Smartphone Addiction Control Model: Mechanisms of Loneliness, Anxiety, Self-Control, and Motivation (Postprint)

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Abstract

[目的]Mobile phone addiction constitutes a major factor affecting individuals' physiological and psychological well-being in the information technology era, and research on the development pathways of mobile phone addiction can provide more scientific and personalized solutions for its intervention and treatment. [方法]Literature review. [结果]Previous research investigating the development pathways of mobile phone addiction has drawn upon definitions and models of internet addiction, primarily employing questionnaire survey methods to construct single mediation or moderation pathways for mobile phone addiction. [局限]There is a lack of a distinctive definition of mobile phone addiction and integration of addiction factors and their pathways. [结论]This paper first proposes a distinctive definition of mobile phone addiction, then integrates multiple pathways of mobile phone addiction to establish a dynamic control model with loneliness and anxiety as mediators and self-control and motivation as moderators, and finally reviews cognitive experimental findings on mobile phone addiction to provide a comprehensive and thorough scientific basis for intervention.

Full Text

Preamble

Smartphone addiction represents a primary factor affecting people' s physical and mental health in the information technology era. Investigating the pathways through which smartphone addiction develops can provide more scientific and personalized frameworks for intervention and treatment. Previous research exploring these pathways has primarily relied on questionnaire methods, constructing single mediation or moderation models based on definitions and patterns borrowed from internet addiction research. However, these approaches

suffer from two key limitations: the lack of a distinctive definition of smartphone addiction and the absence of integration among addiction factors and their pathways. This paper addresses these gaps by first proposing a distinguishing definition of smartphone addiction, then integrating multiple pathways to establish a dynamic control model with loneliness and anxiety as core mediators and self-control and motivation as moderators. Finally, we review cognitive experimental findings on smartphone addiction to provide comprehensive scientific evidence for intervention strategies.

Keywords: distinctive definition of smartphone addiction; pathways of smartphone addiction; dynamic model; intervention strategies; cognitive experiments

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1. Distinctive Definition of Smartphone Addiction

The conceptual ambiguity surrounding smartphone addiction primarily stems from the interchangeable use of terms such as smartphone addiction, internet addiction, and mobile phone dependence. Based on historical definitions of smartphone addiction and the measurement dimensions of existing scales, we can distinguish smartphone addiction from internet addiction. While both essentially constitute behavioral or technological addictions, smartphone addiction exhibits unique characteristics in content, form, and impact severity. Furthermore, research indicates that mobile phone dependence and addiction differ in degree—dependence represents a preparatory stage where physiological changes are not yet pronounced, whereas addiction involves pathological symptoms. Despite terminological differences, both concepts emphasize the physical and psychological harm caused by excessive use. Therefore, this review adopts the definition proposed by Xiong et al. (2012): smartphone addiction or dependence refers to physical or psychological discomfort symptoms resulting from inappropriate mobile phone use.

1.1 Distinction Between Smartphone Addiction and Internet Addiction

Researchers have drawn on internet addiction concepts for two main reasons: internet addiction research predates smartphone addiction and has matured considerably, while the behavioral symptoms of smartphone addiction—withdrawal, salience, and compulsivity—mirror those of internet addiction. Liu et al. (2017) identified two major similarities: conceptual overlap (smartphone addiction includes aspects of internet addiction such as information-seeking and gaming) and similar scale items across years, both emphasizing withdrawal, conflict, relapse, and compulsivity dimensions. However, recent scale development has revealed distinctive features of smartphone addiction. Su et al. (2014) highlighted new characteristics such as APP usage and updates in their College Student Smartphone Addiction Scale, while Chen et al. (2017) added clinical

pathological features like eye and neck pain from excessive use—the hallmark of the "head-down tribe."

Beyond scale development, fundamental differences between mobile phones and computers as media create significant distinctions. As illustrated in [Figure 1: see original paper], these differences have been noted extensively in domestic and international literature. Recent reviews emphasize that smartphones, as composite media, offer multi-channel influences, greater convenience, and human-centered design while serving as status symbols (e.g., pursuit of Apple brand updates). This accessibility increases addiction opportunities, with dependence on smartphones exceeding that on computers. Kim et al. (2018) found that smartphone addiction has greater impact on anxiety and depression than internet addiction due to easier access and convenience.

