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ORIGINAL RESEARCH

The Relationship of Parent-Child Technoference and Child Problematic Smartphone Use: The Roles of Parent-Child Relationship, Negative Parenting Styles, and Children's Gender

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Purpose: With the increasing ubiquity of smartphones in our daily lives, technoference has emerged as a novel threat to family relationships and child development. This study explored the impact of parent-child technoference on child problematic smartphone use and its underlying mechanism and potential gender difference among children.

Participants and Methods: The participants were 3032 fourth-grade students (42.6% female; 80.6% one-child families; 32.9% lower income level families, 33.3% middle income level families; Mage = 10.59 years, SD=0.32) from 535 primary schools. Students in the target classes were invited to participate anonymously in the questionnaire survey in classrooms. Then, SPSS, AMOS and other software were used to analyze the data.

Results: 1) Parent-child technoference, negative parenting styles and child problematic smartphone use were positively correlated with each other, while they were negatively correlated with parent-child relationship; 2) Parent-child technoference can not only directly and positively predict child problematic smartphone use, but also indirectly and positively predict child problematic smartphone use through parent-child relationship and negative parenting styles respectively; 3) Parent-child relationship and negative parenting styles play a chain mediating role between parent-child technoference and child problematic smartphone use; 4) There are significant gender differences in the chain mediation model.

Conclusion: The results showed that parent-child technoference significantly affected child problematic smartphone use through a chain mediation of parent-child relationship and negative parenting styles. Gender differences were observed, with girls experiencing a more pronounced disruption in the parent-child relationship, while boys were more likely to develop problematic smartphone use. In cases of strained parent-child relationships due to technoference, girls also tended to perceive more negative parenting styles. These findings promote parents' understanding of the influencing factors and mechanisms of child problematic smartphone use, especially helpful for follow-up measures to prevent and intervene child problematic smartphone use from the perspective of families and parents.

Keywords: parent-child technoference, parent-child relationship, negative parenting styles, child problematic smartphone use, gender difference

Introduction

Family is an important site for effective prevention and intervention of child problematic smartphone use. The responsible upbringing, active engagement, and sustained attention of parents constitute crucial cornerstones for a child's healthy development. However, with the widespread adoption of smartphones, a unique and prevalent societal phenomenon has emerged in the 21st century, referred to as "technoference". This term encompasses the disruption and interruption in everyday human interaction or coexistence due to digital and mobile technology devices.[1,2] Existing research has revealed that technoference significantly impacts the family ecosystem, posing risks to family relationships,[3,4] interpersonal interactions,[5,6] and child-rearing.[2,7] However,

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few studies have explored the specific mechanism of technoference affecting children problematic smartphone use by family ecology.[8–10] The parent-child relationship[11,12] and family parenting styles[13] are crucial factors shaping child problematic smartphone use within the family context. And there has been limited attention paid to younger children. Younger children tend to rely more heavily on their families and parents. Therefore, this study investigates how parent-child technoference impacts elementary school students' problematic smartphone use, particularly focusing on the roles of parent-child relationships, negative parenting styles, and potential gender differences.

Literature Review

Parent-Child Technoference and Child Problematic Smartphone Use

Technoference was originally defined as everyday intrusions or interruptions in couple interactions or time spent together that occur due to technology.[2] But in fact, technoference can occur in any type of interpersonal relationship and may range from interruptions in face-to-face conversations to the feelings of intrusion an individual experiences when his or her partner decides to check a device during couple leisure, even if partners were not interacting at that exact moment.[2] The relationship between personality traits and psychobiological mechanisms of resilience and vulnerability as regards the impact of parent-child technoference on child problematic smartphone use has been paid attention to by many studies, such as depression, anxiety, and stress and so on.[14–16] The current study focuses on parent-child relationships. Based on the specific circumstances of technoference between parents and children, these interferences may influence child problematic smartphone use in two distinct ways. Firstly, based on Observational Learning Theory,[17] children are likely to observe and subsequently emulate their parents' patterns of smartphone usage, thus directly affecting their own reliance on mobile devices. Secondly, Expectancy Violations Theory (EVT) states that in the process of social interaction with others, if the other person's behavior is inconsistent with the individual's expectation, this breach of expectation causes arousal and forces the individual to make a series of cognitive assessments of the breach.[18] It explains the effect of expectation breach caused by technological interference on the behavior of interpersonal objects in parent-child interaction. Research has also found that when children's yearning for parental attention remains unfulfilled, it may engender a propensity for internalizing problematic behaviors.[19] Consequently, within the dynamic of parent-child interaction, instances where parents utilize electronic devices and consequently diminish their attention towards their children may inadvertently heighten the occurrence of internalizing issues.[20] One noteworthy manifestation of such problems is the development of internet addiction.[21] Furthermore, in addition to the presence of internet addiction, empirical investigations have also uncovered a positive association between technoference between parents and children and the subsequent emergence of smartphone addiction or dependence among middle school students.[22,23]

