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## Childhood Risks and Problematic Smartphone Use: Dual Processes of Life History Strategy and Psychological Distress

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### Abstract

*Problematic smartphone use (PSU) and its negative consequences among adolescents are so commonly observed that they have become a matter of public concern. Utilizing life history (LH) theory, this study aims to examine how childhood risks (i.e., childhood harshness and unpredictability) would be associated with adolescent PSU via cognitive and emotional processes of LH strategy and psychological distress. A sample of 459 Chinese high school students aged from 14 to 18 ( $M = 16.90$ ) participated in this study and voluntarily completed an anonymous survey. The results showed that childhood unpredictability and psychological distress were positively correlated with PSU, whereas childhood harshness and the two processes of LH strategy were negatively correlated with PSU. Path analysis further supported a partial mediation model, in which childhood unpredictability increased PSU, via serial mediators of the emotional process of LH strategy and psychological distress. The findings support the efficacy of LH theory in elucidating the development of behavioral addiction. However, the direct and negative association of childhood harshness with PSU was unexpected. It implicates the complexity of childhood environment on adolescent behavioral addictions and warrants further investigation.*

**Keywords:** problematic smartphone use; childhood unpredictability; life history theory; psychological distress; adolescents

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### Introduction

In the last twenty years, smartphones have become one of the most essential devices of modern life in mainland China. The number of smartphone users reached 882 million in 2019, representing a penetration rate of 53% of the population (Statista, 2019, 2020). Moreover, according to the China Internet Network Information Center (2021), 99.6% of users access the Internet via smartphones. Along with the widespread use of smartphones, a high prevalence of problematic smartphone use (PSU) was shown, particularly among adolescents. PSU, also known as smartphone addiction, generally refers to excessive, addictive, and/or inappropriate use of smartphones with adverse consequences (Billieux et al., 2015). Although PSU has not been officially classified as an addictive

disorder, it shares several common symptoms with other behavioral addictive disorders such as gambling and gaming disorders: compulsive use, tolerance, withdrawal symptoms, and functional impairment (Y.-H. Lin et al., 2016). It is also consistently and positively associated with various physical and mental health problems such as musculoskeletal pain (Shah & Sheth, 2018), poor sleep quality (M. X. Zhang & Wu, 2020), and symptoms of depression and anxiety (S.-G. Kim et al., 2019).

## **PSU in Adolescents**

Over one-fifth of adolescents exhibit addictive use of smartphones (Zou et al., 2019), with an increasing trend observed in recent years (e.g., Buctot et al., 2023; Vaghasiya et al., 2023), likely due to adolescents having weaker self-control than adults (Casey & Caudle, 2013). Given its high prevalence rate and its negative health impacts, PSU has been drawing increasing research attention in recent years.

According to the Interaction of Person-Affect-Cognition-Execution (I-PACE) model (Brand et al., 2019), childhood experiences are considered biopsychological constitutions for the development of technological addictions in adolescence and adulthood. Empirical data support this claim by showing that adolescents from disadvantaged backgrounds (e.g., divorced families and lower SES) tend to exhibit a higher level of PSU (F.-C. Chang et al., 2019), while childhood neglect and psychological abuse are related to a higher risk of PSU in Chinese adolescents (Sun et al., 2019). A three-wave longitudinal study also found that early childhood SES, childhood unpredictability, and parent-child relationships had impacts on the development of adolescents' PSU (Lai et al., 2022). While these findings shed important light on the childhood antecedents of PSU, the research effort so far is somewhat fragmented and lacks a cohesive theoretical framework that elucidates a comprehensive examination of the underlying mechanism between childhood experiences and PSU. Therefore, this study aims to fill the research gap by utilizing life history (LH) theory, a macro-level framework that describes how individuals respond to the environment and maximize fitness in the life cycle (Ellis et al., 2009; Figueredo et al., 2006).

