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Invalidating environment and smartphone addiction: the chain mediating effect of regulatory emotional self-efficacy and psychache

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With the proliferation of smartphones and the development of the internet, excessive smartphone use has become widespread among college students, making the issue of smartphone addiction increasingly severe. Invalidating environment may be a key influencing factor in increasing adolescents' smartphone addiction. Existing studies have not directly explored the effects of the invalidating environment on smartphone addiction and its underlying mechanisms. Guided by Interaction of Person-Affect-Cognition-Execution model (I-PACE), this study examined the relationship between invalidating environment and college students' smartphone addiction using a serial mediation model that included regulatory emotional self-efficacy and psychache as hypothesized mediators. Using convenience sampling, 493 college students (69% female, 31% male; Mage = 19.52 years, SD = 1.88) were recruited to complete four standardized questionnaires—the Invalidating Childhood Environment Scale, the Mobile Phone Addiction Tendency Scale, the Regulatory Emotional Self-Efficacy Scale, and the Psychache Scale. Data were collected face-to-face via an online survey platform, with researchers present throughout to provide supervision and guidance. The results revealed that invalidating environment positively predicted smartphone addiction among college students. Both regulatory emotional self-efficacy and psychache independently mediated this relationship, and together, they also formed a significant sequential pathway, where lower regulatory emotional self-efficacy was associated with greater psychache, which in turn predicted higher levels of smartphone addiction. This study is the first to identify invalidating environment as a key predictor of smartphone addiction among college students, particularly within the context of Chinese culture, where emotional expression in families tends to be more restrained. The findings offer potential guidance for the development of prevention and intervention strategies targeting smartphone addiction.

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Introduction

With the proliferation of smartphones and the development of the internet, excessive smartphone use has become widespread among college students (Statista, 2021), leading to a growing concern over the issue of smartphone addiction. Smartphone addiction, also known as smartphone dependence or excessive smartphone use, is characterized by an individual's excessive reliance on their smartphone and an inability to control its use, leading to recurrent failure in managing the behavior, which causes functional impairment or distress (Billieux et al., 2015; Ting and Chen, 2020). Studies showed that excessive smartphone use can lead to a variety of negative outcomes for college students. Adolescents who are overly reliant on smartphones show a significant correlation with anxiety, depression (Elhai et al., 2017; Hou et al., 2021; Jun, 2016; Yang et al., 2019), and sleep problems like difficulty falling asleep and poor sleep quality (Li et al., 2020; Thomée et al., 2011). Moreover, smartphone addiction is negatively associated with academic performance among college students globally, and high-frequency smartphone users spent less time on academic attention, interest, and investment (Amez and Baert, 2020; Tian et al., 2021). Additionally, prolonged smartphone use reduced face-to-face interactions, increased social anxiety (Darcin et al., 2016; Kor-niienko and Barchi, 2020), and higher chances of interpersonal conflicts (Park et al., 2014). Therefore, prevention and intervention for smartphone addiction were crucial for the healthy development of college students.

Existing research indicated that various factors influenced smartphone addiction among college students, including individual intrinsic traits and external environments. Intrinsic traits mainly comprised depression (Ting and Chen, 2020), self-control ability (Billieux et al., 2015; Billieux et al., 2008), self-efficacy (Billieux, 2012), self-esteem (Andreassen et al., 2016), and personality traits such as neuroticism (Billieux et al., 2015; Cocoradă et al., 2018; Erdem and Uzun, 2022). External environmental factors primarily included parenting style (Gladkaya et al., 2018), parental rejection (Zhu et al., 2019); family environment (e.g., domestic violence, parental addiction) (Kim et al., 2018); life stress (e.g., family stress, emotional stress, academic stress, interpersonal relationship stress) (Chiu, 2014); peer relationship (Wang et al., 2017). Although existing research highlights the important role of the family environment in college students' smartphone addiction, there remain significant gaps in understanding how the family emotional environment specifically influences the development of smartphone addiction. Firstly, few studies explored the impact of invalidating environment, which is a kind of family emotional environment, on smartphone addiction among college students. According to biosocial theory, such invalidating environment significantly impact emotional capabilities, leading to emotional instability and greater emotional distress (Fergusson et al., 2005; Linehan, 1993). The Interaction of Person-Affect-Cognition-Execution (I-PACE) model further suggests that these emotional deficits increase tendencies to escape reality and seek stimulation, raising the risk of smartphone addiction (Brand et al., 2019). Therefore, invalidating environment may be a key factor in triggering smartphone addiction among college students. Secondly, the mechanisms by which invalidating environment affects smartphone addiction are not well understood. Drawing on biosocial theory (Linehan, 1993) and the I-PACE model (Brand et al., 2019), it is theoretically plausible that regulatory emotional self-efficacy (RESE) and psychache may mediate this relationship. An invalidating environment may impair individuals' emotional regulation abilities and increase their psychological pain, which in turn could promote excessive smartphone use as a maladaptive coping strategy. Thirdly, most research on invalidating environment has been

