are answered on a scale from 0 (*never*) to 6 (*always*); thus, higher scores suggest greater levels of engagement. Carmona-Halty et al. (2019) presented supporting evidence for the validity of the UWES-9S. The reliability of the scale in our study was excellent (α = .93, Ω = .93, AVE = .64, CR = .94).

Statistical Analyses

Analyses were conducted using SPSS 23 (IBM Corp., 2015). Descriptive statistics were calculated and Pearson bivariate correlations were estimated. Moreover, because all the variables were measured using self-report questionnaires, common-method bias could be a problem. We used Harman's single-factor test to assess for this bias. According to this method, all the study variables are entered in an exploratory factor analysis. Afterwards, the results of the unrotated factor matrix are examined to determine the number of factors with eigen-values higher than one. The assumption of this procedure is that if common-method variance is present, then the majority of the covariance of the variables will be accounted for by a single-factor, or only one factor will emerge (Podsakoff & Organ, 1986).

The PROCESS macro was used to carry out the multiple mediation analysis (Hayes, 2018). The assumptions of normality, multicollinearity, independence of errors, and homoscedasticity were tested prior to conducting the analyses. Because the last assumption was not met, heteroscedasticity-consistent estimators were used (Davidson-MacKinnon). Model 6 was applied to test for the serial mediation path from critical thinking disposition (antecedent variable) to perceived stress (first mediator) to PSU (second mediator) to student engagement (dependent variable). Sociodemographic variables, such as age and sex, were entered as covariates, as evidence suggests a significant effect on academic engagement (Perkmann et al., 2021). The bootstrapping method (i.e., 5,000 resamples) was used to assess the statistical significance of the indirect effects, using 95% confidence intervals. An effect was considered significant if the 95% CI did not include zero.

Results

Preliminary Analysis

Table 1 shows the descriptive statistics and Pearson bivariate correlations between the study variables. As presented, critical thinking was negatively associated with perceived stress (r = −.25) and PSU (r = −.24), and positively related to student engagement (r = .27). Furthermore, perceived stress was positively correlated with PSU (r = .30) and negatively related to academic engagement (r = −.30). Finally, PSU and academic engagement were negatively correlated (r = −.27).

Table 1. *Descriptive Statistics and Correlations Between Study Variables.*

Variable	*M*	*SD*	1	2	3	4
1. Critical thinking	3.47	0.63	1			
2. Perceived stress	2.69	0.80	−.25**	1		
3. PSU	27.38	10.99	−.24**	.30**	1	
4. Academic engagement	2.54	1.53	.27**	−.30**	−.27**	1

Note. **p < .01.

Regarding the common-method bias, the exploratory factor analysis suggested by Harman's single factor test (Podsakoff & Organ, 1986) indicated that six factors were extracted, and the first one accounted for only 26% of the variance. Because more than one factor was extracted, and the first one only accounted for a small proportion of the variance, common-method bias was not an issue in our study.

Serial Mediation Model

Figure 2 and Table 2 present the results of the serial mediation model. As shown, the results indicate a significant total effect of critical thinking on academic engagement, $B = 0.67$, $SE(HC3) = 0.09$, $p < .001$. Regarding the covariates, the total effect of age on academic engagement was significant, $B = -0.08$, $SE(HC3) = 0.03$, $p = .009$, while the total effect of sex was not, $B = 0.12$, $SE(HC3) = 0.11$, $p = .304$. Moreover, all of the direct effects were statistically different from zero (i.e., $p < .001$). In addition, because the 95%CI did not include zero, the results suggest that all of the indirect effects were statistically significant. That is, first, perceived stress mediated the association between critical thinking and academic engagement, indirect effect = 0.12, Boot*SE* = 0.03, 95% CI [0.06, 0.19]. Second, PSU mediated the link between critical thinking and academic engagement, indirect effect = 0.07, Boot*SE* = 0.02, 95% CI [0.03, 0.13]. Finally, perceived stress and PSU serially mediated the relation between critical thinking and academic engagement, indirect effect = 0.02, Boot*SE* = 0.01, 95% CI [0.01, 0.03]. In sum, lower levels of critical thinking were associated with higher levels of perceived stress, which in turn were linked to higher PSU. Finally, greater PSU was related to lower levels of academic engagement. The complete serial mediation model accounted for 8.5% of the variance in academic engagement, and it was statistically significant, $F_{(3,637)} = 18.61$, $p = <.001$.

