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The Application of Data Mining in Analyzing the Relationship between Interpersonal Relationship Distress and Smartphone Addiction of College Students



Abstract: - This research employed computer technology to analyze data from 1737 university students, investigating the impact of smartphone usage on changes in their interpersonal relationships. Additionally, a predictive model was developed to understand patterns of smartphone use. A cross-sectional survey was conducted using the Smartphone Addiction Scale, Interpersonal Relationship Assessment Scale, Basic Psychological Needs Scale, and Negative Coping Style Scale among college students. The study examined how distress in interpersonal relationships among college students predicts smartphone addiction and explored the mediating effects of basic psychological needs and negative coping strategies in this relationship. Findings revealed that: (1) Distress in interpersonal relationships is a predictor of smartphone addiction among college students; (2) Basic psychological needs act as an intermediary factor between interpersonal relationships and smartphone addiction; (3) Negative coping strategies also serve as an intermediary factor between interpersonal relationships and smartphone addiction; (4) Both basic psychological needs and negative coping strategies jointly play a chain mediating role in the association between interpersonal relationships and smartphone addiction.

Keywords: Data Mining (DM), Smartphone Addiction (SA), Interpersonal Relationship Distress (IRD), Basic Psychological Needs (BPN), Negative Coping Strategies (NCS).

I. INTRODUCTION

The proliferation of smartphones has ushered in an era of unparalleled convenience, offering access to a vast array of content and services such as social networking, mobile payments, gaming, and online shopping. With a smartphone at hand, individuals can seamlessly navigate through various aspects of life. However, this technological advancement has also given rise to a concerning phenomenon known as smartphone addiction. This condition entails excessive and compulsive usage of smartphones, resulting in significant disruptions to one's physical, psychological, and social well-being. Smartphone addiction, categorized as a behavioral disorder, manifests in the overindulgence in features like gaming, internet browsing, and messaging, often leading to detrimental effects on academic, professional, and personal pursuits. The 50th "Statistical Report on Internet Development in China" [1] reveals staggering figures, indicating that smartphone internet users in China have surpassed 1.047 billion, with a staggering 99.6% of internet users accessing online content via smartphones. Notably, individuals aged 20-29 represent a considerable portion, approximately 180 million people. Given that university students predominantly fall within this demographic, it underscores the prevalence of extensive smartphone usage among this group. The potential ramifications of smartphone overuse and addiction on the physical, mental, and social development of college students necessitate a thorough investigation into the underlying factors contributing to this phenomenon. Hence, this study aims to explore the determinants of smartphone addiction among college students, with the objective of devising targeted intervention strategies. By identifying these factors, interventions tailored to address the unique challenges faced by this demographic can be developed, thereby safeguarding the physical and mental well-being of college students.

The emergence of "Mobile Phone Addiction" coincides with the rapid evolution of mobile communication devices, encompassing both behavioral and technological dependencies. Alternative terms like "Problematic Mobile Phone Use," "Excessive Mobile Phone Use," or "Mobile Phone Dependence" have been coined to delineate the phenomenon of excessive smartphone utilization. Foreign researchers often employ the term "smartphone use problem" to characterize this behavior. Bianchi and Phillips [2] introduced the concept of smartphone problem, denoting instances where individuals persist in smartphone usage despite prohibitions or potential hazards, indicative of a lack of social or self-control. In China, the term "tendency toward smartphone

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addiction” is utilized, as defined by Shi [3], portraying a compulsive state wherein an individual’s physical, psychological, and social functions are significantly impaired due to unregulated smartphone utilization. Hu [4] defines smartphone addiction as the improper and excessive usage of smartphones leading to a loss of control, disrupting normal psychological and social functions, representing the advanced stage of addiction following diagnostic criteria. Chinese scholars, including Su et al. [5], have also conceptualized smartphone addiction as “smartphone addiction,” delineating a condition where individuals encounter psychological or behavioral issues due to smartphone abuse. While the academic community presents varied interpretations of smartphone addiction, most psychological researchers classify it as a behavioral addiction, characterized by uncontrollable smartphone usage resulting in substantial impairments across physiological, psychological, and social domains [6,7]. This study adopts the widely acknowledged concept of “smartphone addiction” for research purposes.