The Mediating Role of Parent-Child Relationship

Positive parent-child interactions, attention, understanding and responsiveness form the foundation of a high-quality parent-child relationship. In return, a strong parent-child relationship serves as a protective factor against children's problem behaviors. Children with high quality parent-child relationships typically display fewer problem behaviors.[24] Currently, there are no studies directly examined the mediating role of parent-child relationships in the link between parent-child technoference and problematic smartphone use among elementary school students. However, studies in adolescents have found that those who perceive higher levels of parental technoference tend to experience heightened conflict in their relationships with their parents[25] and lower-quality parent-child communication.[26] According to the Compensation Advantage Theory,[27] unmet psychological needs offline can be compensated for through online networks.[27] For instance, adolescents who find their psychological needs unfulfilled in family life may turn to the Internet for compensation,[27,28] potentially developing problematic smartphone use.[29] The parent-child relationship is crucial for children to receive social support and satisfy their psychological needs. When children do not receive care and warmth from their parents, they may seek satisfaction elsewhere, possibly leading to problematic smartphone use. Studies also show that a strong parent-child relationship significantly reduces adolescent smartphone addiction,[30] while high-quality parent-child communication and attachment play key roles in reducing both smartphone addiction and problematic smartphone use.[26,31]

The Mediating Role of Negative Parenting Styles

Parenting styles refers to the behaviors used in raising and educating children, and the set of stable coping patterns that are hidden behind them.[32] In this study, negative parenting styles included punishment, blame and shame. Research has shown that technoference can impact the quality of parenting. For example, one study found that mothers with high levels of technoference in parenting exhibited lower parenting quality.[2] Another study involving a more diverse sample found that technology use involvement and conflict were also associated with parenting quality, with increased technology interference leading to diminished parenting quality among couples.[33] Studies have shown that there is a close relationship between parenting quality and parenting style. One study obtained results revealed that low-quality parenting behaviors in which parents experience more conflicts and partner's sabotage in parenting practices are associated with more authoritarian and negative parenting styles.[34] Negative parenting styles, such as rejection and overprotection, tend to be predictors of smartphone addiction and online gaming disorder in children and adolescents,[35,36] whereas positive parenting styles are protective, for example, children with warm and democratic parenting styles are less likely to become addicted to smartphones.[37,38] Therefore, it is reasonable to hypothesize that prolonged technological interference in parent-child interactions not only diminishes parenting quality but also impacts parenting styles. Based on the Compensatory Advantage Theory,[27] children and adolescents desire parental support and warmth within family, and positive parenting provides this crucial support. In contrast, negative parenting can deprive them of this support. When children and adolescents lack warmth and care, they may be less likely to seek help in real-life situations, turning instead to their smartphones for comfort.[39,40]

A Chain Mediation Model

Some studies have found that the actual experience of parent-child interaction is one of the most important factors influencing parental self-efficacy,[41] and that a good parent-child relationship represents positive interaction between parents and children,[42] which makes parent-child communication more fluid and effective.[43] Parents with high self-efficacy are more likely to adopt positive parenting styles, while parents with low self-efficacy are more likely to adopt negative parenting styles due to a lack of positive parent-child interactions and inability to perform their parenting roles well.[44,45] Therefore, it is reasonable to assume that parent-child relationship and negative parenting style may have a chain mediation effect.

Gender Differences

Significant gender differences have been found in previous studies related to technoference. Compared to boys, girls were more likely to use smartphones to cause technological interference in interactions.[46] Girls are more likely to experience technoference due to smartphone use, and girls were more likely to interrupt communication due to texting on their smartphones, while boys were more likely to interrupt communication due to playing games on their smartphones.[47] In a study exploring parental neglect through maternal video screen time, it was found that girls were more likely to perceive and have more influence on their mothers' longer video screen time, while boys did not.[48] In terms of differences in perceived parenting styles, there were significant gender differences in the way parents treated their children,[49] with boys perceiving more authoritative or rejection and interference parenting styles from their parents, while girls perceive more warm parenting styles.[50–53] In conclusion, although previous work has not yet explored gender differences in adolescents' perceived technological interference between parents and children, gender differences in the occurrence of technological interference and in boys' and girls' perceptions of parenting behaviors are evident from the available studies.