## **LH Theory and PSU**

LH theory asserts that individuals' allocation of finite resources such as time and energy to various activities pertaining to growth and reproduction is related to the environments in which the individuals find themselves (Ellis et al., 2009; Figueredo et al., 2006). The childhood environment is particularly important for one's resource allocation style and well-being in adolescence and adulthood (Belsky et al., 1991). Within LH theory, two specific facets of childhood environments may pose risks to individuals: (i) childhood harshness, defined as the morbidity-mortality rate in the early stage of one's life, commonly assessed by childhood socioeconomic status (CSES; Ellis et al., 2009); and (ii) childhood unpredictability, referring to the extent of stability of the local environment that a child experiences (Doom et al., 2016; Ellis et al., 2009). As expected, childhood risks such as harsh parenting, physical abuse/neglect, emotional abuse/neglect, and unstable family lives (e.g., resulting from parental separation and/or divorce) have been found to be linked to mental health problems (Hughes et al., 2017; Liu, 2017). Childhood risks were also positively associated with addictive behaviors such as gambling and excessive Internet and/or social media use (Lim et al., 2020; Seo et al., 2020).

According to LH theory, the negative associations between childhood risks and addictive behaviors, including PSU, can be elucidated by one's adoption of a specific style of resource allocation (i.e., LH strategy), determined by their childhood environment (Belsky et al., 1991; Lu & Chang, 2019). By definition, LH strategy is a specific term used in LH theory to describe how an individual allocates resources between the present and future in developmental environments (Belsky et al., 2012; Ellis et al., 2009), characterized as a continuum from "fast" (prioritizing present fitness) to "slow" (prioritizing future fitness; Ellis et al., 2009). The development of LH strategy is presumed to be evolutionarily adaptive to the environment for reproductive fitness (Hurst & Kavanagh, 2017). LH theory posits that a poorer and more unstable childhood environment results in faster LH strategy (Ellis et al., 2009). There are accumulating empirical data supporting the applicability of LH theory in explaining inter-individual differences in behavioral outcomes by considering the variances of individuals' LH strategy resulting from phenotypic plasticity in response to environmental cues, with harsher environment priming leading to faster LH strategy (e.g., L. Chang et al., 2019; Del Giudice et al., 2014).

Previous research has clearly shown variances in psychological traits or behavioral patterns (e.g., sexual debut, age of reproduction, impulsivity, and reward preference) across cultures along the fast-slow LH continuum (e.g., L. Chang et al., 2019; MacDonald, 1997; Salas-Rodríguez et al., 2021). For instance, individuals with faster LH

strategy tend to focus more on immediate rewards and be more willing to take risks for reward, whereas those with slower LH strategy tend to show opposite preferences (Amir et al., 2016; Giudice et al., 2015). LH strategy can also be manifested as cognitive and emotional processes in terms of their psychological features (Figueredo et al., 2006; Zhu et al., 2018). A cognitive process refers to impulse/cognitive control, planning, and future orientation, whereas an emotional process refers to emotional attachment and connections with others (Zhu et al., 2018). Individuals with faster LH strategy have been found to adopt higher levels of present orientation and weaker impulse and cognitive control (e.g., Copping et al., 2013; Griskevicius et al., 2011; Mittal & Griskevicius, 2014). In terms of emotional process, faster LH strategy is associated with higher likelihood of insecure attachment, poor social relationships, less social connection, and weaker support (Szepeswol & Simpson, 2019; Zhu et al., 2018).

Despite its potential evolutionary benefits in harsh and unstable environments, faster LH strategy may not always lead to socially desirable outcomes in contemporary societies. For example, previous research has shown that individuals with faster LH strategy are more vulnerable to addictions (e.g., alcohol use disorder, food addiction, substance use, and gambling disorder; Richardson et al., 2014; Tifferet et al., 2011; H. Zhou et al., 2023). This vulnerability is plausible due to the psychosocial and/or behavioral features (e.g., preference for immediate gratification) of faster LH strategy, which increases engagement in addictive behaviors. Indeed, self-control and self-regulation are core protective traits against addiction development (Wills et al., 2016), with their foundation for further development established at a young age (Davidson et al., 2015). Although there is good evidence for the link between LH strategy and addictive behaviors, the relative influences of emotional and cognitive processes of LH strategy on one's susceptibility to addictions deserve further investigation. This study particularly aimed to gain better knowledge of the independent roles of cognitive and emotional processes on the association between childhood risks and PSU in adolescents. Studying these dual processes can inform us not only on the role of LH strategy on PSU, but also address the relative importance of these processes in the development of addictive behaviors among adolescents who have experienced childhood risks.