Reviewing the early research on smartphone addiction, it primarily focused on exploring the influencing factors of smartphone addiction, including:

- Core Individual Characteristics: Such as personality traits, social cognition, psychopathology, and other intrinsic traits.
- Subjective Perceptions: Research delved into individuals’ subjective experiences, encompassing negative emotions, personal conflicts, and social support, among others.
- Emotional Responses: Studies examined emotional reactions, coping strategies, and expectations related to internet usage.
- Family Environment: The family environment was also investigated, looking at factors like parental conflicts, parenting styles, and attachment relationships.

Additionally, some studies treated smartphone addiction as an independent variable and explored its negative impacts on individuals. The negative effects of smartphone addiction on individuals have been explored, such as burnout, procrastination and lower grades in learning, as well as affecting creativity and sleep quality and, more seriously, depression. Research also found that smartphone addiction not only adversely affects college students’ academic and mental well-being but also social functioning.

At present, many researchers have begun to study the role of environment on college students’ smartphone addiction, especially family environment and school environment. Within the context of the school environment, the quality of peer relationships directly influences students’ smartphone addiction. Interpersonal relationships can affect individuals’ psychological and social environments either directly or indirectly, and they are also influenced by individuals’ psychological and social environments [8]. In studies related to interpersonal relationships and smartphone use, Masoud et al. (2012) measured the smartphone usage patterns of 387 Tehran University students and examined their impact on interpersonal interactions [9]. They found that smartphone use could influence the depth and breadth of interpersonal relationships, leading to interpersonal difficulties during interactions. Kim et al. (2017) conducted research that revealed in South Korean university students, addressing smartphone addiction issues among college students and addressing underlying communication problems are critical for promoting healthy development in interpersonal relationships and reducing interpersonal difficulties [10].

Li et al. conducted a study that showed a significant direct effect of interpersonal adaptation on smartphone addiction [11]. Students who are less socially adept may tend to express their opinions and emotions more through the virtual world of the internet, which could potentially lead to smartphone addiction. Individuals with poorer interpersonal relationship conditions and a greater sense of loneliness are more susceptible to smartphone addiction [12, 13]. Interpersonal relationships impact college students’ smartphone dependence through feelings of loneliness [14]. Higher levels of interpersonal relationship distress and loneliness are associated with a higher degree of smartphone dependence [15]. Additionally, individuals with poor parent-child relationships struggle to establish close interpersonal relationships and may seek self-satisfaction through online means [16]. The higher the level of interpersonal relationship distress, the higher the levels of smartphone addiction and school alienation [17]. In conclusion, we propose Hypothesis 1: College students’ interpersonal relationship distress can significantly predict smartphone addiction.

When examining the link between interpersonal relationships and addiction to smartphones, it is important to consider potential factors that may mediate this relationship. Previous studies have identified basic psychological needs and negative coping mechanisms as significant mediators. The self-determination theory [18] introduced by Deci and Ryan in 2000 emphasizes the importance of fulfilling fundamental psychological needs for personal growth, integration, and well-being. These needs include autonomy, competence, and relatedness. Autonomy refers to a desire for independence in one’s actions, while competence involves feeling effective in tasks [18]. Relatedness pertains to social connection and support. When adolescents’ basic psychological needs are not met in real life situations, they may seek alternative fulfillment online which suggests that the internet can provide substitutes for unmet psychological needs among teenagers [19]. The close connection between teenagers’ online

gaming addiction and their fundamental psychological needs has been observed in various studies. Zhang et al. (2017) found that the relationship between social support and internet addiction is mediated by basic psychological needs [20]. Similarly, Liang et al. (2019) discovered that psychological needs play a mediating role in the link between peer victimization and online gaming addiction among Chinese adolescents [21]. Furthermore, previous research on smartphone addiction indicates that mobile phone dependency is significantly influenced by psychological needs [22]. By addressing these needs, effective interventions can be implemented to tackle smartphone addiction among college students. For example, lower satisfaction with basic psychological needs predicts a higher level of mobile phone addiction among female college students [23]. Previous research has shown that the interpersonal adjustment of college students can be predicted by their basic psychological needs [24]. Building upon this existing literature, hypothesis 2 of this study suggests that the relationship between college students' smartphone addiction and interpersonal distress is mediated by their basic psychological needs.