Figure 2. *Results of the Serial Mediation Analysis.*

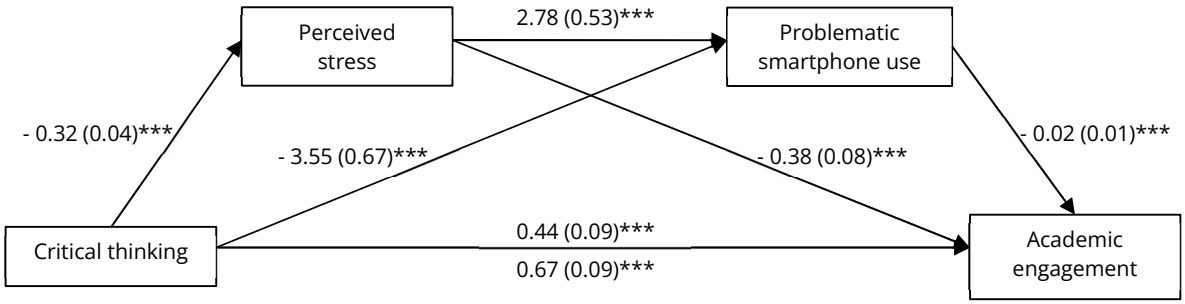


Table 2. *Effects in the Multiple Mediation Model (N = 641).*

	B	*SE (HC3)*	*p*	LLCI	ULCI
Total effects					
CT → academic engagement	0.67	0.09	<.001	0.48	0.85
Sex → academic engagement	0.12	0.11	.304	−0.11	0.35
Age → academic engagement	−0.08	0.03	.009	−0.15	−0.02
Direct effects					
CT → perceived stress	−0.32	0.04	<.001	−0.42	−0.23
CT → PSU	−3.55	0.67	<.001	−4.87	−2.23
Perceived stress → PSU	2.78	0.53	<.001	1.72	3.83
Perceived stress → academic engagement	−0.38	0.08	<.001	−0.54	−0.23
PSU → academic engagement	−0.02	0.01	<.001	−0.03	−0.01
CT → academic engagement	0.44	0.09	<.001	0.25	0.62
Indirect effects	Boot Effect	Boot *SE*		Boot LLCI	Boot ULCI
CT → perceived stress → academic engagement	0.12	0.03		0.06	0.19
CT → PSU → academic engagement	0.07	0.02		0.03	0.13
CT → perceived stress → PSU → academic engagement	0.02	0.01		0.01	0.03

Note. CT = Critical thinking. PSU = Problematic smartphone use. B = unstandardized coefficient; SE (HC3) = Heteroscedasticity Consistent Standard Error; LLCI = 95 % lower limit confidence interval; ULCI = 95 % upper limit confidence interval. Boot = statistics for the indirect effects are the result of the bootstrapping method. Covariates: age and sex.

Discussion

Most adolescents today are growing up in an increasingly digitalized reality, frequently connecting with peers and learning about the world through a smartphone (Crone & Konijn, 2018; Granic et al., 2020). Therefore, it is essential to understand the role that the use of technology might play in the development of numerous academic, social, and health-related outcomes. Based on several theoretical frameworks, the present study used a sample of Spanish adolescents to analyze a mediation-based model of the cross-sectional link of critical thinking with academic engagement, as serially mediated by perceived stress and PSU.