Addiction subjects also differ significantly. While internet addiction predominantly affects males, smartphone addiction shows higher rates among females. Smartphone addiction begins at earlier ages and affects broader populations. Research on personality types indicates that Type A individuals (high desire and anxiety) lack regulatory strategies when facing stress and emotional problems, making them more prone to excessive smartphone use. Domestic studies have also found smartphone addiction closely related to neuroticism, psychoticism, and introversion-extraversion dimensions.

In summary, smartphone addiction is a more complex concept than internet addiction, sharing similarities while exhibiting new characteristics. However, domestic research has overlooked internal relationship models, such as whether original internet addicts transitioning to smartphone addiction experience greater impact than new smartphone addiction groups—the digital native versus digital immigrant distinction.

1.2 Degrees and Types of Smartphone Addiction

Excessive smartphone use affects physical and mental health, with scholars naming it mobile phone dependence, smartphone addiction, or problematic mobile phone use based on severity. Bianchi and Phillips (2005) developed the Mobile Phone Problem Usage Scale (MPPUS), focusing on inappropriate usage contexts and financial debt without mentioning physiological or psychological problems. Walsh et al. (2007) conceptualized smartphone addiction as comprising three aspects: withdrawal, salient behavior, and uncontrollability/compulsivity. While dependence and problematic use focus on usage time and inappropriate use, addiction adds pathological characteristics. Domestic research recognizes this distinction, viewing dependence as a preparatory stage without significant physiological changes. However, most studies on mobile phone dependence actually use Xiong et al.' s (2012) Mobile Phone Addiction Tendency Scale, which measures pathological addiction dimensions: withdrawal, salience, social comfort, and mood alteration. This measurement consistency allows us to incorporate mobile phone dependence research findings.

The definition of smartphone addiction has evolved from interpersonal tool dependence to behavioral addiction involving physiological and psychological maladjustment, then to operational definitions completing the transition from substance to behavioral and technological addiction. This review adopts Xiong et al.' s (2012) definition emphasizing discomfort symptoms from inappropriate use.

When classifying smartphone addiction types, communication scholars argue people use media to satisfy specific needs. Based on functional usage, Tu et al. (2010) identified three main purposes: interpersonal communication, entertainment, and information gathering. Woong (2005) distinguished between habitual motivations (time-killing, escapism) and instrumental motivations (entertainment, arousal). Thus, smartphone addiction includes entertainment addiction, information addiction, and social networking addiction. Research methods divide into two categories: questionnaire-based pathway analysis (focusing on loneliness, anxiety, self-control, and motivation) and experimental studies examining cognitive abilities. Through synthesizing mediation models, we construct a dynamic control model with loneliness and anxiety as core mediators and self-control and motivation as moderators, then review cognitive experiments to explain intervention mechanisms.

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2. Dynamic Control Model of Smartphone Addiction: Loneliness and Anxiety as Core Mediators, Self-Control and Motivation as Moderators

[Figure 1: see original paper] illustrates the smartphone addiction dynamic control model. International models such as Billieux et al. (2015) have proposed three pathways: (1) excessive reassurance-seeking among individuals with insecure attachment and social anxiety; (2) impulsivity and low self-control leading to problematic use; and (3) extraversion driving motivation for extensive social networking. Analyzing these mechanisms in the Chinese context reveals that smartphone addiction relates to loneliness and anxiety from lack of social support, impulsivity and low self-control, and social/entertainment motivations. Individual physiological-psychological traits and social relationships affect smartphone addiction directly or indirectly through loneliness, anxiety, self-control, and motivation, forming multiple pathways as shown in [Figure 1: see original paper].

Before examining the core mediating roles of loneliness and anxiety and the moderating roles of self-control and motivation, we first review their direct effects on smartphone addiction.