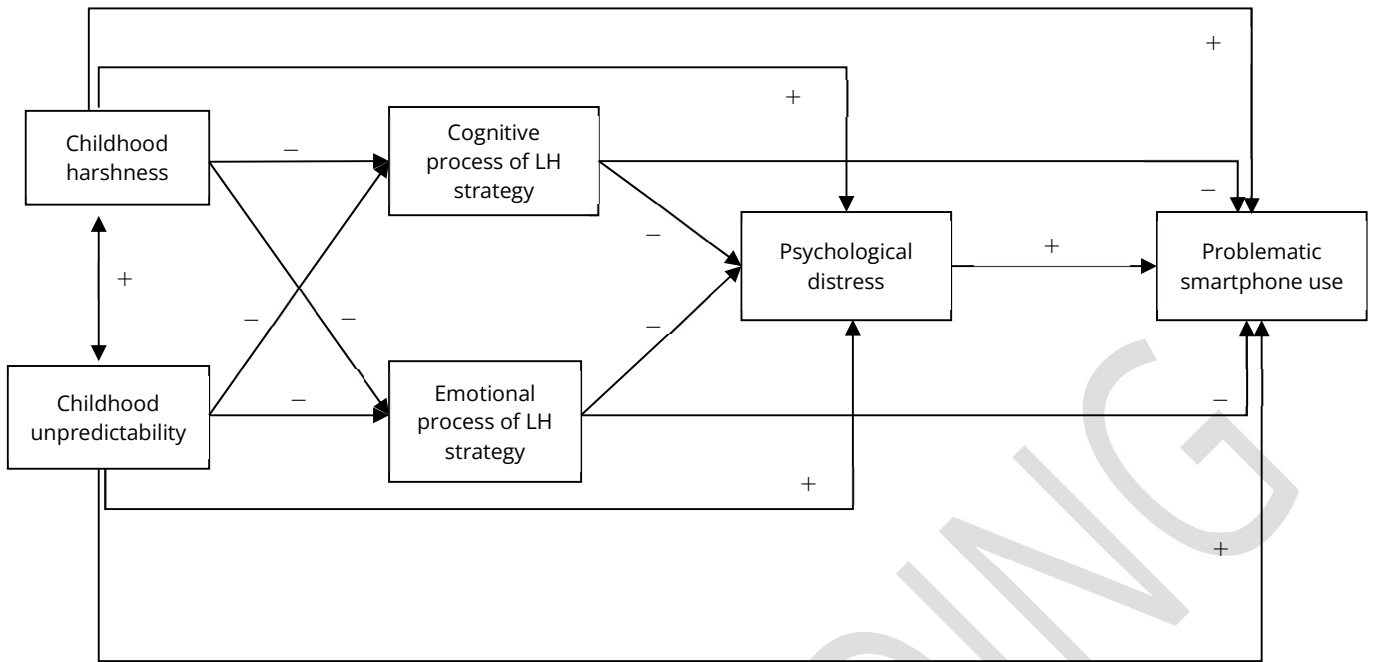
## **The Role of Psychological Distress**

The I-PACE model proposes that negative emotional responses (e.g., psychological distress), triggered by external and internal stressors, are salient psychological antecedents of addictive behaviors, including PSU (e.g., Gu et al., 2024; Ji et al., 2021; H. S. Kim et al., 2023). Previous studies have consistently demonstrated the risk effect of psychological distress on addictive Internet and smartphone use in both adults (Elhai et al., 2020; Teng et al., 2021; Wu et al., 2018) and adolescents (Chen et al., 2021; G. Li et al., 2019). As noted in the I-PACE model, technological devices such as the Internet and smartphones are major means of social interaction, entertainment, and coping with (di)stress, particularly for adolescents (Meng et al., 2020; Squires et al., 2021). Adolescence, a developmental stage characterized by rapid physical and behavioral changes, is often a time of mental and emotional turbulence that could lead to increased mental distress or disorders (Paus et al., 2008). Based on the LH framework for psychopathology (Hurst & Kavanagh, 2017), faster LH strategy would be positively related to the incidence of psychopathology, including depression and anxiety, as those with faster LH strategy are more prone to social, emotional, and psychological difficulties when growing up in unstable and adverse environments. Indeed, previous research has also shown that negative childhood environments and experiences, as well as faster LH strategy, are associated with depression and/or anxiety (Gardner et al., 2019; Yang et al., 2022). Therefore, this study would include psychological distress into the LH framework and empirically explore the potential mediating roles of the dual processes of LH strategy and psychological distress in the associations between childhood risks and PSU.