Cognitive and behavioral efforts to cope refer to mitigating the adverse effects of stressful situations. These efforts typically fall into two categories: passive and active coping strategies. Xiong et al. (2018) identified passive coping style as a factor in the relationship between loneliness and smartphone addiction among college students [25]. Similarly, He et al. (2018) also observed that passive coping style serves as both a mediator and a modifier variable [26]. Qiu et al. (2021) propose that passive coping style acts as a factor in the relationship between self-perception and smartphone addiction [27]. The association between passive coping style and interpersonal relationships has also been explored. According to a study conducted by Han et al. in 2017, there is a noticeable association between the atmosphere in dormitories and the adoption of passive coping strategies [28]. This finding is further supported by Fu's research in 2019, which reveals a significant positive correlation between disturbances in interpersonal relationships and the mental well-being of university students [29]. In conclusion, we propose hypothesis 3: negative coping styles act as mediators between college students' distress caused by interpersonal issues and their addiction to smartphones.

So, how do the basic psychological needs affect the interpersonal relationship of college students? What role does negative coping play between these two variables? Son et al. (2013) found that when an individual's basic psychological needs could not be met, the individual would initiate less positive coping styles and more negative coping styles [30]. Similarly, Xia and Ye (2014) showed that basic psychological needs have a significant impact on negative coping style [31], which is the mediating variable between social support and Internet addiction [20]. Chinese scholar Gao and Chen proposed the "compensation failure" hypothesis for internet addiction based on whether an individual's psychological development is hindered [32]. According to this hypothesis, internet usage is a compensatory behavior during the psychological development process of adolescents when it is hindered. If "constructive compensation" is formed, then compensation is completed, and normal development is restored, resulting in normal internet behavior. If "pathological compensation" is formed, it leads to compensation failure, causing developmental deviations or interruptions, which is characterized as internet addiction behavior. According to the compensation failure hypothesis, environmental and psychological factors during internet use could potentially become hindering factors in an individual's psychological development, leading to the emergence of internet addiction phenomena. So, can the aforementioned psychological factors in college students' smartphone addiction align with the compensation failure theory model?

Therefore, this study proposes Hypothesis 4: Basic psychological needs and negative coping styles mediate the chain relationship between interpersonal relationship distress and smartphone addiction in college students.

Currently, data mining is extensively utilized in the analysis, modeling, and evaluation of data. Data mining refers to the extraction of concealed, unfamiliar yet potentially valuable information from vast quantities of data. The objective of data mining involves constructing a decision model that forecasts future behavior by leveraging historical action data. Therefore, this study will use data mining technology to analyze the user data of college students, study the changes of college students' use of smart phones and their interpersonal relationships, and investigate the impact of basic psychological needs and negative coping styles on college students' use of smart phones and interpersonal relationships. At the same time, a predictive model of smartphone usage pattern is established through data mining technology, and it is related to the quality and stability of interpersonal relationship.

II. METHOD

A. Research Population and Sample

Convenience sampling was employed to recruit university students from Guangdong Province. A total of 1782 individuals participated in the survey, resulting in the acquisition of 1737 valid questionnaires, yielding an

efficiency rate of 97.47%. Among these respondents, males accounted for 741 (42.7%), while females constituted 996 (57.3%).

B. Research Investigation Method

The questionnaire included sections on personal demographics, including grade, gender, and place of origin. Students from the first semester to the eighth semester were randomly selected by counselors, and a unified questionnaire was used to ask the surveyors to fill in the questionnaire truthfully, including basic personal information (grade, gender, and place of origin).