conducted in Western countries, with limited studies in the Chinese cultural context. The cultural and social system in China, shaped by Confucian values, tends to encourage more restrained emotional expression within families (Tsai et al., 2006). Studies have shown that Chinese parents and children are generally less emotionally expressive than their Western counterparts, as open displays of emotion, particularly negative ones, are often viewed as disruptive to harmony (Chen et al., 2014; Wang and Barrett, 2015). These cultural norms may contribute to the formation of an emotionally invalidating family environment. Therefore, it is important to explore whether this subtle and repressed family emotional environment, which is prevalent in Chinese families, has a distinct impact on smartphone addiction among Chinese college students. This study addresses critical gaps by examining how invalidating environment contribute to smartphone addiction through underlying psychological mechanisms. It underscores the often overlooked yet critical role of negative parental emotional responses in shaping children's emotional functioning and addictive behaviors. Situated within the Chinese cultural context, where emotionally restrained parenting is prevalent, the study offers culturally relevant insights that extend existing theory and inform potential intervention efforts.

Invalidating environment and smartphone addiction

Derived from Linehan's biosocial theory, invalidating environment refers to a family climate in which a child's emotional expressions are ignored, misinterpreted, or punished (Linehan, 1993). In such an environment, parents typically exhibited four characteristic responses to their child's negative emotions: inaccurate communication, misattribution, discouragement of negative emotional expression, and oversimplification of problem-solving efforts. This meant that the child's emotional experiences were not accurately understood, and their negative emotions were frequently rejected, suppressed, or punished, leaving the child in a state of chronic negative emotions (Linehan, 1993). According to the I-PACE model, individuals who encountered negative emotions and could not effectively resolve them were more likely to engage in addictive behaviors as a means of escaping reality or relieving emotional distress (Brand et al., 2019). Smartphones, in particular, are easily accessible, socially accepted, and emotionally gratifying, making them a common tool for avoidant coping (Kardefelt-Winther, 2014). As these individuals increasingly rely on smartphones to relieve negative emotions or gain momentary comfort, they may become trapped in a reinforcing cycle of compulsive use (Brand et al., 2019; Musser et al., 2018). Over time, this maladaptive coping strategy can escalate into smartphone addiction. Empirical studies offer preliminary support for this link. For instance, prior research has shown that parental emotional neglect is associated with greater smartphone dependence among adolescents (Cha and Seo, 2021; Lee et al., 2018), and that psychologically controlling parenting also contributes to smartphone addiction through impaired emotional autonomy (Li and Liu, 2025). Based on this theoretical and empirical foundation, we propose Hypothesis 1: Invalidating environment positively predicts smartphone addiction.

Regulatory emotional self-efficacy as a mediator. RESE referred to an individual's belief in their ability to effectively manage their own emotions, including managing negative emotions and expressing positive emotions (Bandura et al., 2003; Caprara et al., 2008). According to biosocial theory, parental responses to children's negative emotions in invalidating environment impaired children's emotional recognition and regulation skills (Crowell et al., 2009). In such environment, normal emotional expressions

were often ignored or punished, leading children to adopt extreme emotional expressions to gain attention, oscillating between suppression and extreme expression (Musser et al., 2018). Over time, these children failed to accurately describe and manage their emotions, resulting in chronic emotional distress and a belief in their inability to regulate emotions effectively, leading to low RESE (Meng et al., 2024). According to self-efficacy theory, individuals with low RESE were less likely to take positive measures to regulate emotions, believing these efforts would be ineffective (Bandura et al., 2003; Benfer et al., 2018). Correspondingly, studies found that individuals with low RESE were more likely to resort to excessive smartphone use (Liu et al., 2021; Xiao and Huang, 2022). Therefore, we propose Hypothesis 2: RESE mediate the relationship between invalidating environment and smartphone addiction.