First, the results showed that lower levels of critical thinking were associated with an increased perception of stress, which supports H1, in accordance with previous findings (Escolà-Gascón et al., 2021; Kim et al., 2015). Critical thinking might help to reduce stress levels because it allows individuals to reflect about and question stress-inducing stimuli, as well as to reinterpret the experience of uncertainty by identifying the reasons why an individual might feel stressed (Escolà-Gascón et al., 2021). In addition, a few intervention studies have found that training critical thinking helps to ameliorate stress (Okide et al., 2020; Ugwuozor et al., 2021). Nonetheless, the aforementioned studies have not been conducted on adolescent samples. In relation to this matter, the research of Flor et al. (2013) suggests that teaching critical thinking skills fosters an internal locus of control and has a positive impact on the psychological well-being of adolescents. Therefore, our study expands on the preliminary evidence indicating that promoting critical thinking attitudes might help adolescents manage their perception of stressful situations.

Second, our results indicated that increased levels of perceived stress were linked to higher scores on PSU, which provided support for the second hypothesis. As mentioned earlier, the association between stress and PSU is well established in the cyberpsychology literature (Chiu, 2014; Q.-Q. Liu et al., 2018; Samaha & Hawi, 2016; Wang et al., 2020; H. Yang et al., 2021). Although some studies suggest that the link between smartphone overuse and stress might be bi-directional (Stanković & Nešić, 2022; Stanković et al., 2021), most of the research explains this connection by asserting that smartphones are being used as a mechanism to alleviate negative emotions and experiences of pain, tension, and loneliness (Chiu, 2014), as a tool to pass the time and reduce negative feelings, but without eliminating the source of these emotions (Q.-Q. Liu et al., 2018), to escape from problems (Wang et al., 2020), and to satisfy needs in the face of adversity (H. Yang et al., 2021). That is, the association between stress and PSU seems to be best explained by the theories that have proposed that smartphones are used as a coping mechanism by a minority of people (Elhai et al., 2019; Griffiths, 2019; Kardefelt-Winther, 2014). Relatedly, according to Elhai and collaborators (2019), because smartphones have been an integral part of the lives of most of today's adolescents, and because these devices have increasingly more applications that facilitate information seeking, entertainment, and social connections, it seems understandable that many adolescents would continue to use smartphones to find relief if no other, more beneficial, option is presented to them.

Third, we also found evidence to support the third hypothesis of our study, which assumed that higher levels of PSU would be associated with lower levels of academic engagement. Prior research has indicated that the most frequently studied negative educational outcome deriving from PSU is academic achievement (e.g., Bukhori et al., 2019; Grant et al., 2019; Hawi & Samaha, 2016; Nayak, 2018; Samaha & Hawi, 2016; Winskel et al., 2019). For instance, a recent meta-analytic study found that engagement is a proximal robust predictor of academic performance (Lei et al., 2018). Thus, fostering academic engagement seems a promising path to improve academic outcomes in adolescents. Nonetheless, at present, no previous research has shed light on the association between PSU and academic engagement among adolescents. Therefore, our study provides novel evidence that expands prior results suggesting that higher PSU might be associated with a decreased attitude toward learning and academic achievement in high school students (Hong et al., 2012; Mahapatra, 2019; Soomro et al., 2019; Z. Yang et al., 2019a, 2019b).

Interestingly, although no specific hypothesis about the direct relation between critical thinking and PSU was posited, our results indicate a strong and negative association between both dimensions. Our findings might be understood from the I-PACE (Brand et al., 2019) and pathways model (Billieux et al., 2015; Canale et al., 2021), suggesting that some personal characteristics might be at the core of PSU. Several studies have suggested that low critical thinking is associated with a tendency toward a problematic usage of digital technology. For instance, it has been linked to problematic Internet (D. Liu et al., 2021) and social media use (Thomas, 2020). To the best of our knowledge, there is no prior research about the association between critical thinking and PSU. Therefore, our novel findings could set the base for more research regarding this connection. To support this contention, Dwyer

et al. (2014) suggested that critical thinking could be especially important in a 21st century setting where new information is constantly being produced. Thus, individuals who engage critically with that information are better equipped to solve problems constructively, draw reasonable conclusions, and make informed decisions. Consequently, fostering critical thinking could potentially help adolescents make better decisions regarding digital environments and their smartphone usage, although more research is needed to support this idea.