[Figure 2: see original paper] depicts these direct relationships. Loneliness represents a subjective state of social isolation accompanied by painful feelings of rejection. It directly predicts smartphone addiction—individuals with higher

loneliness use phones to cope with or avoid isolation, developing dependence. Anxiety involves fear responses to evaluative situations; smartphones effectively reduce real-world anxiety through online social interaction. According to the social compensation hypothesis, high social anxiety individuals prefer "safer"online communication to compensate for real-world social discomfort, making social anxiety a significant predictor of smartphone addiction. Loneliness and anxiety also interact, with studies showing significant positive correlations. In lonely states, people experience anxiety, emptiness, helplessness, and despair, while smartphone functions can fundamentally eliminate anxiety caused by loneliness. Thus, loneliness and anxiety are core direct predictors of smartphone addiction.

Self-control and motivation also predict smartphone addiction. Self-control refers to the ability to inhibit desires and change habitual behaviors, negatively correlating with addiction across its four dimensions: impulse control, work focus, entertainment moderation, and temptation resistance. According to Baumeister's (1982) self-control energy model, self-control depends on limited psychological resources consumed by information processing and social interaction. Smartphones, as carriers of multiple content types, deplete these resources differently. Smartphone addiction reduces self-control, which in turn affects addiction severity. Motivation, explaining the internal reasons for behavior, influences smartphone addiction and mediates the loneliness-addiction relationship. While motivations include entertainment and interpersonal use, entertainment motivation primarily drives addiction. Katz' s uses and gratifications theory suggests media contact satisfies needs for information, conformity, fashion, and emotional catharsis, which regulate smartphone use. The direct effects of loneliness, anxiety, self-control, and motivation on smartphone addiction have been validated internationally.

2.1 Social Support Pathways to Smartphone Addiction

[Figure 3: see original paper] illustrates the relationship between social support and smartphone addiction. Social support—information conveying love, worth, and being needed—protects individuals from adverse environments and correlates with well-being and mental health. Wu (2018) proposed three mechanisms: main effect model (direct protection), buffering model (enhancing coping abilities and reducing negative emotional impact), and third-state model (stress response).

From the main effect model, social support negatively correlates with smartphone addiction. Analyzing subjective support, objective support, and support utilization reveals that while social support as a latent variable negatively predicts smartphone addiction, objective support' s impact is not significant. This finding, consistent with Chen (2015), suggests social support affects addiction through subjective support and utilization influencing loneliness. Individuals with high loneliness have poorer peer relationships and lower acceptance levels, with loneliness negatively predicting friendship quality and triggering social anxiety, thereby affecting addiction levels. Li and Zhang (2015) confirmed that

lack of social support increases loneliness, which in turn increases smartphone addiction, with loneliness playing a partial mediating role. This protective effect extends to pregnant women in early pregnancy—when they perceive family and friend support, loneliness and depression decrease, regulating excessive use.

Social support also affects smartphone addiction through the buffering model by alleviating anxiety from life stressors. Lack of social support creates stress and negative emotions that 冲击 self-concept, reducing clarity and increasing rumination, leading to smartphone dependence. When individuals cannot establish stable real-world relationships, stress-induced anxiety drives them to seek spiritual sustenance online. Conversely, good psychological resilience reduces smartphone dependence.

While real social support directly affects addiction, objective support' s non-significant impact stems from its inclusion of online social support. Individuals lacking real-world support seek comfort through mobile media, obtaining network social support that compensates for psychological health deficits. Liu et al. (2014) found network social support partially mediates the relationship between smartphone addiction and psychological harmony, with good online support protecting against dependence. Jiang and Bai (2014) detailed how network social support' s four dimensions (emotional, informational, instrumental, and membership) reduce loneliness and anxiety, improving mental health. However, some scholars note long-term reliance on mobile social interaction may not change real-world support deficits and could worsen addiction.

In summary, social support influences smartphone addiction through three mechanisms: direct effects, buffering negative emotions (loneliness), and alleviating stress-induced anxiety. Loneliness and anxiety mediate these relationships.