C. Research Instrument

1) *Interpersonal relationship scale*: The Interpersonal Relationship Assessment Scale [33], developed by Zheng, was used to assess college students' interpersonal relationship distress. This scale comprises four factors: conversation-related distress, communication-related distress, interpersonal interaction distress, and opposite-sex interaction distress. Scoring was done using a method where "yes" was assigned a value of "1," and "no" was assigned "0," with scores summed up. Higher scores indicate greater interpersonal distress. Scores between 0 and 8 suggest relatively low distress in interpersonal interactions, 9 to 14 indicate some degree of distress in friend interactions, 15 to 28 indicate significant distress in friend interactions, and scores exceeding 20 suggest severe interpersonal distress and noticeable psychological difficulties. The study yielded internal consistency coefficients of 0.842, 0.852, 0.885, and 0.865 for the four factors examined, while the overall scale demonstrated an internal consistency coefficient of 0.893.

2) *Basic psychological needs scale*: The Basic Psychological Needs Scale [34], originally developed by Deci and Ryan, and revised by Liu et al. in 2013, was used in this study. It comprises of three elements: the need for autonomy, the need for relatedness, and the need for competence, totaling 21 items. The Likert scale with a 5-point scoring system was utilized, where higher scores indicate a higher level of satisfaction with fundamental psychological needs. In this investigation, the internal consistency coefficients obtained for these three factors were 0.727, 0.800, and 0.752 respectively. Furthermore, the overall internal consistency coefficient achieved by the entire scale was measured at 0.825.

3) *Negative coping style scale*: The study utilized the Simplified Coping Style Questionnaire, which was developed by Xie [35]. It comprises of two dimensions: positive coping and negative coping, encompassing a total of 20 items. A scoring system ranging from 0 to 3 was employed, with higher scores indicating a stronger inclination towards engaging in negative coping behaviors. The internal consistency coefficient for the negative coping dimension in this research was determined to be 0.720.

4) *Smartphone addiction scale*: The Smartphone Network Addiction Scale [36], developed in 2017 by Hu et al., was utilized for the purpose of this study. It consists of four factors: social addiction, entertainment addiction, information addiction, and shopping addiction, comprising a total of 24 items. A scoring method based on a 5-point Likert scale was employed, where higher scores indicate a greater severity of smartphone addiction. The internal consistency coefficient for the scale used in this study was determined to be 0.902.

D. Data Processing

Data processing was conducted using SPSS 27.0 statistical software and the Process plugin program.

III. RESULTS

The examination of common method bias was conducted using Harman's single-factor test. The findings revealed the presence of 13 factors, with the first factor explaining only 17.05% of the variance. This percentage falls below the critical threshold of 40%, indicating a lack of significant common method bias in this study.

A. Overall Distribution of Smartphone Addiction among College Students

In this study, the total score on the Smartphone Addiction Scale for college students is 120 points. When examining the scores of 1,737 participants, they were divided into three score ranges. Among them, 1,268 individuals scored 60 or higher, accounting for 72.9% of the total. There were 221 individuals scoring 80 or higher, representing 12.8%. This 12.8% of students can be considered as severely addicted to smartphones.

B. Overall Distribution of Interpersonal Relationship among College Students

The distribution of interpersonal relationships is illustrated in Table 1. Some college students encounter considerable challenges in their interpersonal relationships. In this investigation, the scores for college students' interpersonal relationships ranged from 0 to 28, with an average score of (8.37 ± 7.122) points. The findings

suggest that approximately 19.1% of the surveyed college students face difficulties in their interpersonal relationships, indicating that nearly one-fifth of them experience significant problems such as communication issues, forming friendships, interacting with others, and establishing romantic connections.

Table 1: Overall Distribution of Interpersonal Relationship

	score	Description	n	%
Interpersonal relationship	0-8 points	Good interpersonal relationship	968	55.7%
	9-14 points	The interpersonal relationship is generally	438	25.2%
	15-28 points	Poor interpersonal relationships	331	19.1%

C. Correlation Analysis between Interpersonal Relationship Distress and Smartphone Addiction among College Students

The correlation analysis revealed a significant positive association between the overall score of interpersonal distress and its four factors with the total score of addiction to smartphones. Refer to Table 2 for details.