## **The Present Study**

Based on the above theorization, this study proposed a conceptual model (Figure 1) that depicts the mediating roles of cognitive and emotional processes of LH strategy and psychological distress on the relationship between psychosocial environmental factors in childhood (i.e., childhood harshness—low CSES, and childhood unpredictability) and PSU. We hypothesized childhood harshness and childhood unpredictability to be the exogenous variables that would negatively predict not only both cognitive and emotional processes of LH strategy but also psychological distress and PSU. The cognitive and emotional processes of LH strategy would also be negatively associated with psychological distress, which in turn would be positively associated with PSU.

**Figure 1. The Hypothesized Model.**



Note. LH strategy: Life history strategy. The residuals of emotional and cognitive processes of LH strategy were allowed to covary but not shown in the figure.

## Methods

### Participants and Procedures

Four hundred and sixty-six high school students from a public school in Hebei, China, participated in the study and voluntarily completed an anonymous survey in the Chinese language in June 2019. Seven participants, aged over 18 years old, were excluded from the final sample. Therefore, 459 students (61.9% female) aged between 14 and 18 ( $M = 16.90$ ,  $SD = 0.62$ ) were used in the subsequent data analyses.

Before filling out the survey, all participants were informed of their rights to anonymity, confidentiality, and withdrawal. They signed a consent form indicating their voluntary participation without any compensation. They responded to a paper-and-pencil questionnaire in their classrooms. A trained research assistant was present to offer assistance as required but otherwise did not intervene in the administration of the questionnaires. All the materials and data were kept confidential in the assistant's laboratory. Ethics approval was obtained from the research ethics committee of the corresponding author's institute.

### Measures

#### PSU

It was assessed by Smartphone Addiction Inventory (SPAI) developed among Chinese youths by Y.-H. Lin et al. (2014). It included 26 items (e.g., *I feel restless and irritable when the smartphone is unavailable*) with a 4-point Likert response scale (1 = *strongly disagree* to 4 = *strongly agree*). A total score was computed, with a higher score indicating a higher level of PSU. The reliability of SPAI was .89 in this study.

#### Cognitive and Emotional Processes of LH Strategy

The two processes were measured by the K-SF-42 (Short Form of Arizona Life History Battery; *K* being a specific symbol in population biology originally referring to the resource allocation strategy for maximizing longevity rather than gamete production; Figueredo et al., 2005, 2017) and reflect one's LH strategy on the "fast-slow" continuum. The scale has also been validated among Chinese students (M. X. Zhang et al., 2020).

The cognitive process was assessed by the dimension of Insight, Planning, and Control of the K-SF-42, which consists of 6 items (e.g., *I can find something positive even in the worst situations*; future-oriented planning; and

*When I encounter problems, I don't give up until I solve them*; personal control) on a 7-point Likert scale (−3 = *strongly disagree* to 3 = *strongly agree*). A higher total score on these items indicated slower LH strategy adoption, emphasizing future-oriented planning and personal control.

The emotional process was measured by three dimensions: Mother/Father Relationship Quality, Family Contact and Support, and Friend Contact and Support (Figueredo et al., 2017), totaling 18 items (e.g., *How much time and attention did your biological father give you when you needed it?*) on a 4-point scale (0 = *not at all* to 3 = *a lot*). A higher total score represented a higher level of adoption of slower LH strategy, emphasizing the establishment and experience of affective attachment and bonding. The reliabilities were .88 and .89, respectively, in this study.

### **Psychological Distress**

It was measured by the Chinese version of Lovibond and Lovibond's (1997) Depression Anxiety and Stress Scale (DASS-21; Taouk et al., 2001). The scale includes three dimensions of psychological distress, with 21 items (e.g., *I found myself getting upset rather easily*) on a 4-point Likert scale (0 = *Do not apply to me at all* to 3 = *Apply to me very much*). A higher total score represented a greater level of psychological distress. The Cronbach's alpha of this scale was .93 in this study.