(2) Loneliness and Social Anxiety in Interpersonal Relationships Social support' s impact on smartphone addiction is essentially fully mediated by social adaptation, which includes interpersonal, learning, and self-adaptation. Interpersonal adaptation shows the strongest effects—good interpersonal adaptation protects against addiction by providing real-world satisfaction pathways, reducing virtual social tool dependence. When individuals cannot establish stable real-world relationships, they experience loneliness and social anxiety, driving them to seek spiritual sustenance online. Zhang et al. (2015) confirmed loneliness fully mediates the relationship between interpersonal adaptation and smartphone dependence. Low interpersonal adaptation leads to lack of support, creating loneliness and excessive dependence. This low adaptation also generates negative judgments about social situations, causing social anxiety. Shi et al. (2017) found significant positive correlations between social anxiety and smartphone dependence, with anxiety triggering escapist motivation to seek comfort through phones. Social anxiety represents a complete manifestation of interpersonal problems leading to addiction—higher interaction anxiety increases loneliness and addiction probability. Anxiety and loneliness have dual

pathways: anxiety fully mediates loneliness-addiction relationships, while loneliness mediates attachment anxiety-addiction relationships. Individuals high in social anxiety have unstable feelings and interpersonal sensitivity, using phones more for contact than face-to-face communication. Thus, social support' s interpersonal pathways operate through loneliness and social anxiety.

(3) Moderating Roles of Self-Control and Motivation While social support and interpersonal relationships affect smartphone addiction through loneliness and anxiety, self-control and motivation moderate these pathways. Zhao et al. (2017) found sensation seekers lacking control show more severe addiction when social support is lacking. Individuals lacking support and good interpersonal relationships tend toward loneliness, boredom, and depression, with boredom predicting low self-control. Lemay (2013) confirmed bored individuals show higher ego depletion and lower future self-control. Mascho (2012) found high boredom correlates with poorer smoking self-control, involving cognitive and motivational shifts. As loneliness is a second-order factor of boredom, Wu (2018) found interpersonal problems affect addiction through self-control mediation. Social motivation also moderates addiction—Louis (2008) found sensation seeking, lack of motivation, and lack of control predict adolescent smartphone use. Gan (2014) categorized motivations into entertainment, relaxation, and personality needs, with social and entertainment needs positively correlating with addiction. Psychological needs mediate the loneliness-dependence relationship. Self-control and motivation thus moderate the pathways from social factors to smartphone addiction.

(4) Reciprocal Influences Social support and interpersonal relationships affect smartphone addiction through loneliness, anxiety, self-control, and motivation, but smartphone addiction also negatively impacts social support and relationships. Addiction leads to avoidant social behavior, lack of peer support, and unmet social needs, creating loneliness and anxiety that exacerbate addiction. Zhang et al. (2018) found loneliness and anxiety reduce self-control and create escapist motivation. Reduced real-world social time from addiction increases loneliness, anxiety, and interpersonal indifference. Both directions of influence rely on the core mediating roles of loneliness and anxiety and the moderating roles of self-control and motivation.

2.2 Personality Traits, Emotions, and Smartphone Addiction Pathways

[Figure 4: see original paper] illustrates pathways from personality and emotions to smartphone addiction. Eysenck defined personality as the sum of behavioral patterns that predict and explain behavior. Due to its stability, personality serves as a key psychological predictor in behavioral research, making personality-smartphone addiction relationships a major focus internationally. Studies examining "Big Five" personality and smartphone use found extraverts

show higher usage frequency (calls and texts), while low agreeableness correlates with gaming preference. Loneliness and anxiety play core roles between personality traits and addiction.

(1) Eysenck Personality Dimensions The Eysenck Personality Questionnaire measures four traits: introversion-extraversion, neuroticism, psychoticism, and lie scale. Introversion-extraversion negatively correlates with addiction, while neuroticism and psychoticism positively correlate. Loneliness mediates the relationship between neuroticism/psychoticism and addiction—introverted, neurotic, or psychotic individuals directly predict addiction and indirectly trigger it through loneliness. Wu and Du (2015) confirmed these relationships and found the lie scale negatively correlates with addiction. Ryan and Xenos (2011) specified that high neuroticism and loneliness individuals spend more time on phones. Zhang et al. (2017) argued these personality traits inherently involve loneliness, anxiety, and low control—psychotic individuals show loneliness and poor adaptation; neurotic individuals show anxiety, strong emotional reactions, and impulsivity. While introverts develop addiction through loneliness, extraverts do so through interpersonal needs, impulsivity, and sensation seeking. Not all relationships are unidimensional—extraverts use phones for interpersonal communication but also for stimulation and sensation seeking, making them vulnerable to addiction. Zhang et al. (2017) added that low self-identity and self-efficacy increase anxiety, loneliness, poor control, and addiction likelihood. In summary, Eysenck' s dimensions affect addiction through loneliness and anxiety mediation, moderated by self-control and self-efficacy motivation.