Psychache as a mediator. Psychache referred to a deep, persistent, and unbearable psychological pain or inner torment. It encompasses intense feelings of shame, humiliation, anguish, despair, loneliness, dread, failure, and abandonment, with a belief that the pain is irreversible (Holden et al., 2001; Orbach et al., 2003; Shneidman, 1993). According to biosocial theory, invalidating environment significantly impacted the development of psychache. In such environment, parents often responded negatively to their child's emotional expressions with statements like "You shouldn't feel that way" or "Don't overthink it." These negative responses led to their children's emotional suppression and misinterpretation, preventing the child's emotional experiences from being properly understood and addressed (Linehan, 1993). Over time, this suppression fostered children's self-doubt and internal conflict, further intensifying the child's psychache and emotional burden (Chen and Liu, 2021; Musser et al., 2018). In sum, higher levels of emotional suppression by parents predicted greater psychache in children (Holden et al., 2021). Faced with such unbearable psychological distress, individuals often seek ways to relieve or escape their pain (Holden et al., 2001; Shneidman, 1993). One common coping strategy is to engage in emotionally distracting or soothing activities (Kardefelt-Winther, 2014). In the digital age, smartphones provide immediate access to entertainment, social validation, and emotional escape, making them a convenient outlet for those experiencing psychache (Elhai et al., 2016; Ting and Chen, 2020). Indeed, research suggests that individuals with higher levels of psychache are more likely to develop emotional dependency on their smartphones, using them for comfort and support, which gradually leads to smartphone addiction (Chen and Liu, 2021; Wang and Zhang, 2022). Therefore, we propose Hypothesis 3: psychache mediates the relationship between invalidating environment and smartphone addiction.

The sequential mediation effect of RESE and psychache.

According to the theory of RESE, individuals with low RESE were less likely to use positive emotional regulation strategies, making it harder for them to manage negative emotions promptly and effectively (Bandura et al., 2003). This failure to regulate emotions increased the intensity and duration of negative feelings, leading to their accumulation and amplification, which in turn heightened individuals' psychache (Bandura and Wessels, 1997; Gross, 1998). Indeed, multiple studies found a significant negative correlation between RESE and psychache. Lower levels of RESE were associated with higher levels of psychache (Chen et al., 2020; Li et al., 2019; Wang and Jiang, 2019). Similarly, longitudinal research showed that higher level of RESE not only alleviated psychache in the short term but also offered long-term protective effects. In a one-year follow-up study, individuals with higher

initial levels of RESE experienced significantly lower levels of psychache after one year compared to those with lower initial levels of RESE (Wang and Jiang, 2019). In sum, it could be inferred that invalidating environment undermine an individual's RESE, increasing their level of psychache. To alleviate this psychache, individuals may increasingly resort to using smartphones, ultimately leading to the development of smartphone addiction. Thus, we propose Hypothesis 4: RESE and psychache serve as sequential mediators between invalidating environment and smartphone addiction.

Methods

Participants. 493 college students (69% female, 31% male) from a university in Hubei Province participated in this study. The participants' mean age was 19.52 years ($SD = 1.88$). Participants were recruited through convenience sampling, and data were collected face-to-face using Wenjuanxing, a widely used online survey platform in China. Participants completed the questionnaire on their smartphones, with the researchers present throughout the process to provide face-to-face instructions and guidance.

Ethical approval for this study was obtained from the Ethics Committee of the Department of Psychology, School of Philosophy, Wuhan University (approval reference number: 2018050601). This study was conducted in accordance with the relevant ethical guidelines, including the Declaration of Helsinki. All participants were fully informed about the study's purpose, procedures, and potential risks and provided their consent to participate.

Procedure and measures

Invalidating environment. Invalidating environment was measured using the Invalidating Childhood Environment Scale (Mountford et al., 2007). It contains 14 items, such as "If I was upset, my parents said things like: 'I'll give you something to really cry about!'" Participants are asked to rate their experience up to the age of 18 years. Each item is rated on a Likert-type scale (1 = never; 5 = all the time) for parents. Higher scores reflect a greater perception of invalidation by their parents. In this study, the Cronbach's α coefficient was 0.86, the McDonald's ω coefficient was 0.88.