Table 2: Correlation between Interpersonal Relationship Distress and Smartphone Addiction

Variable	M	SD	1	2	3	4	5	6
1. Confusion of conversation behavior	2.16	2.054	—					
2. communication behavior puzzle	2.08	2.317	0.766**	—				
3. The trouble of receiving people and things	1.30	1.706	0.694**	0.614**	—			
4. Conflicting intercourse with the opposite sex	2.10	2.063	0.681**	0.717**	0.615**	—		
5. Interpersonal relationship distress	8.37	7.122	0.901**	0.901**	0.818**	0.867**	—	
6. Smartphone addiction	67.76	13.667	0.196**	0.163**	0.175**	0.124**	0.187**	—

D. Mean, Standard Deviation and Correlation Coefficient of all Variables

The correlation analysis utilized the mean scores of interpersonal distress, fundamental psychological requirements, adverse coping strategies, and smartphone dependency. The findings indicated an inverse relationship between interpersonal distress and basic psychological needs, while demonstrating a positive association with negative coping styles and smartphone addiction. Moreover, basic psychological needs exhibited a negative correlation with negative coping styles and smartphone addiction. Additionally, there was a positive correlation observed between negative coping styles and smartphone addiction. Refer to Table 3 for details.

Table 3: Descriptive Statistics Results and Correlation Matrix of Each Variable

Variable	M	SD	1	2	3
1. Interpersonal relationship distress	8.37	7.122	—		
2. basic psychological need	9.89	1.271	-0.442***	—	
3. negative coping style	9.04	4.520	0.301***	-0.242***	—
4. Smartphone addiction	67.76	13.667	0.187***	-0.299***	0.393

Note: n=1737, ***P < 0.001.

E. Mediation Analysis

The SPSS macro program developed by Hayes was utilized to apply the non-parametric percentile Bootstrap method for testing the mediating effect. Model 6 in Process was selected for conducting a chain mediation effect

test, while controlling for gender and grade. In this study, we examined college students' interpersonal distress as a predictor variable, smartphone addiction as an outcome variable, and basic psychological needs and negative coping styles as mediating variables. The results of regression analysis indicated that overall, there was a significant prediction of smartphone addiction by interpersonal distress ($\beta=0.215, P<0.001$). Mediation effect analysis revealed that interpersonal distress significantly predicted basic psychological needs ($\beta=-0.443, P<0.001$). When both interpersonal distress and basic psychological needs were included in the regression equation, it was found that interpersonal distress significantly predicted negative coping styles ($\beta=0.242, P<0.001$), whereas basic psychological needs also had a significant prediction on negative coping styles ($\beta=-0.135, P<0.001$). Furthermore, when all three variables - interpersonal distress, basic psychological needs, and negative coping styles - were simultaneously entered into the regression equation, it was observed that basic psychological needs significantly predicted mobile phone addiction ($\beta=-0.222, P < 0.001$), while negative coping styles also had a significant prediction on mobile phone addiction ($\beta = 0.343, P < 0.001$). As depicted in Table 4, basic psychological needs and negative coping styles act as sequential mediators between interpersonal distress and mobile phone addiction.

Table 4: Regression Analysis of Variable Relationships in the Mediation Model

Regression equation		Global fitting index			Significance of regression coefficient	
Result Variables	Predicted Variable	R	R ²	F	β	t
Basic psychological need	Sex	0.446	0.199	143.429***	0.061	2.650**
	Grade				-0.033	-1.449
	Interpersonal relationship distress				-0.443	-20.589***
Negative coping style	Sex	0.325	0.106	51.196***	-0.005	-0.222
	Grade				0.009	0.371
	Interpersonal relationship distress				0.242	9.544***
Smartphone addiction	Sex	0.449	0.202	87.455***	0.013	0.558
	Grade				0.052	2.262*
	Interpersonal relationship distress				-0.012	-0.504
	Basic psychological need				-0.222	-9.170***
	Negative coping style				0.343	15.102***

Note: *P<0.05, **P<0.01, ***P<0.001.