(2) Big Five Personality Dimensions The Chinese Big Five Personality Inventory Brief Version (CBF-PI-B) measures neuroticism, extraversion, conscientiousness, openness, and agreeableness. Hui et al. (2017) found neuroticism, conscientiousness, and openness relate to smartphone addiction. Neurotic individuals (anxious, impulsive, low control) prefer phone socializing; low conscientiousness individuals (poor self-control, disorganized) easily become immersed; low agreeableness individuals (suspicious, hostile) rely on phones to cope with loneliness and anxiety; low openness individuals (unwilling to experience new things) develop dependence to escape inner loneliness. Low-intensity usage motivation can weaken personality traits' impact on addiction. Thus, Big Five traits affect addiction through loneliness and anxiety mediation, moderated by self-control and usage motivation.

(3) Emotions Emotional processing characteristics of smartphone addicts have garnered attention. Studies show negative emotions correlate with addiction severity—higher negative emotion levels increase addiction. According to mood-congruence theory, individuals attend more to stimuli matching their mood. Addicts experiencing loneliness, depression, and anxiety have negative mood biases, exacerbating addiction. Negative emotions affect addiction both directly and indirectly through loneliness and anxiety. Addicts' negative emo-

tions inherently include loneliness and anxiety. Coping styles involving lonely avoidance and anxiety from negative emotions, plus lack of emotion regulation strategies, predict addiction. Zhang and Jiang (2017) found Chinese individuals' use of expressive suppression (a negative strategy) positively predicts addiction. Smartphone addiction also worsens negative emotions by impairing positive emotion expression and negative emotion regulation. Individuals with poor emotion regulation self-efficacy show more anxiety, depression, and irritability.

Escapist motivation and self-control also moderate these relationships. The negative reinforcement emotion processing model suggests addiction' s dominant motivation is escaping negative emotions. High impulsivity individuals experiencing setbacks easily develop escapist psychology, seeking psychological compensation through phones. Self-control significantly impacts addiction and emotional states—high self-control correlates with positive states, while low self-control accompanies gambling, addiction, and aggression.

2.3 Family Relationships: Parent-Child Relations and Conflict

[Figure 5: see original paper] illustrates family pathways to smartphone addiction.

(1) Parent-Child Relationships Families shape personality, with parent-child relationships being primary. Parenting styles, attachment, conflict, and communication affect development. Family influence pathways involve: (a) childhood experiences affecting loneliness, anxiety, self-control, and motivation components of attachment relationships—parental favoritism causes interpersonal selfishness and loneliness; rejection creates low self-identity anxiety; maternal overprotection reduces self-control. Long-term exposure creates insecure attachment (fearful, preoccupied) causing loneliness, anxiety, and poor control. Psychoanalytic theory views addiction as attachment disorder manifestation —smartphone dependence represents transferred and compensated attachment needs. Insecure attachment characteristics (worthlessness, distrust) drive individuals to seek security online. (b) Parental modeling affects loneliness and anxiety—parental "phubbing" significantly predicts adolescent addiction as it represents parental neglect, causing loneliness and anxiety when facing unsolvable problems. This makes smartphone addiction a significant developmental issue for children.

(2) Parental Conflict Perceived parental conflict and cognitive evaluations create insecurity and loneliness. Negative evaluations with self-blame cause anxiety, loneliness, and adaptation problems. Addiction motivation involves escaping painful negative emotions—high loneliness, anxiety, and low self-control individuals depend more on phones under escapist motivation. Thus, parenting styles and parental conflict affect addiction through loneliness and anxiety, influenced by escapist motivation and low self-control.

2.4 Physiological Factors: Quality of Life (Sleep Quality)

[Figure 6: see original paper] illustrates physiological pathways.