Smartphone addiction. Smartphone addiction was measured using Mobile Phone Addiction Tendency Scale for college students (Xiong et al., 2012). It consists of 16 items and four factors, including withdrawal symptoms (e.g., "I feel uncomfortable if I haven't used my smartphone for a long time"), salience (e.g., "During class, I often focus on my smartphone, which affects my ability to concentrate on the lecture"), social comfort (e.g., "I prefer chatting on my smartphone rather than engaging in face-to-face communication"), and mood changes (e.g., "When my smartphone frequently loses connection or signal, I become anxious and irritable"). Participants were asked to rate on a 5-point scale from 1 (not at all like me) to 5 (very much like me). It has high reliability and validity and is widely used in the Chinese context. Higher scores reflect greater dependence on smartphones. In this study, the Cronbach's α was 0.90, the McDonald's ω coefficient was 0.90.

Regulatory emotional self-efficacy (RESE). RESE was measured using RESE Scale (Caprara et al., 2008; Wang et al., 2013). This measure has two dimensions: self-efficacy in expressing positive emotion (e.g., "I express my feelings of joy when something pleasant happens") and self-efficacy in managing negative emotion (e.g., "I can quickly get over feelings of irritation after

something disappointing happens”). It consists of 17 items rated on a 5-point scale from 1 (not at all like me) to 5 (very much like me). The higher the score, the better the RESE. In this study, the Cronbach’s α coefficient was 0.92, the McDonald’s ω coefficient was 0.92.

Psychache. Psychache was measured using the Psychache Scale (Holden et al., 2001; Qin, 2008). It consists of 13 items rated on a 5-point scale from 1 (never) to 5 (always), such as “My pain is making me fall apart.” High scores indicate a higher level of psychache. In this study, the Cronbach’s α coefficient was 0.96, the McDonald’s ω coefficient was 0.96.

Data analysis. First, we used SPSS 26.0 to obtain descriptive statistics and correlations among the main variables. Then, a serial mediation analysis was conducted using Model 6 from the PROCESS macro in SPSS. The bootstrap method, with 5000 resamples, was employed to construct a 95% confidence interval (CI) for significance testing of the mediating effects.

Results

Common method bias. To address potential common method bias in the questionnaire data (Podsakoff et al., 2003), we employed several control measures. First, we emphasized the anonymity of the questionnaire to reduce social desirability response bias. Second, some items were scored in reverse order to counteract any response patterns. Additionally, we conducted Harman’s one-factor test to assess common method bias. The results showed that the single factor accounted for 23.20% of the total variance, below the conventional 40% threshold, indicating

that common method bias did not pose a serious threat to this study.

Initial analysis. The descriptive statistics and Pearson’s correlations between the variables were presented in Table 1. Invalidating environment was significantly positively correlated with smartphone addiction ($r = 0.25, p < 0.001$) and psychache ($r = 0.34, p < 0.001$), but negatively correlated with RESE ($r = -0.30, p < 0.001$). RESE showed significant negative correlations with both psychache ($r = -0.28, p < 0.001$) and smartphone addiction ($r = -0.30, p < 0.001$). Additionally, psychache was significantly positively correlated with smartphone addiction ($r = 0.32, p < 0.001$).

Serial mediating analysis. We then examined the serial mediating effect of RESE and psychache in the relationship between invalidating environment and smartphone addiction using Preacher and Hayes’s (2008) procedure and an SPSS macro for testing indirect effects. The analysis showed that a higher level of invalidating environment significantly predicted greater severity of smartphone addiction ($\beta = 0.29, t = 5.77, p < 0.001, R^2 = 0.06$), supporting Hypothesis 1. RESE negatively predicted smartphone addiction ($\beta = -0.24, t = -4.67, p < 0.001$) and psychache ($\beta = -0.22, t = -4.51, p < 0.001$), psychache positively predicted smartphone addiction ($\beta = 0.23, t = 5.01, p < 0.001$) (see Fig. 1).