The Bootstrap method was used to estimate the confidence interval, and 5000 repeated extractions were performed to calculate a 95% confidence interval. The findings indicate that basic psychological needs and negative coping styles play significant mediating roles in interpersonal distress and mobile phone addiction. There are three distinct paths of indirect effects: Path 1 - interpersonal disturbance → negative coping style → mobile phone addiction, with a 95% confidence interval of [0.063, 0.123]; Path 2 - interpersonal distress → basic psychological needs → mobile phone addiction, with a 95% confidence interval of [0.072, 0.129]; Path 3 - interpersonal distress → basic psychological needs → negative coping style → mobile phone addiction, with a 95% confidence interval of [0.016, 0.040]. If none of these paths include zero, they are considered statistically significant. Please refer to Table 5 for more details on these findings.

Table 5: Bootstrap 95% Confidence Interval of Mediating Path

Intermediary path	Effect value	95% Confidence Interval		Relative Mediating effect
		Lower limit	Upper limit	
Interpersonal relationship distress → Negative coping style → Smartphone addiction	0.092	0.063	0.123	41.8%
Interpersonal relationship distress → Basic psychological need → Smartphone addiction	0.100	0.072	0.129	45.5%
Interpersonal relationship perplexity → Basic psychological need → Negative coping style → Smartphone addiction	0.027	0.016	0.040	12.3%

IV. DISCUSSION

A. Overall Situation of Interpersonal Relationship Distress among College Students

A comprehensive analysis reveals that college students experience a certain degree of interpersonal relationship distress. Approximately 25.2% of students reported having generally good relationships, while 19.1% reported having poor relationships, indicating that a portion of college students indeed face interpersonal relationship distress. This distress could potentially affect their normal campus life and psychological well-being during their college years. When examining specific dimensions of interpersonal relationship distress among college students, the order from high to low distress levels is as follows: social interaction distress, conversation-related distress, opposite-sex interaction distress, and interpersonal handling distress. This suggests that college students experience more distress in terms of social interactions, conversational behaviors, and interactions with the opposite sex. This might be attributed to the diverse forms and complexity of friendships among college students. Some students may find it challenging to adapt to the diversity of social interactions and the complexity of communication topics in college, resulting in increased levels of interpersonal relationship distress. Regarding interactions with the opposite sex, during their earlier years in middle and high school, students typically focus more on their studies, as romantic relationships are generally discouraged during this period. Interactions with the opposite sex in middle and high school often revolve around academic pursuits. Consequently, when transitioning to the open and inclusive environment of a college campus, college students may feel more nervous, anxious, and uncertain about their interactions with the opposite sex. Therefore, in the context of school education, there should be an emphasis on nurturing students' social skills and social behaviors.

B. Overall Situation of Smartphone Addiction among College Students

Smartphones play an essential role in the academic lives of college students, and there is no issue with necessary smartphone usage. However, for some college students, their focus on smartphones has exceeded normal levels. Among the 1,737 college students surveyed, the average score for smartphone addiction was 67.76. Furthermore, 221 students, or 12.8%, scored 80 or above, indicating a moderate level of smartphone-related issues, accounting for 60%. This is primarily because the survey respondents were born around the year 2000 and grew up with smartphones. They started using smartphones at an early age and use them more frequently. For many of them, smartphones are considered a necessity. As smartphones become more ubiquitous and offer more features, students' smartphone-related problems are likely to increase. These problems may manifest as anxiety, restlessness, nervousness, and can impact the normal lives and psychological well-being of college students. Therefore, it is crucial to address and provide support for students who may be at risk of developing smartphone addiction. In this study, 221 students, or 18%, exhibited a more severe level of smartphone addiction. These students find it challenging to control their smartphone usage, become engrossed in smartphone games, social interactions via smartphones, online shopping, and tend to create a virtual world within their smartphones. They may even struggle to cope with real-life situations. Without intervention, these issues can lead to more severe psychological problems.