The Current Study

Social interactions is important for individuals' overall well-being and mental health.[25,54,55] In daily life, the quality of social interaction increases happiness;[56] Positive parent-child interaction can greatly improve children's mental health.[57] Recent evidence has indeed shown that mobile technology disrupts face-to-face interactions.[19,58] Prior studies on parent-child technology interference and problematic smartphone use in adolescents focused on individual factors like social

anxiety, core self-evaluations,[59] and social sensitivity and loneliness,[22] overlooking family dynamics and elementary school students. Thus, this study examines these dynamics, investigating the link between parent-child technoference and child problematic smartphone use, with attention to the mediating roles of the parent-child relationship and negative parenting styles, including gender differences. Additionally, this study's specific focus will be on parent-child technoference with smartphones. This emphasis is due to the increasing popularity of smartphones and their unique attributes, including their small size, mobility, and quick access to media content, which contribute to their widespread use in parent-child interactions. Based on the results of the previous literature review, this study aims to investigate the relationship between parent-child technoference and child problematic smartphone use, examining whether the parent-child relationship and negative parenting styles mediate this link, and also focuses on gender differences in this mediation model. The following hypotheses guide this study: parent-child technoference positively predicts child problematic smartphone use (Hypothesis 1). The parent-child relationship and negative parenting styles mediate the relationship between parent-child technoference and child problematic smartphone use (Hypothesis 2). The parent-child relationship and negative parenting styles jointly mediate the connection between parent-child technoference and child problematic smartphone use (Hypothesis 3). Gender differences exist within these models (Hypothesis 4). In summary, this research aims to fill the gap in our understanding of how parent-child technoference impacts problematic smartphone use among elementary school students, with a specific focus on the role of family factors and gender differences. Figure 1 summarizing the research questions addressed.

Methods

Procedure and Participants

This study gathered data from a regional educational quality assessment program in an economically developed coastal city of China. This program was similar to the Organization for Economic Cooperation and Development's (OECD) Programme for International Student Assessment (PISA) and the International Association for the Evaluation of Educational Achievement's (IEA) Trends in International Mathematics and Science Study (TIMSS). Such programs usually select a specific age or grade to represent a period of school stage. Similar to these programs, the study selected fourth-grade students to represent elementary school students and adopted convenience sampling to select the target school. In the 545 target schools, the cluster random sampling method was used to choose several 4th-grade classes. All schools received a letter of information that detailed the study's purposes and procedures, and all the participants' parents agreed that they could participate in this program. Students in the target classes were invited to participate anonymously in the survey in classrooms. The authenticity, independence, and integral nature of all answers and the confidentiality of the information collected were emphasized to all participants by well-trained psychology graduate students. Each

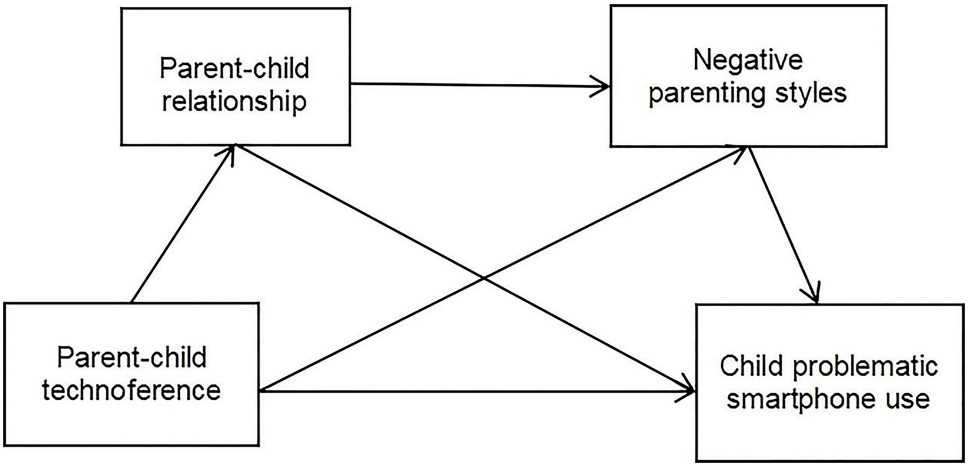

Figure 1 The hypothesized model.

participant completed the measures independently in a self-administered format to safeguard confidentiality. All participation was voluntary, and the data were kept completely confidential.

A total of 18,649 fourth-grade students from 535 primary schools in coastal cities participated in the questionnaire survey, and 18,384 valid questionnaires were recovered, with a recovery rate of 98.58%. Since the dependent variable of this study is child problematic smartphone use, owning and being able to use smartphones is a prerequisite for the study. Therefore, we screened out 3404 primary school students who owned owns and can use smartphones (18.52% of all students participating in the test), and after cleaning up invalid answers (4.34% in total) and missing data (6.86% in total), the data of the remaining 3023 students were found. The mean age of the children was 10.59, with a standard deviation of 0.32, among them, 57.4% were boys, 42.6% were girls; 80.6% were from one-child families and 19.4% were from non-one-child families; 32.9% were from lower income level families, 33.3% were from middle income level families, and 33.7% were from higher income level families.