After controlling for the effect of RESE and psychache, the direct effect of invalidating environment on smartphone addiction was still significant (direct effect = 0.13, Boot SE = 0.05, Boot 95% CI = [0.03, 0.23]), which indicates that RESE and psychache partially mediate the relationship between invalidating environment and smartphone addiction. Moreover, the bootstrap method revealed significant mediation effects of RESE (indirect effect = 0.07, Boot SE = 0.02, Boot 95% CI = [0.03, 0.12]; supporting Hypotheses 2) and psychache (indirect effect = 0.07, Boot SE = 0.02, Boot 95% CI = [0.03, 0.12]; supporting Hypotheses 3), and a significant chain mediation (indirect effect = 0.02, Boot SE = 0.01, Boot 95% CI = [0.00, 0.04], $R^2 = 0.16$; supporting Hypotheses 4) (see Table 2).

Discussion

This study examined the impact of invalidating environment on smartphone addiction among Chinese college students, guided by the I-PACE model. Results showed that invalidating environment

Table 1 Descriptive statistics and correlations among the key variables (N = 493).

	M	SD	1	2	3
1 Invalidating environment	2.17	0.66	—		
2 Smartphone Addiction	2.70	0.75	0.25***	—	
3 RESE	3.48	0.65	-0.30***	-0.30***	—
4 Psychache	1.62	0.72	0.34***	0.32***	-0.28***

Note: *** $p < 0.001$.
RESE regulatory emotional self-efficacy.

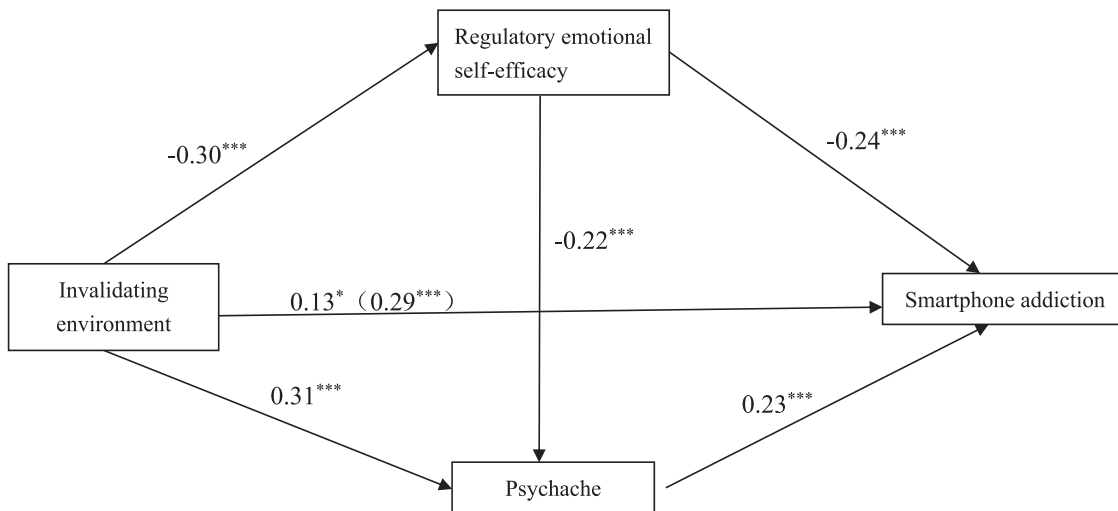


Fig. 1 Serial mediating paths between invalidating environment and smartphone addiction.

Table 2 Serial mediating models between invalidating environment and smartphone addiction (N = 493).

	Effect	Boot SE	Boot LLCI	Boot ULCI
Indirect effect 1	0.07	0.02	0.03	0.12
Indirect effect 2	0.07	0.02	0.03	0.12
Indirect effect 3	0.02	0.01	0.00	0.04
Total indirect effect	0.16	0.03	0.10	0.22
Direct effect	0.13	0.05	0.03	0.23
Total effect	0.29	0.05	0.19	0.38

Indirect effect 1: Invalidating environment→Regulatory emotional self-efficacy→Smartphone Addiction.
 Indirect effect 2: Invalidating environment→Psychache→Smartphone Addiction.
 Indirect effect 3: Invalidating environment→Regulatory emotional self-efficacy→Psychache→Smartphone Addiction.
 Direct effect: Invalidating environment→Smartphone Addiction.

positively predicted smartphone addiction, with RESE and psychache serving as both independent and sequential mediators. These findings highlight how parental responses to negative emotions can shape addiction-related behaviors through internal emotional and cognitive mechanisms.