Furthermore, despite the fact that no inferences were made about the relation between critical thinking and academic engagement, our results suggest that these variables are positively linked. Critical thinking has been associated with positive emotions toward achievement (Thomas, 2020) and better academic performance (Fong et al., 2017; Musa, 2020), beyond general cognitive ability (Ren et al., 2020). Based on these results, a tentative conclusion is to think that critical thinkers might be more captivated by school content and apply key ideas in different settings, which makes them more engaged and motivated in their schoolwork (Agger & Koenka, 2020).

Finally, regarding the fourth hypothesis, our evidence supports the serial mediation model in which lower levels of critical thinking were associated with higher levels of perceived stress, which were linked to increased PSU, thereby resulting in a decrease in academic engagement. Further, our findings highlight the importance of testing integrative models from an empirical perspective to gain a better understanding of this complex phenomenon. Thereby, we consider that our study provides empirical data to support the I-PACE (Brand et al., 2019) and maladaptive coping (Elhai et al., 2019; Griffiths, 2019; Kardefelt-Winther, 2014) models regarding PSU in adolescents. In sum, our results show a plausible path that integrates a personal characteristic, such as low critical thinking disposition, which may make some adolescents more prone toward experiencing stress, and which they might attempt to dampen by using their smartphone as a coping strategy that may eventually lead to a decrease in academic engagement. Furthermore, Canale et al. (2021) proposed that the excessive reassurance pathway to PSU is consistent with the maladaptive coping strategy proposal. Moreover, these researchers also indicated that PSU following the impulsive pathway might be prompted by thoughtless urgency and lack of planning (Canale et al., 2021). In addition, our study also provides indirect support for at least two of the pathways leading to PSU (Billieux et al., 2015), by presenting empirical data to suggest that PSU might be a maladaptive coping mechanism (i.e., excessive reassurance pathway) and that it may result from a diminished capacity to think critically (i.e., impulsive pathway). Based on these preliminary findings, investigators should aim in future studies to evaluate whether this interpretation of the results remains when using tests for the different paths leading to PSU (e.g., Kuss et al., 2018).

The main strength of our research was presenting evidence to support an integrative model that considers potential antecedents and consequences of PSU. Nonetheless, our study is not without limitations. First, although our serial mediation model was based on theoretical grounds, we used cross-sectional data. Thus, we cannot make proper assumptions regarding the causal relations between the study variables. Future research could address this limitation by implementing a longitudinal design. Second, self-report data is susceptible to certain cognitive biases. In our study we dismissed common method bias, but we did not test for social desirability bias. Because of the sensitive nature of the variables we assessed, it is possible that the adolescents may have overestimated their critical thinking disposition or underestimated their PSU levels (Krumpal, 2013). Although there are differences between the aspects being tapped by self-report and behavioral measures (Dang et al., 2020), investigators in future studies might want to assess critical thinking skills and objective smartphone usage to overcome this limitation. For instance, Ryding & Kuss (2020) have found that screen usage time and checking patterns are the most common strategies to objectively assess PSU. Third, the reliability indexes of the perceived stress and critical thinking scales were lower than expected, despite replicating the results of previous studies (Cohen & Williamson, 1988; Giménez Hernández et al., 2010). Accordingly, Ziegler et al. (2014) argued that short scales (i.e., fewer than 10 items) should focus more on construct representation than internal consistency, especially when used in group instead of individual interpretation. Nonetheless, future research work should use longer versions of these scales to surmount this shortcoming. Finally, the established cut-off score to the determine high-risk PSU for the SAS-SV is 31 points for males and 33 points for females (Kwon et al., 2013). In our sample, the mean score for PSU was 27.38 in general, 25.12 for males, and 29.20 for females. These results suggest that the mean of our sample is below the corresponding cut-off scores, indicating low-risk PSU. Although there are current discussions about the transcultural validity and present appropriateness of this criterium, the cut-off score proposed by Kwon et al. (2013) remains the most widely used parameter to determine high- and low-risk PSU (Olson et al., 2022). Therefore, our results are representative of a low-risk PSU community sample of adolescents and should be interpretated with caution. Future studies might analyze our model in a high-risk PSU sample to assess the potential replicability of our results.