Measures

Parent-Child Technoference

The questionnaire for measuring parent-child technoference was adapted from the The Technoference Scale (TTS).[26] First, considering that smartphones are the most popular in households, and studies also have found that smartphones are the device with the highest frequency of interference,[60] so, in order to enhance the validity of the questionnaire, this study focused on smartphones as the devices of technoference. Second, considering the accuracy of respondents' grasp of the meaning of the options, and in order to enable respondents to better correspond to their own feelings, as well as to emphasize the degree rather than the frequency of technoference, the original 5-point scale (1= "Not at all" to 5= "Very much") was changed to a 4-point scale (1= "Strongly disagree" to 4= "Strongly agree"). Third, the newly adapted questionnaire places more emphasis on the negative effects of technological involvement, with special emphasis on 'playing with smartphone' in the question formulation to distinguish the necessary use of smartphones for work or life reasons. The new questionnaire was answered by students with four questions (eg, "My parents ignore my needs because of playing with their smartphones all the time"). It was averaged on a 4-point Likert-style scale (1 = "strongly disagree" to 4 = "strongly agree"), with a higher score indicating more technology interference. The validity of the questionnaire was tested by confirmatory factor analysis, and the model fit was good (CFI=0.99, TLI=0.96, RMSEA=0.09, SRMR=0.01). Cronbach's α for parent-child technoference was 0.87.

Parent-Child Relationship

The adapted Network of Relationships Inventory (NRI)[61] was used in this study. For example, NRI includes "How much do you and this person play around and have fun". It was adapted in this study (eg, "How much do you and your parents play around and have fun"). The questionnaire consisted of 8 items (eg, "Parents will encourage me"), and the average score was calculated on a 5-point Likert-style scale (1 = "never" to 5 = "always"). The higher the score, the better the parent-child relationship. The validity of the questionnaire was tested by confirmatory factor analysis, and the model fit was good (CFI=0.96, TLI=0.94, RMSEA=0.09, SRMR=0.02). Cronbach's α for parent-child relationship was 0.78.

Negative Parenting Styles

The questionnaire for measuring negative parenting styles used the subscale of negative parenting styles of the Co-parenting Relationship Scale (CRS) developed jointly by Kim and Teti (2014).[62] There are 18 items in total (eg, "No matter what is not done well, parents first blame or blame me"). The students answered the questions on a 5-point Likert-style scale (1= "never" to 5= "always"), and the average score was calculated. The higher the score, the more negative the parenting style. The validity of the questionnaire was tested by confirmatory factor analysis, and the model fit was good (CFI=0.92, TLI=0.91, RMSEA=0.07, SRMR=0.04). Cronbach's α for negative parenting styles was 0.95.

Child Problematic Smartphone Use

A simplified version of the Mobile Phone Problem Use Scale (MPPUS-10)[63] was used to measure elementary students' problematic smartphone use, including 10 items (eg, "When I am in a bad mood, I use my phone to make me feel better"). The students answered the questions on a 5-point Likert-type scale (1= "completely disagree" to 5= "completely

agree") and the average score was calculated. The higher the score, the more dependent the individual was on smartphones. Cronbach's α for child problematic smartphone use was 0.95.

Covariates

This study also collected information on socioeconomic status of the family (1 = "Lower income level", 2= "middle income level", 3 = "Higher income level") and the number of children (1 = "Only child", 2= "Many children"). Among them, family income, the educational level of both parents and the occupation of both parents are selected as the measurement indicators of family socioeconomic status and are quantified.[64] Finally, with reference to existing studies, the five variables of family income, the years of education of both parents, and the occupations of both parents were converted into standard Z-values and then summed,[65] that is, the higher the socioeconomic status of each family, the higher the socioeconomic status of the family. These variables were included as covariates given their associations with key study variables in prior studies.[66–68]

Data Analysis

After the data were collected, the test data was exported by the test platform technicians according to the coding manual given by the project team and a database was created. Before the data analysis, the data was cleared up to eliminate the blank questionnaires and missing data to obtain the data for this study. The Harman single-factor test was used to conduct a common method bias test for all the questions used in the model. It was found that there were 6 factors whose characteristic roots were greater than 1. The variance explained by the first factor was 30.52%, less than the critical standard of 40.0%, indicating that there was no serious common method bias in this study.[69] In this study, SPSS 21.0 was used for basic data description and correlation analysis, and Mplus 7.1 was used to test the mediation effect. This research randomly selected 5000 bootstrap examples from the data to estimate the 95% bias-corrected confidence intervals of the direct and indirect effects to examine whether there were statistically significant direct or indirect effects. If the confidence intervals did not include 0, the effect was considered to be significant.[70] Finally Amos 22.0 was used to test multigroup comparisons of students' gender.

Results

Preliminary Analyses

Means, standard deviations and correlations among all study variables are presented in Table 1. Parent-child technoference was positively correlated with negative parenting styles and child problematic smartphone use, while it was negatively correlated with parent-child relationship. Parent-child relationship was negatively correlated with negative parenting styles and child problematic smartphone use. Negative parenting styles was positively correlated with child problematic smartphone use.