C. The Relationship between College Students' Interpersonal Relationship Distress and Smartphone Addiction

The results of the correlation analysis indicated that interpersonal relationship distress, as well as its individual dimensions, showed a positive correlation with smartphone addiction. This suggests a close association between the quality of interpersonal relationships and smartphone addiction. In other words, as college students experience and perceive higher levels of interpersonal relationship distress in their academic and personal lives, and as they encounter more dimensions of interpersonal distress, their level of smartphone addiction tends to be higher. Regression analysis confirmed that college students' interpersonal relationship distress can predict smartphone addiction, thus supporting Hypothesis 1. The more interpersonal relationship distress experienced by college students, the higher their degree of smartphone addiction. This finding aligns with the research conducted by Gan, Zhang, and others [14, 37]. After studying the relationship between self-control, interpersonal distress, and smartphone addiction among vocational college students, it has been further confirmed that interpersonal distress is significantly associated with smartphone addiction. Interpersonal relationships reflect an individual's psychological state in pursuit of satisfying their social needs. Poor interpersonal relationships and the resulting interpersonal distress are crucial factors influencing smartphone dependence [38]. Therefore, efforts to reduce college students' addiction to smartphones may involve enhancing their interpersonal skills and improving their relationships with others.

D. The Mediating Role of Basic Psychological Needs in the Relationship between College Students' Interpersonal Relationship Distress and Smartphone Addiction

The results suggest that the relationship between college students' interpersonal distress and smartphone addiction is influenced by their basic psychological needs. The mediating effect of these needs accounts for 45.5% of the overall impact, supporting hypothesis 2. This finding supports previous research on the significance of basic psychological needs in understanding smartphone addiction [22, 39]. It can be inferred that college students' level of basic psychological needs is predicted by their interpersonal disturbance, which subsequently affects the severity of smartphone addiction. Therefore, addressing interpersonal distress could potentially reduce smartphone addiction by promoting greater satisfaction with basic psychological needs.

The theory of basic psychological needs posits that when an individual's basic psychological needs are not satisfied, they may develop behavior patterns characterized by a loss of self-control and a tendency to move away from their intrinsic experiences [40]. This underscores the significance of satisfying basic psychological needs in maintaining an individual's psychological well-being. Empirical research has also confirmed that when individuals' basic psychological needs are not met, it can lead to the emergence of negative behaviors such as excessive use of the internet and smartphones, an excessive pursuit of material wealth, smoking, and eating disorders [41-43]. Therefore, when college students experience obstacles to satisfying their basic psychological needs, they may exhibit certain negative behaviors, and smartphone addiction is a typical negative behavior that emerges when basic psychological needs are obstructed.

The interaction between college students and their roommates and classmates is very close, and research data shows that the primary motivation for college students to use smartphones is their need for interpersonal communication [44]. When interpersonal relationships encounter problems and are not handled well, it can have a significant negative impact on college students' satisfaction with their relational needs. According to the Uses and Gratifications Theory, when individuals' psychological needs are unmet, it can trigger a craving for social media, especially when their needs are not met in real-life situations, this desire becomes even stronger. Once individuals obtain a certain level of satisfaction through social media, this behavior is rapidly reinforced and quickly becomes uncontrollable [45]. Therefore, when college students experience interpersonal communication problems in real life, and their need for social interaction is hindered, using smartphones for socializing, entertainment, gaming, and other activities can quickly alleviate the negative emotions caused by unmet psychological needs, providing them with alternative satisfaction. However, excessive smartphone use can lead to an unhealthy dependence on smartphones, resulting in smartphone addiction.