### **Childhood Harshness**

It was indicated by one's socioeconomic status in childhood (Belsky et al., 2012; Doom et al., 2016) and assessed by a 4-item scale (i.e., the childhood socioeconomic status; CSES scale) that was adopted from the 3-item measure for CSES proposed by Giskevicius et al. (2011) and validated in a Chinese sample by Wang et al., (2017). This 4-item scale has been commonly used in previous studies in Chinese populations (e.g., M. X. Zhang et al., 2020; P. Zhang et al., 2024). Participants responded to four items (e.g., *My parents had a higher social status in the neighborhood when I was growing up*) on a 7-point Likert response scale (1 = *strongly disagree* to 7 = *strongly agree*). Each item score was reversed and then summed up, with a higher score indicating a higher level of childhood harshness. The internal consistency of the CSES scale was .85 in this study.

### **Childhood Unpredictability**

Referring to previous studies (M. X. Zhang et al., 2020; Y. Q. Zhou et al., 2018), a 7-item measure was used to assess childhood unpredictability. The measure requires the participants to assess the extent of their (unstable) childhood situations regarding family income, residence, and parenting. Participants answered all items on a 5-point Likert response scale (0 = *no* to 4 = *severe*). A sample item of the measure is *Parents or other members of the family often quarrel*. A higher mean score indicated a higher level of unpredictability in participants' earlier lives. The internal consistency was .68 in this study.

### **Background Information**

Gender (0 = *female*, 1 = *male*), age (years), and length of daily smartphone use (hours) were included in this study.

### **Data Analyses**

Preliminary statistics (i.e., descriptive statistics and correlation coefficients) were calculated in SPSS 24. The proposed path analysis model (Figure 1) was tested by AMOS 24. Following the recommendation of Hair et al. (2006), we evaluated the model fit by the following fit indices: Comparative Fit Index (CFI), Goodness of Fit Index (GFI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR). Moreover, based on the bias-corrected percentile method, standardized coefficients were estimated with a 95% confidence interval by 10,000 bootstrap samples.

# Results

## Preliminary Analysis

All participants reported that they were smartphone users with access to smartphones. Nearly half of them (49.7%) spent over 5 hours on smartphone use every day. Table 1 shows the main variables' means, standard deviation, and bivariate correlation coefficients. Age was not significantly associated with PSU nor with any other variables. Gender was correlated with childhood unpredictability ( $r = .09, p < .05$ ) and cognitive process ( $r = .10, p < .05$ ), with boys reporting higher levels of childhood unpredictability and greater adoption of the cognitive process of LH strategy.