Testing the Mediating Effects of Parent-Child Relationship and Negative Parenting Styles

Before testing the mediating model, a simple linear regression between parent-child technoference and child problematic smartphone use was conducted. The results showed that parent-child technoference can significantly positively predict child problematic smartphone use (β=0.75, p <0.001, R^2=0.49). Then parent-child relationship and negative parenting

Table 1 Descriptive Statistics and Intercorrelations Between Variables

	M	SD	1	2	3	4
1 Parent-child technoference	2.39	1.01	-			
2 Parent-child relationship	3.87	0.88	−0.54**	–		
3 Negative parenting styles	2.83	1.19	0.69**	−0.58**	–	
4 Child problematic smartphone use	2.66	1.31	0.70**	−0.72**	0.76**	–

Note: **p<0.01.

styles were included as mediators in the association between parent-child technoference and child problematic smartphone use (see Figure 2), while controlling for the number of children and socioeconomic status of the family. The fitting index of the chain mediation model was acceptable: χ^2/df=11.87 (χ^2=71.24, df=6), CFI=0.99, TLI=0.98, RMSEA=0.06, and SRMR=0.02.[71] From the Figure 2, parent-child technoference positively predicted negative parenting styles (β=0.56, p<0.001) and child problematic smartphone use (β=0.25, p<0.001) and negatively predicted parent-child relationship (β=−0.61, p<0.001). Also, parent-child relationship negatively predicted negative parenting styles (β=−0.27, p<0.001) and child problematic smartphone use (β=−0.35, p<0.05). Furthermore, negative parenting styles positively predicted child problematic smartphone use (β=0.39, p<0.001).

A bias-corrected bootstrap test was conducted to assess the statistical significance of the indirect paths. Table 2 presents the results after controlling for the number of children and socioeconomic status of the family. The three indirect paths were found to be significant, as the 95% confidence interval did not include zero.[72] The mediating effect value of indirect path 1 (parent-child technoference →parent-child relationship→ child problematic smartphone use) was 0.214, indirect path 2 (parent-child technoference →negative parenting styles →child problematic smartphone use) was 0.218, and indirect path 3 (parent-child technoference → parent-child relationship negative parenting style → child problematic smartphone use) was 0.064. The mediating effects accounted for 66.49% of the total effect.

A Cross-Group Comparison Between Girls and Boys of the Mediation Model

To examine potential gender difference in the mediation model involving parent-child relationship and negative parenting styles, this study established separate models for girls and boys using the same procedure described earlier. For the girls' model, all indices indicated a good fit, χ^2/df=3.09 (χ^2=37.08, df=12), CFI=0.99, TLI=0.99, RMSEA=0.04, and the boys' model also fitted well, χ^2/df=7.72 (χ^2=92.63, df=12), CFI=0.98, TLI=0.97, RMSEA=0.06. Overall, the indicators fell within an acceptable range, suggesting suitability for conducting multi-group path analysis.[73]

This study employed the unrestricted model (where all parameters are freely estimated) and the restricted model (where the regression path coefficients are constrained to be equal) for model comparison, as shown in Table 3. The results indicate good fit for both the restricted and unrestricted models, as observed from the fitting indices in the table When comparing the models with equal parameters, the calculated change value of the Chi-square test is 43.07 (ΔCMIN/Δdf = 4.79), corresponding to the p value of 0.000 (the p value in the table) < 0.001. Hence, the significant change in the Chi-square value indicates inconsistency between the two models, suggesting a significant moderating effect of child gender.

Moreover, Figure 3 illustrates the specific standardized path coefficients. Notably, three paths exhibit significant gender differences. First, the path representing the impact of parent-child technoference on child problematic smartphone use varies between boys (β=0.27, p<0.001) and girls (β=0.20, p<0.001), with a critical ratio of differences between

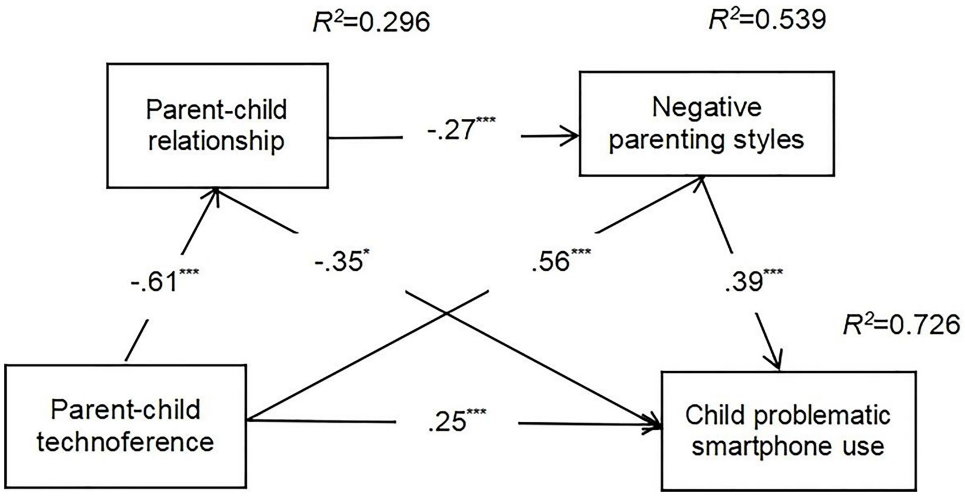

Figure 2 The chain mediation model.
Notes: The solid black line is significant, not shown covariates in the model diagram. *p<0.05, ***p<0.001.