(1) Quality of Life and Sleep Quality of life, a health and living standard indicator, includes physical health, physiological function, general health, energy, social function, emotional function, and mental health. Physical health, energy, emotional function, and general health predict smartphone addiction, with loneliness partially mediating this relationship. Poor physical health and low energy reduce social activity, increasing loneliness and helplessness, driving phone use for social interaction. Low emotional function individuals lack confidence and self-exposure, turning to phones to alleviate anxiety when facing pressures. Sleep quality, as a quality-of-life indicator, prominently shows this pattern—sleep problems trigger anxiety and increase addiction severity. Mental health or personality components involving anxiety and loneliness also cause sleep disorders directly affecting addiction. Conversely, smartphone addiction disrupts emotional balance, increasing negative emotions (anxiety, loneliness, low motivation) that affect sleep quality. Balancing these negative emotions requires self-control and motivation—strong usage intentions and impulses make dependence difficult to control. Self-schema theory and Davis's (2001) cognitive-behavioral model suggest low subjective health evaluations cause self-doubt, low self-efficacy, and negative self-evaluation, negatively predicting addiction. Individuals dissatisfied with their bodies, with low self-motivation, seek self-presentation satisfaction online, increasing addiction likelihood. Thus, quality of life affects addiction through loneliness and anxiety, while self-control and motivation (self-efficacy) moderate this relationship.

(2) Neuroscientific Evidence Various physiological-psychological traits and social-family relationships affect smartphone addiction through loneliness and anxiety mediation and self-control/motivation moderation. While primarily supported by questionnaire-based mediation analyses, recent neuroscience provides physiological evidence. Magnetic resonance spectroscopy (MRS) of smartphone-addicted adolescents revealed imbalanced GABA/Glx ratios in the anterior cingulate cortex, correlating with depression, anxiety, insomnia, and impulsivity. Nine weeks of cognitive-behavioral therapy restored these ratios and regulated addiction. Diffusion tensor imaging (DTI) showed white matter microstructural changes in reward circuits, control, and executive function brain regions. Voxel-based morphometry (VBM) revealed gray matter structural differences affecting cognitive function, impulse control, emotion, and reward. These findings confirm that loneliness, anxiety, self-control, and motivation have scientific physiological bases in addiction pathways. Researchers have also adapted internet addiction experimental paradigms to study attention selectivity, control, shifting, and memory in smartphone addicts, which we discuss next.

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3. Experimental Studies on Cognitive Characteristics

Experimental research addresses qualitative study limitations and tests theoretical propositions. Domestic smartphone addiction experiments primarily investigate causal relationships with cognition, revealing negative attention bias, reduced selective attention, decreased attentional inhibition, and impaired memory. Deep analysis of these experiments validates the dynamic control model' s scientific basis and provides scientific understanding of addicts' cognitive characteristics to guide interventions.

3.1 Attention Experiments

(1) Negative Attentional Bias Attention represents the first step in cognitive information processing. Hua et al. (2016) used dot-probe paradigms to test attentional bias toward phone-related versus neutral words, finding addicts showed bias toward phone-related words—consistent with self-schema theory where individuals attend to stimuli matching their traits. This bias has emotional characteristics: addicts detect sad faces faster than happy or neutral ones, showing serial search for emotional expressions and heightened sensitivity to negative emotions. Lei et al. (2017) divided attention into orienting and disengagement phases, finding internet addicts showed rapid orienting to negative emotions and cartoon faces, plus difficulty disengaging from angry real faces. This confirms self-schema theory' s attention advantages and how social difficulties causing anxiety and loneliness affect negative emotion bias and threat information disengagement.

(2) Reduced Selective Attention The brain selectively attends to information rather than responding to all stimuli. Researchers using Flanker tasks found smartphone addicts showed lower accuracy and longer reaction times than controls when judging target arrow directions, with longest reactions for incongruent arrows, indicating weaker selective attention. This demonstrates addiction impairs attentional capacity. While Lei et al. (2017) studied internet addiction' s attention-emotion characteristics, smartphone addiction research remains limited. However, both addictions likely share features—social addicts experience alexithymia (difficulty interpreting/responding to emotions) causing social anxiety and loneliness, confirming anxiety and loneliness' s core mediating roles.