Despite the aforementioned limitations, the results of our study have at least one important implication. Research suggests that critical thinking can improve with specific training (Abrami et al., 2015; Alsaleh, 2020). Concerning the variables that moderate the effectiveness of critical thinking interventions, the meta-analysis of Abrami et al. (2015) found that training had a positive and significant effect in learners from elementary to undergraduate levels, across different subject matter and irrespective of the duration of the intervention (e.g., from one hour to over one semester long). Following Ennis's (1989) classification, scholars have found that experimental groups showed increased critical thinking over controls despite employing direct, infusion, immersion, or mixed approaches (Abrami et al., 2015). Similarly, these authors found that using the strategies of dialogue and anchored problem-solving yielded larger effects than mentoring, although all three favored the experimental groups and the best results were found when these strategies were combined. Finally, some studies have indicated that the most effective techniques for teaching critical thinking are dialogues in which the teacher poses a question, whole-class and small-group discussions led by the teacher, applied problem-solving, and role playing (Abrami et al., 2015).

In addition, critical thinking training may include general or specific content (Ennis, 2018). Although Ennis (2018) indicated that most teaching concentrates on general critical thinking, he asserted that subject-specific programs are important because they emphasize reflective thinking focused on what to believe or do in a particular field. Consequently, interventions aiming to reduce the risk of developing PSU in adolescents should focus on teaching about how to think critically to enhance healthy digital technology usage. For instance, Escolà-Gascón et al. (2021) suggested that critical thinking could be employed to detect fake news online. Similarly, future studies could focus on the most problematic aspects of PSU for adolescents and encourage group discussions, problem-solving, and role playing to foster a beneficial use of the smartphone.

Furthermore, according to our results, adolescents might be using smartphones as a maladaptive coping mechanism; therefore, future interventions could aim to teach youth about personal resources and adaptive strategies to manage stress levels. For example, Arrivillaga et al. (2022) found that emotional intelligence, which is the ability to perceive, understand, and manage emotions effectively (Mayer et al., 2016), acted as a buffer against PSU. In addition, another study found that adolescents with higher risk for PSU tended to use more maladaptive coping strategies than low-risk users (e.g., rumination, self-blame, blaming others, and catastrophizing; Extremera et al., 2019). Therefore, it can be inferred from our findings that teaching adaptive emotion regulation strategies (i.e., positive reappraisal, positive refocusing, refocus on planning, and putting the situation into perspective) could shield adolescents from experiencing intense stress, which would help them to lower PSU and become more motivated, engaged, and successful in school. Finally, studies have suggested that positive parental mediation is negatively associated with PSU in adolescents (Meeus et al., 2019; Nielsen et al., 2020). Accordingly, our results might point toward the importance of preventing PSU by fostering parental mediation of adolescents' smartphone use, as an external form of regulation, which might also have a positive impact on their academic success.

Conclusion

Our study has provided evidence which suggests that perceived stress and PSU act as serial mediators between critical thinking and academic engagement, meaning that adolescents with reduced critical thinking have a greater tendency to perceive stress, which, in turn, leads to PSU as a maladaptive strategy, resulting in less academic engagement. Finally, by placing critical thinking as an antecedent of interest of PSU, future intervention programs should consider the role of critical thinking in the context of healthy usage of smartphones among adolescents.

Conflict of Interest

The authors do not have any conflicts of interest to report.

Authors' Contributions

Christiane Arrivillaga: conceptualization, formal analysis, funding acquisition, investigation, methodology, and writing—original draft, review, and editing. **Lourdes Rey**: conceptualization, funding acquisition, methodology, project administration, supervision, and writing—review and editing. **Natalio Extremera**: conceptualization, funding acquisition, methodology, project administration, supervision, and writing—review and editing.

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