Table 2 Bias-Corrected Bootstrap Test on the Mediating Effects

Path	Standardized β	95% CI	
		BootLLCI	BootULCI
X1→M1→Y	0.214	0.184	0.217
X1→M2→Y	0.218	0.185	0.228
X1→M1→M2→Y	0.064	0.051	0.069
Indirect effects	0.496	0.445	0.489
Total effect	0.746	–	–

Notes: X1 = Parent-child technoference, M1 = Parent-child relationship, M2 = Negative parenting styles, Y = Child problematic smartphone use.

Table 3 Fitting Results of Model Comparison

Model	χ^2	df	χ^2/df	CFI	TLI	RMSEA	$\Delta\chi^2$	Δdf	$\Delta\chi^2/\Delta$df	P
Unrestricted model	121.64	24	5.07	0.99	0.98	0.04				
Restricted model	164.71	33	4.99	0.98	0.98	0.04	43.07	9	4.79	0.000

parameters (c.R. Value) of 2.50, and the absolute value exceeds 1.96, indicating a moderating effect of gender on the relationship between parent-child technoference and child problematic smartphone use. Specifically, higher levels of parent-child technoference are associated with increased problematic smartphone use in boys. Second, the path reflecting the influence of parent-child technoference on parent-child relationship differs between boys (β=−0.52, p<0.001) and girls (β=−0.57, p<0.001), with a critical ratio between parameters (c.R. Value) of 2.33, and the absolute value exceeds 1.96, suggesting a moderating effect of gender on the association between parent-child technoference and parent-child relationship. In this case, greater parent-child technoference tends to have a more detrimental impact on the parent-child relationship among girls and their parents. Third, the path illustrating the influence of parent-child relationship on negative parenting styles between boys (β=−0.23, p<0.001) and girls (β=−0.36, p<0.001), with a critical ratio between parameters (c.R. Value) of 4.07, and the absolute value exceeds 2.58, indicating a moderating effect of gender on the relationship between parent-child relationship and negative parenting styles. Specifically, when the parent-child relationship is disrupted, girls are more likely to experience heightened levels of negative parenting styles compared to boys.

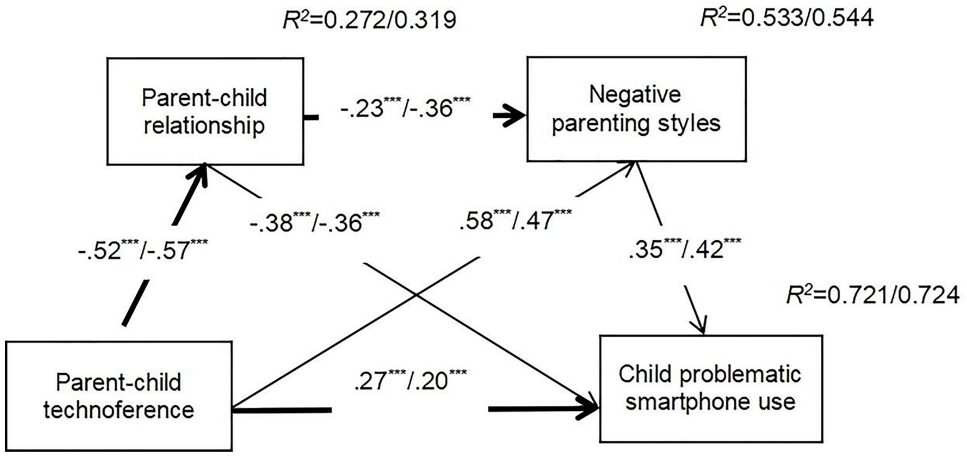

Figure 3 Boys/girls multiple group comparison model.
Notes: Thin black solid lines indicate significant paths, and thick black solid lines indicate significant gender differences between paths. ***p<0.001.

Discussion

By considering the impact of parent-child technoference on child development and the spillover effect within different family subsystems, this study examined the association between parent-child technoference and child problematic smartphone use, while exploring potential mediating mechanisms. The results not only enhance people's understanding of the relationship between parent-child technoference and child problematic smartphone use, but also offer a fresh perspective for the preventing and intervening in child problematic smartphone use.