(3) Decreased Attentional Inhibition Self-control research has examined inhibitory responses. Stop-signal paradigm studies found high-dependence individuals responded too quickly to non-stop signals and too slowly to stop signals, showing poorer inhibitory control. This reflects reduced self-control and increased impulsivity post-addiction. Chen et al. (2016) confirmed smartphone addicts have poorer attentional executive control. Lee (2015) explained this through cognitive load theory: smartphones compress time-space, delivering massive information causing frequent checking habits that increase information

load and baseline cognitive output, raising inhibitory control demands. Mind wandering—shifting from external tasks to internal thoughts—moderates this relationship: high mind-wandering addicts show poorer executive control, while low mind-wandering reduces addiction' s impact. This aligns with context regulation hypotheses where task demands determine the mind wandering-executive control relationship. Under high demands, good executive control limits task-unrelated thoughts, but under low demands, it generates more mind wandering. Smartphone addicts show high mind wandering during difficult tasks, significantly increasing error rates.

Beyond experimental contexts, addiction severity correlates with choices between high-delayed versus low-immediate rewards—low-addiction individuals overwhelmingly prefer delayed rewards regardless of delay length, while high-addiction individuals show decreased self-control and increased impulsivity. These attention experiments demonstrate cognitive impacts operate through loneliness, anxiety, self-control, and motivation.

3.2 Memory Experiments

Attention' s refreshing, inhibition, and shifting aspects influence working memory execution. Using N-back tasks, Sun et al. (2017) found internet addicts showed normal behavioral performance at low cognitive load (n=0) but consumed more cognitive resources. At higher loads (n=1,2···), accuracy decreased and reaction times slowed. ERP measurements revealed larger P2 amplitudes (requiring more attentional resources, lower automation) and smaller N2 executive control amplitudes (poorer control, slower processing), indicating addiction affects control and memory.

Memory includes prospective and retrospective components. Ding and Guo (2015) used prospective memory paradigms to find evaluative tendencies affect ongoing task performance. Pan et al. (2018) used dual-dimension N-back training, finding negative emotions modestly but objectively affect working memory, with dual-dimension training showing greater ecological validity than single-dimension. Xia (2018) found modest main effects in retrospective and low-association prospective memory tasks among smartphone addicts. These studies indicate smartphone addiction affects memory capacity through cognitive load and emotion, with loneliness, anxiety, self-control, and motivation as core elements.

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4. Intervention Strategies and Future Directions

Smartphone addiction causes physical-psychological, social, and family problems, including academic burnout and sleep issues. Intervention research thus has practical significance. This review' s distinctive definition provides scientific boundaries, the dynamic control model identifies core intervention targets

(loneliness, anxiety, self-control, motivation), and cognitive experiments validate these elements while informing scientific interventions.

Existing interventions target these core elements. Zhang (2018) proposed psychodrama techniques using social role-playing to resolve conflicts and improve interpersonal adaptation, essentially adjusting loneliness and social anxiety. Mindfulness therapy, increasingly popular domestically and internationally, intervenes comprehensively by correcting cognition, reducing loneliness and anxiety, and improving self-control and motivation. Domestic mindfulness-based cognitive-behavioral group therapy has proven effective in reducing addiction by enhancing mindfulness, reducing impulsivity and anxiety. Attention research has been applied to interventions—selective attention to positive information improves emotional states and mental health. Chen and Yu (2017) demonstrated attentional bias training effectively alleviates college students' smartphone addiction tendencies.

Despite progress, smartphone addiction research has limitations: lack of systematic theory and innovative perspectives, over-reliance on foreign research; narrow subject focus (primarily college students, with few studies on migrant workers, elderly, military personnel); and superficial examination of social factors without deep institutional and cultural analysis. Future research should deepen understanding of sociocultural influences and group differences. For instance, Petersen et al. (2005) found elderly phone use negatively correlates with loneliness—might smartphone addiction's cognitive changes mitigate age-related memory decline? While literature emphasizes harms, smartphones as communication tools can also benefit users, as Han (2018) found in Beijing migrant women' s parent-child relationships, where phones facilitate cross-time-space communication and parental supervision.

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Note: Figure translations are in progress. See original paper for figures.