**Table 1.** The Descriptive Information and Correlation Coefficients Among All the Variables ( $N = 459$ ).

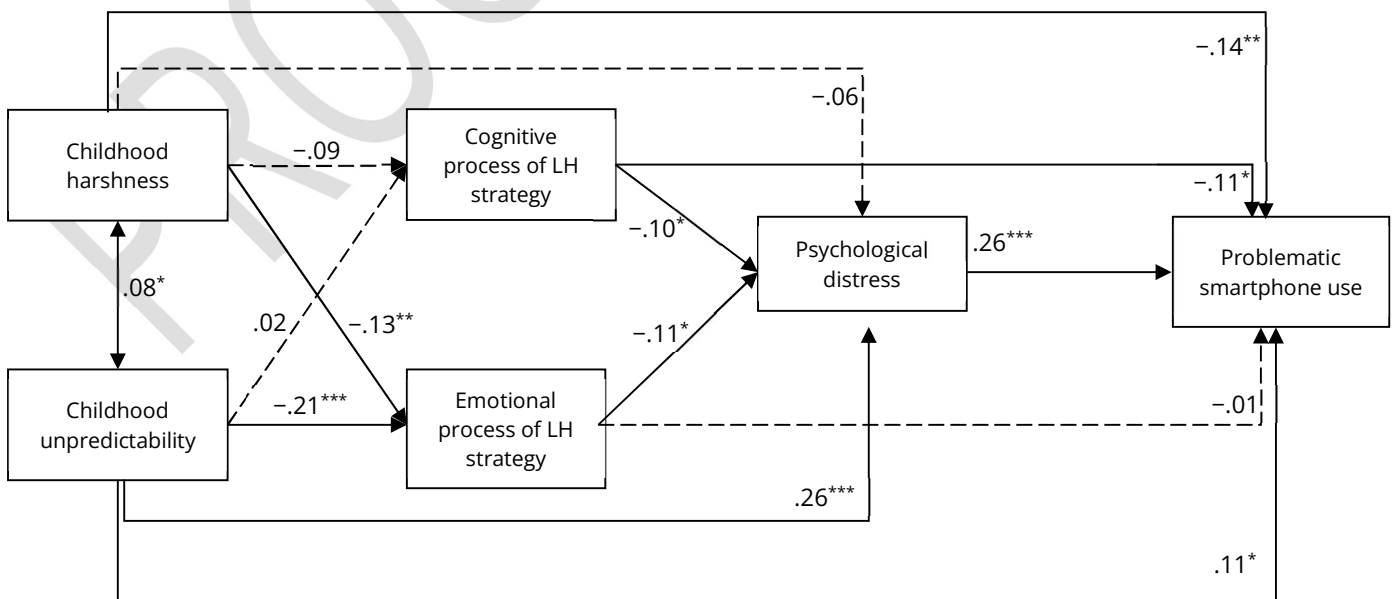
	<i>M</i>	<i>SD</i>	1	2	3	4	5	6	7	8
1. Problematic smartphone use	61.48	10.62	-							
2. Psychological distress	15.70	12.24	.31***	-						
3. Cognitive process of LH strategy	6.80	5.68	-.13**	-.12*	-					
4. Emotional process of LH	34.08	9.50	-.10*	-.19***	.30***	-				
5. Childhood harshness	5.03	1.27	-.13**	-.01	-.08	-.14**	-			
6. Childhood unpredictability	0.79	0.64	.17***	.28***	.03	-.22***	.08	-		
7. Age	16.90	0.62	-.02	.01	.08	.05	.02	.05	-	
8. Gender	-	-	-.03	-.03	.10*	-.05	.07	.09*	-.02	-

Childhood unpredictability and psychological distress had positive and significant correlations with PSU ( $r = .17$  and  $.31, p < .001$ ). Childhood harshness as well as the emotional and cognitive processes of LH strategy, were negatively associated with PSU. Moreover, both childhood harshness and unpredictability had significant and negative correlations with the emotional process of LH strategy ( $r = -.14, p < .01$  and  $r = -.22, p < .001$ ), but not with the cognitive process ( $p > .05$ ).

## Path Analysis

The proposed partial mediation model (Figure 1) was tested by path analysis. Gender was included as a control variable for childhood unpredictability and cognitive process given its significant correlations with them. Model fit indices reached the satisfactory levels:  $\chi^2(4) = 4.04, \chi^2/df = 1.01, p = .401, CFI = 1.000, GFI = .997, RMSEA = .005, 90\% CI [.000, .071], SRMR = .019$ . All the path coefficients of the final partial model are shown in Figure 2.

**Figure 2.** The Final Model.



Note. \* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$ . LH strategy: Life history strategy. The residuals of emotional and cognitive processes of LH strategy were allowed to covary but not shown in the figure.

Bootstrapping approach for direct and indirect effect tests showed both childhood harshness and unpredictability having significant direct but opposite effects on PSU, with childhood harshness's effect being negative,  $\beta = -.144$ , 95% CI [-.239, -.042], while childhood unpredictability's effect being positive,  $\beta = .110$ , 95% CI [.008, .209]. The indirect effect of childhood harshness on PSU was not significant,  $\beta = .003$ , 95% CI [-.033, .037], but it had a significant indirect effect on psychological distress,  $\beta = .022$ , 95% CI [.004, .051]. On the other hand, the indirect effect of childhood unpredictability on PSU was significant, and this was through the emotional process of LH strategy and psychological distress, and through psychological distress alone,  $\beta = .074$ , 95% CI [.029, .124]. Moreover, cognitive and emotional processes of LH strategy also exerted negative indirect effects through psychological distress on PSU,  $\beta = -.026$ , 95% CI [-.056, -.003] and  $\beta = -.028$ , 95% CI [-.067, -.001] respectively. The summary of the coefficients of both direct and indirect effects in the final partial model explains 13.5% of the variance in PSU.