We make several significant contributions to the literature on invalidating environment and smartphone addiction. Most importantly, this study introduces the invalidating environment as a novel and direct predictor of smartphone addiction. While previous research has established links between invalidating environment and maladaptive outcomes such as borderline personality disorder (Crowell et al., 2009; Musser et al., 2018), non-suicidal self-injury (Holden et al., 2021), and eating disorders (Ford et al., 2011; Gonçalves et al., 2021), our study is one of the first to empirically demonstrate a direct relationship between invalidating environment and smartphone addiction. Our findings emphasize that when parents dismiss, ignore, or punish their children's emotions, they significantly heighten the risk of addictive behaviors, particularly smartphone dependency. This contribution goes beyond previous studies by showing that invalidating environment not only exacerbate psychological and social difficulties but also directly contribute to the development of addiction, an area that has been relatively underexplored. Future research could further examine whether invalidating environment similarly influence other addictive behaviors, such as substance abuse or internet gaming addiction.

Moreover, building upon the I-PACE model (Brand et al., 2016), our findings highlight how negative emotional interactions within the family serve as an external trigger for addictive behaviors. The I-PACE framework explains that addictive behaviors arise from the dynamic interplay between internal vulnerabilities (e.g., emotional distress) and external cues (e.g., smartphone notifications) (Brand et al., 2019; Brand et al., 2016). While this model has been applied to internet gaming (Brand et al., 2019) and substance misuse (Brand and Wegmann, 2021), recent studies have extended it to problematic smartphone use by demonstrating how emotional dysregulation and impulsivity interact with digital triggers to drive overdependence (Cho and Kim, 2025; Elhai et al., 2017). Our study adds a novel layer to this framework by showing that smartphone addiction is significantly influenced by invalidating environment. Specifically, when children experience their emotions being dismissed, ignored, or punished within the family, they are unable to effectively manage or regulate their feelings. This emotional dysregulation increases the likelihood of using smartphones as a coping mechanism, as they provide an immediate way to escape or alleviate negative emotions. Thus, we emphasize that the invalidating environment plays a critical role in the escalation of smartphone addiction,

offering new insights into how external factors can trigger and sustain addictive behaviors.

The mediating roles of RESE and psychache further clarify the mechanisms underlying the relationship between invalidating environment and smartphone addiction. The results of this study indicate that RESE and psychache serve as both independent and chain mediators in this relationship. This finding confirms the critical role of RESE and psychache in the formation of addictive behaviors. This aligns with prior research demonstrating that deficits in emotion regulation and elevated emotional distress are key risk factors for behavioral addictions (Cho and Kim, 2025; Feng and Dou, 2024; Yildiz, 2017). The I-PACE model suggests that when individuals face negative emotions, a lack of effective emotional regulation skills may lead them to engage in addictive behaviors (such as excessive smartphone use) to alleviate these negative feelings (Brand et al., 2019). This process is further maintained and reinforced through positive and negative reinforcement mechanisms, where the addictive behavior provides immediate gratification, such as feelings of pleasure or the avoidance of negative emotions (Brandtner et al., 2021). In this study, invalidating environment lowers child's RESE, making them feel incapable of using positive strategies to manage negative emotions (Bandura et al., 2003; Benfer et al., 2018). The accumulation of negative emotions exacerbates their sense of psychache. This heightened level of psychache drives individuals to seek smartphones as a tool to escape and regulate their emotions. The immediate gratification provided by smartphone use further exacerbates addictive behavior (Elhai et al., 2016; Ting and Chen, 2020). These findings reinforce the I-PACE model's emphasis on the critical interaction between affective vulnerabilities and external triggers in the development of addictive behaviors. Importantly, our study contributes new empirical evidence by demonstrating how invalidation environment, through the disruption of RESE and the intensification of psychache, forms a cascade mechanism that can ultimately lead to smartphone addiction. This underscores the importance of strengthening college students' RESE and alleviating their psychache to interrupt this pathway in preventive and therapeutic interventions targeting smartphone addiction.