Parent-Child Technoference and Child Problematic Smartphone Use

This study investigates the association between parent-child technoference and child problematic smartphone use. The results indicate a significant positive impact of parent-child technoference on child problematic smartphone use, thereby confirming this research Hypothesis 1. The finding is consistent with prior research,[74,75] suggesting that parent-child technoference directly contributes to child problematic smartphone use. The Cognitive-Behavioral Model of pathological Internet use can be utilized to explain this outcome. The model not only views pathological Internet use as a dynamic development process, but also emphasizes the influence of non-adaptive cognition on pathological Internet use. The basic construct of this theory is that remote factors such as events in life will first lead to the corresponding non-adaptive cognition of individuals, and then further trigger the avoidance behavior of Internet addiction. Non-adaptive cognition is the proximal factor leading to Internet addiction.[76] In our study, given that elementary school students are still reliant on their parents, frequent parent-child technoference (remote factor) can generate negative self-cognition (proximal factor) in children, subsequently leading to behavioral problems, particularly problematic smartphone use.[77]

The Mediating Role of Parent-Child Relationship and Negative Parenting Styles

Consistent with the Hypothesis 2, this study has demonstrated that parent-child relationship mediated the association between parent-child technoference and child problematic smartphone use. Two potential explanations for this phenomenon exist. Firstly, technological interference can distract parents, contributing to the destruction of parent-child relationship;[19] Secondly, interference arising from parental smartphone use during interactions with their children may provoke conflicts, ultimately detrimentally impacting the parent-child relationship.[78] In the subsequent stage of the mediating process, exerts a negative influence on child problematic smartphone use. Prior research has also established a connection between parent-child discord, particularly parent-child conflicts, and increased tendencies toward internet addiction behaviors in adolescents.[79] According to Social Support Theory, a positive parent-child relationship reflects available family support resources from parents,[80,81] significantly correlating with adolescents' psychological satisfaction.[82] Conversely, unmet psychological needs among teens in the family context may drive them to seek fulfillment online.[83,84] Since smartphones offer abundant internet resources, they become a natural avenue for virtual compensation, ultimately contributing to problematic smartphone use in addicted children.[29,85]

In line with Hypothesis 2, negative parenting styles act as another important mediating mechanism. The results support the Substitution Theory,[86] where parental smartphone addiction can reduce nurturing behaviors during interactions and may trigger negative parenting behaviors, such as hostility.[2,59] And negative parenting styles such as rejection also can cause children to experience negative emotions.[87] Children in this age group already have the ability to differentiate negative emotions, and can accurately identify and subtly perceive negative emotions.[88] Consequently, children are aware of these negative parenting behaviors.[89] Additionally, excessive technology use can hinder effective parent-child interactions,[78] further contributing to children's negative evaluation of their parents' parenting. In the latter part of this mediation pathway, negative parenting styles contribute to increased problematic smartphone use among elementary school students. This can be attributed to the lack of warmth and encouragement from parents when negative parenting styles are employed, which would typically serve as a crucial source of family social support. According to the Compensatory Advantage Theory, individuals may turn to smartphones as a means of escaping psycho-social problems in the real world,[27] seeking solace and satisfaction through these devices to alleviate distress.

Finally, the results confirm Hypothesis 3, demonstrating that parent-child relationship and negative parenting styles play a chain mediating role in the influence of parent-child technoference on child problematic smartphone use. The

disharmony of parent-child relationship may lead parents to adopt negative parenting styles, potentially attributed to breakdown of the parent-child relationship imposing parenting pressure on parents. According to Stress-Coping Theory,[90] continuous interactions with the surrounding environment can generate pressure if the balance between environmental demands and individual coping resources is disrupted. It can be imagined that parents' addiction to mobile phone use in parent-child interaction will lead to the imbalance of their coping resources, resulting in parent-child interaction disorder. And dysfunctional parent-child interaction can lead to stressful experiences for parents.[91] Increased parenting pressure is often associated with harsher, more authoritarian parenting styles.[92,93]

Gender Difference

This study identified a significant moderating effect of gender on the mediating model involving parent-child relationship and negative parenting styles. First, parent-child technoference is more likely to lead to problematic smartphone use behavior in boys. This phenomenon can be explained by gender differences in mood disorders.[94] In the context of parent-child interaction, technological interference riggers negative emotions in both boys and girls. However, when faced with negative emotions, girls tend to reevaluate them using more positive emotions,[95] while boys adopt the opposite approach. Boys may seek to escape reality through fantasy,[96,97] and smartphones, as open network platforms with strong functionality and easy access, provide them with a means of seeking solace and alleviating negative emotions.[98] Consequently, boys exhibit more smartphone dependent behaviors. Second, parent-child technoference is more likely to disrupt the parent-child relationship between girls and their parents. When parent-child interactions are interrupted by smartphones, parents' attention shifts to their devices, leading to the unmet needs for communication the parent-child relationship,[99] thus causing its deterioration.[77] Girls tend to place greater emphasis on relationships than boys and are more sensitive to emotional information in relationships.[100] As a result, the parent-child relationship between girls and their parents may be more adversely affected by technology interference. Third, when the parent-child relationship is damaged, girls experience more negative parenting styles than boys. This may be influenced by gender stereotypes and expectations, with girls are often being taught to be submissive, sensitive, and encouraged to form close, dependent relationships.[101,102] Therefore, when the parent-child relationship deteriorates, girls may be more sensitive to it, leading to significantly higher negative impact and experiences compared to boys.[88,103] Studies have also confirmed that when mothers communicate negatively with girls, girls are more likely to perceive rejection and negation from their mothers compared to boys.[104]