## Discussion

Smartphones have gradually become an essential part of daily life for Chinese adolescents (Cha & Seo, 2018). Our findings showed that many of our Chinese adolescent participants used smartphones for long hours (i.e., five hours or above) every day. Based on LH theory, the present study proposed and tested a conceptual model that denoted the effects of childhood environment risk factors (i.e., high childhood harshness and unpredictability) on PSU via dual processes of LH strategy (i.e., emotional and cognitive processes) and psychological distress. Results of path analysis showed that this conceptual model generally fitted the data well. Childhood harshness and unpredictability were significantly and negatively related to the emotional, but not cognitive, process of LH strategy. The emotional process of LH strategy was negatively related to psychological distress, which was positively associated with PSU.

Based on LH theory, LH strategy explains how the cues of environmental risks lead to individuals showing distinct psychological features in emotional and cognitive processes that prompt risk-taking behaviors, antisocial behaviors, or even addictive behaviors (Del Giudice & Belsky, 2011; M. X. Zhang et al., 2023; Zhu, 2018). Our findings lend support to the application of LH theory to PSU by demonstrating that self-reported harshness and unpredictability in the childhood environment harm the emotional process of LH strategy, which then promotes both psychological distress and PSU in this adolescent sample. Previous studies have shown that individuals with slower LH strategy would develop stronger emotional bonds and social connections with others, whereas individuals with faster LH strategy tend to exhibit weaker bonds and connections (Zhu et al., 2018). These patterns could be explained by a more secure attachment style among those who grew up in a stable and abundant environment (Lu et al., 2022). Moreover, consistent with previous research that showed that individuals lacking social support or connections tend to suffer in their mental health (e.g., Orben et al., 2020; Qi et al., 2020), our findings reflected a negative effect of the emotional process of LH strategy on psychological distress and PSU in adolescents. Although our study showed a relatively weak or even non-significant relationship between childhood risk factors and the cognitive process of LH strategy, the cognitive process also exerted negative effects on psychological distress and PSU. In the previous studies, consistent results suggested environmental factors, especially for childhood risks, influence the development of fast/slow LH strategy (Ellis et al., 2009), which was regarded as a whole psychological structure. As many features exist in LH strategy, including psychological ones, our findings further reflect that childhood risks seem to have more effects on psychological features related to the emotional process of LH strategy.

The relationship between LH strategy and PSU that our conceptual model hypothesized and our data confirmed further supports the application of LH theory to behavioral addiction. Specifically, the cognitive process of LH strategy had both negative direct and indirect (via psychological distress) effects on PSU. These results add to an increasing amount of empirical evidence that suggests that a cluster of related traits in LH dimensions (short vs. long time perspectives, immediate vs. delayed rewards, and high vs. low levels of risk-taking) tend to exert opposite effects on individuals' mental and behavioral health (Figueredo et al., 2006). Furthermore, the emotional process of LH strategy only exerted an indirect effect via psychological distress on adolescents' PSU. Lower emotional attachment and less social support would trigger more depression or anxiety (Peñate et al., 2020), which further contributes to adolescents' PSU. While further replication is needed, the finding suggests addictive behaviors such as problematic smartphone and/or Internet use may stem from some types of fitness-enhancing functions. From the LH perspective, immersing in behaviors that lead to immediate rewards may be more rational than engaging in activities that require long-term investment if one's environment is outside of one's control. As constructive use

of smartphones and digital media can provide immediate and positive outcomes ranging from enhanced productivity (Bertschek & Niebel, 2016) to facilitated social engagement (Y. Kim et al., 2016), it is not difficult to see why smartphone use could start as “adaptive” behavior that contributes to adolescents’ attempt to control their environment.