In addition to its theoretical contributions, the study suggests potential directions for preventing and intervening smartphone addiction among college students. These approaches emphasize the importance of fostering a supportive family emotional environment and equipping students with the skills to manage their emotions. More specifically, for parents, training and educational programs can be implemented to emphasize the importance of validating their children's negative emotions. These programs aim to enhance parents' ability and sensitivity in responding to their children's negative emotions. By encouraging parents to adopt more positive, warm, and supportive responses, they can develop skills to create a supportive family emotional environment. This approach helps reduce the frequency of triggers for negative emotions in their children, thereby decreasing the factors that contribute to smartphone addiction. For college students, interventions such as training, group counseling, and individual counseling can be used to enhance their RESE, helping them develop positive strategies for managing negative emotions. By improving their ability to handle negative emotions, the accumulation of negative emotions can be reduced, and psychological distress and psychache can be alleviated. This, in turn, disrupts the process where students rely on smartphones to escape negative emotions or seek positive feelings, ultimately reducing the incidence of smartphone addiction. In summary, this study highlights potential strategies at both the family and individual levels that may inform future prevention and

intervention efforts for smartphone addiction, contributing to both research and clinical practice.

The current research has several limitations that future studies should address. First, the cross-sectional design used in this study cannot establish causality. Future research should employ experimental or longitudinal methods to further validate the theoretical model. Second, the data collection relied on self-report questionnaires, which may introduce common method bias and overestimate common variance. Although Harman's one-factor test suggested that common method variance was not a serious concern in our study, it does not fully eliminate the possibility of bias. Future studies should incorporate multiple perspectives and objective measures. For instance, measuring the invalidating environment from both children's and parents' viewpoints could provide a more comprehensive understanding. Third, the Invalidating Childhood Environment Scale is a retrospective measure, which may be affected by recall bias. To address this issue, future research could consider using experimental priming methods to activate the subjective experience of emotional invalidation in the present moment, thereby allowing researchers to examine its causal effects in a controlled setting and reduce reliance on retrospective self-report. Fourth, the convenience sampling method used in this study may not fully represent the entire population of Chinese college students, potentially limiting the generalizability of the findings. Future research should utilize randomized sampling techniques to enhance the generalizability of similar studies. Finally, in addition to the two mediating variables examined in this study, future research could explore alternative explanations and other potential mediating mechanisms between invalidating environment and smartphone addiction, such as personality traits (e.g., neuroticism, impulsivity) or mental health factors (e.g., depression, anxiety); and the possible moderating variables (e.g., classroom climate, peer friendships) in the relationship. Investigating these variables may provide a more comprehensive understanding of the pathways linking invalidating environment and smartphone addiction, and the boundary conditions of their relationship.

Conclusions

This study found that invalidating environment significantly predicts smartphone addiction among Chinese college students, with RESE and psychache serving as both independent and sequential mediators. These findings deepen our understanding of the emotional and cognitive pathways through which invalidating environment dynamics influence smartphone addiction and suggest potential directions for prevention and intervention targeting smartphone addiction. However, given the cross-sectional design, reliance on self-report measures, and use of a convenience sample from a single region, the results should be interpreted with caution. Future studies using longitudinal designs and more representative samples are needed to further validate and extend these findings.

Data availability

Data are available from the corresponding author on reasonable request.

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Author contributions

BBY: Conceptualization, supervision, writing—original draft, writing—review and editing. MSQ: Conceptualization, project administration, investigation, methodology, data curation, formal analysis, writing—original draft, writing—review and editing. Zhj: Investigation and methodology. All authors reviewed the manuscript.

Competing interests

The authors declare no competing interests.

Ethical approval

Ethical approval for this study was obtained from the Ethics Committee of the Department of Psychology, School of Philosophy, Wuhan University (approval reference number: 2018050601; date of approval: 6 May 2018). The scope of this approval covered all study procedures, including participant recruitment, questionnaire survey, data collection, and data analysis, as described in the manuscript. All procedures were conducted in accordance with the ethical standards of the institutional and national research committees, as well as the Declaration of Helsinki and relevant guidelines and regulations. This study did not involve vulnerable or special populations.

Informed consent

Written informed consent was obtained in person by the researcher prior to participation in the questionnaire survey conducted between September and December 2021. All participants were adult university students aged 18 or above, and no minors or other vulnerable populations were included. Each participant received a standardized written consent form outlining the study's objectives and procedures, assuring anonymity and confidentiality, noting potential risks, and emphasizing the voluntary nature of

participation and the right to decline or withdraw at any time without penalty. Before accessing the questionnaire, participants were required to read the consent form carefully and confirm their agreement by signing or electronically acknowledging consent. The form also granted permission for anonymized data to be used for academic research and publication purposes. The study involved no more than minimal risk and did not include any form of physical or psychological intervention. Through this process, all participants provided explicit informed consent prior to their inclusion in the study.

Additional information

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