E. Mediating Role of Negative Coping Styles in the Relationship between College Students' Interpersonal Relationship Distress and Smartphone Addiction

The findings suggest that negative coping strategies play a mediating role in the association between college students' distress in interpersonal relationships and addiction to smartphones, accounting for 41.8% of the overall impact, thus supporting Hypothesis 3. These results are consistent with previous studies that have highlighted the significance of negative coping styles in relation to smartphone addiction [25-27,46]. College students' interpersonal relationship distress predicts negative coping styles, and negative coping styles predict the degree of smartphone addiction. Negative coping styles are a powerful influencing factor on addiction.

These results also validate the stress-coping model of addiction [47]. When individuals face significant stress, coping strategies serve as essential intermediary mechanisms for safeguarding their mental health. Addictive behaviors are the coping responses of addicted individuals when facing stressors. Their function is to reduce the negative effects of stress or increase positive emotions in addicted individuals [48]. In the case of college students facing obstacles in interpersonal relationships, individuals are more likely to experience negative emotions such as anxiety, depression, and loneliness both in the present and in future developmental stages. They often struggle to resolve these emotions through positive and effective coping strategies and instead resort to avoidance, pastimes, and self-soothing as maladaptive coping mechanisms. Smartphones, as one of the significant platforms and tools for interpersonal communication, may become a refuge for some college students seeking to escape real-life troubles. In other words, smartphone addiction can be seen as a negative coping mechanism used by college students to alleviate negative emotions and avoid stressful situations when dealing with interpersonal relationship distress [25, 49]. Therefore, it is essential to both cultivate college students' interpersonal relationship skills and promote positive coping mechanisms to reduce their dependence on smartphones from the source.

F. Chain Mediation of Basic Psychological Needs and Negative Coping Styles in the Relationship between College Students' Interpersonal Relationship Distress and Smartphone Addiction

The study also found that there is a connection between smartphone addiction and interpersonal relationship distress among college students. This relationship is influenced by basic psychological needs and negative coping styles, with these factors mediating 12.8% of the effect, thus confirming Research Hypothesis 4. These findings support the “loss-compensation” hypothesis, which aligns with previous studies conducted by Zhang, Xia, and others [20, 31].

The fulfillment of psychological needs acts as the primary motivator for human actions. In the absence of meeting these fundamental needs, individuals will experience a compelling urge to address and fulfill them. If basic psychological needs remain unmet for an extended period, individuals may shift their focus to other environments [50]. When individuals encounter more or severe stress-inducing events (under external influences), and their basic psychological needs are not satisfied (development is hindered), adopting negative coping styles more frequently (pathological compensation) may lead to addictive behaviors (deviations in development). This aligns with the “loss-compensation” hypothesis proposed by Gao and Chen [32]. According to this theory, the developmental process of individuals can be briefly described as follows: (1) Individuals develop normally. (2) The development is influenced by external factors (or internal factors), resulting in a state of development hindrance. At this stage, 1) in the development hindered phase, constructive compensation can activate the psychological self-repair process and restore normal development; 2) if pathological compensation is adopted, self-repair cannot occur, eventually leading to loss-compensation, which results in developmental deviations or interruptions. (3) If improvement does not take place, it eventually leads to developmental interruption. According to this theory, when college students face numerous or severe interpersonal relationship issues and distress, their development is somewhat hindered, and psychological needs are not satisfied. During this stage, if college students adopt more positive coping mechanisms, their development remains normal, and smartphone addiction does not occur. However, if college students engage in pathological compensation by employing negative coping mechanisms, it leads to developmental deviations, resulting in smartphone addiction. This study further provides empirical support for the “loss-compensation” hypothesis.

In brief, this study employs data mining technology [51] to examine the smartphone usage data of university students and investigates the correlation between their interpersonal distress and smartphone addiction. Additionally, it explores the mediating roles of fundamental psychological needs and negative coping strategies in this relationship. The findings demonstrate that not only does interpersonal relationship distress directly predict smartphone addiction, but it also indirectly influences smartphone addiction through the separate mediation effects of fundamental psychological needs and negative coping styles, as well as their combined mediation. This research offers valuable insights into how interpersonal relationships impact smartphone addiction among university students, complementing previous studies and providing implications for interventions targeting smartphone addiction in this population.

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