Consistent with previous studies (e.g., Della Vedova et al., 2022; Yue et al., 2021), our study showed psychological distress as a significant correlate of PSU. According to the pathway model of PSU (Billieueux et al., 2015), PSU may stem from the desire to obtain reassurance and to cope with emotional vulnerability and distress. Therefore, when people are experiencing a higher level of depression, anxiety, and/or stress, they may become vulnerable to PSU. More importantly, psychological distress was found to mediate the effects of emotional and cognitive processes of slow LH strategy on PSU. Furthermore, the effect of childhood unpredictability on PSU was also mediated by psychological distress. Previous research consistently demonstrated the impact of childhood adversity on psychological distress (e.g., anxiety and depression; Daryanani et al., 2016; Hazel et al., 2008), a salient predictor of PSU (e.g., Lee et al., 2016; Pera, 2020). While our finding is coherent with previous findings on other mental disorders like depression and anxiety (Hurst & Kavanagh, 2017), it also extends the explanation of the effects of LH strategy on both emotional and cognitive processes on adolescents’ mental health. For adolescents, it seems psychological distress does not only impair their mental health, but it is also one of the underlying mechanisms that link environmental factors and LH strategy to PSU.

Apart from indirect effects via LH strategy and psychological distress, childhood unpredictability also had a direct positive effect on PSU, suggesting that those who went through unstable and adverse childhood experiences (e.g., parental separation and/or divorce, emotional and/or physical neglect/ abuse) were more likely to develop behavioral addiction in adolescence. As proposed by the I-PACE model, childhood experiences serve as biopsychological constitution factors and thus salient determinants of one’s vulnerability to behavioral addictions such as problematic Internet-related use. Our finding is also consistent with the risk-enhancing effect of adverse childhood experiences (e.g., Physical/emotional neglect or abuse) on PSU reported in previous research (e.g., W. Li et al., 2020; Lim et al., 2020). Although the current study adds to the existing literature by elucidating two mechanisms (i.e., via LH strategy formation and increased susceptibility to psychological distress) underlying the link between an unstable childhood environment and adolescent PSU, other underlying biopsychosocial mechanisms may also exist and deserve further investigation. Moreover, it is important to note that there was a negative direct effect of childhood harshness (measured by CSES in the current study). This suggests that adolescents from advantaged families (demonstrated by high SES in childhood) are more likely to exhibit problematic smartphone use. This finding can be plausibly attributed to the multiple pathways through which CSES influences PSU. For example, Y. Lin and Liu (2020) found a positive indirect effect of SES on PSU via higher levels of online psychological need satisfaction but a negative indirect effect via relative deprivation. So, Chinese adolescents growing up from advantaged families may have more access to smartphones or have more opportunities to own a smartphone, which allows them to spend more time on its functions.

Some limitations of this study, along with their implications for future research directions, should be noted. First, convenience sampling may limit the generalization of findings to the entire adolescent population. The current findings should be further tested in a more representative sample of adolescents, encompassing a wider age range and cultural diversity. Second, our cross-sectional survey design precluded the examination of prospective or causal effects of external environments and internal mechanisms on PSU. Longitudinal or experimental research is warranted to verify the replicability of the findings regarding the proposed mediations. Moreover, the assessment tools may introduce self-reported biases. Objective data, especially for PSU, could be collected using advanced technology (e.g., mobile tracking applications for smartphone usage) in future studies. Additionally, the measurement of childhood unpredictability relied on retrospective data of early life events, which might be susceptible to recall bias and suffer from lower reliability and validity (Hardt & Rutter, 2004; Paterniti et al., 2017). Evaluating one’s childhood experience through reports from significant others, such as parents, could be considered in future studies to address this issue. Given the unexpected association between CSES and PSU observed, future studies may not only further examine potential underlying mechanisms, but also consider using other indicators for childhood harshness to ascertain whether similar relationships are observed. Based on the current path model of PSU, studies could expand it to include other psychological potential mediators (e.g., motivations of use) and/or extend it to other addictive behaviors for a more comprehensive understanding of pathways for addiction development in contemporary societies. This would aid in designing cost-effective interventions.



## Conflict of Interest

The authors have no conflicts of interest to declare.

## Authors' Contribution

**Meng Xuan Zhang:** conceptualization, data curation, formal analysis, methodology, visualization, writing—original draft. **Lisbeth Ku:** data curation, writing—review & editing. **Anise M. S. Wu:** supervision, funding acquisition, investigation, project administration, writing—review & editing.

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