Limitations and Implications

Several limitations need to be considered when interpreting the findings. First of all, this study's cross-sectional design limits causal inferences. However, when mediation models are grounded in theory and are partially supported by previous empirical research, cross-section mediation can provide valuable insights into the relationships between variables. Future research should employ longitudinal designs to test this multiple mediation model more robustly. Second, the present study relied on students' self-reports to collect data. In the future, a more diverse range of data acquisition methods can be employed to quantify technical interference. As done by McDaniel BT, Coyne SM and Furman W, Buhrmester D,[2,55] future researchers should be encouraged to examine these relationships more directly using longitudinal and daily diary studies. Furthermore, there may be other unexplored personality and relationship variables that could serve as mediating factors in the relationship between parent-child technoference and child problematic smartphone use. Additionally, in this study, the collection of technoference in the interactive context mainly focuses on interference caused by parents' use of smartphones. However, in the interactive context, interference can be emitted by both sides of the interaction. Thus, future research in the parent-child context should consider paired data of children and parents simultaneously, to account for the mutual influence between family members. This approach would facilitate a more comprehensive and objective exploration of the influence mechanism of technological interference on children and adolescents' problematic smartphone use.

Despite these limitations, this study has identified the mechanism of parent-child technoference on child problematic smartphone use, enriching the literature in the field of technoference. First of all, the subjects focused on primary school students, who are at a critical period of various cognitive development, and smartphones can satisfy their curiosity and

curiosity. What's more, unlike teenagers and college students, who are relatively independent and more influenced by their parents, the study of primary school students expands and enriches the age group in which the field of technological disruption and problematic smartphone use is studied. Secondly, this study provides an empirical framework for future intervention practices by testing the chain mediating effects of parent-child relationship and negative parenting styles. These results help reveal the internal mechanism between parent-child technoference and child problematic smartphone use, providing evidence for the designing effective measures to prevent and intervene in primary school students' problematic smartphone use in practice. With the development of mobile and digital technology, mobile devices have now become indispensable in family life. Particularly, the popularity of smartphones and other portable devices has somewhat impaired social interaction and interpersonal relationship among family members. The results of this study underscore the importance of parent-child relationship and negative parenting styles in future intervention for managing problematic smartphone use among primary school students. As two factors that can be improved and addressed in daily life, they offer new insights for parents on how to enhance parent-child relationships and subsequently modify their parenting styles to reduce child problematic smartphone use behavior. Last but not the least, the findings reveal the moderating role of gender. This provides targeted empirical evidence for interventions among both boys and girls. Therefore, in addressing primary school students' problematic smartphone use, gender-appropriate measures need to be adopted for boys and girls respectively, considering gender differences and implementing tailored interventions. In conclusion, this study not only contributes to a deeper understanding of the relationship between parent-child technoference and child problematic smartphone use, along with its internal mechanism, but also sheds light on the moderating role of gender in the complex dynamics between parent-child technoference, parent-child relationship, negative parenting styles, and problematic smartphone use behaviors among primary school students.

Conclusion

This study firstly demonstrates the serious impact of parent-child technoference on problematic smartphone use in primary school students. To be specific, harkening back to the lessons embedded within family-system theory, parents who are the important people in the family that children contact directly, the interference caused by their smartphone use will indeed directly lead to child problematic smartphone use behavior. Furthermore, the current study shows that parent-child relationship and parents' negative parenting styles are important mediating factors affecting child problematic smartphone use. The technical interference caused by parents' use of smartphones will not only destroy the parent-child relationship, but also make parents take more negative ways in daily parenting behaviors, which will directly or indirectly lead to the formation of child problematic smartphone use behavior. It is worth noting that there are significant gender differences in the chain mediating mechanism of parent-child technoference on child problematic smartphone use. Specifically, girls experience more pronounced disruption in parent-child relationships, while boys are more likely to become dependent on smartphones. Girls also tended to experience more negative parenting in situations where parent-child relationships were strained due to technological distractions. Therefore, in the future intervention of child problematic smartphone use, interveners should not only pay attention to the smartphone use behavior of parents themselves, pay attention to the harmony of family relations and the enthusiasm of parenting style, but also pay attention to the different intervention measures for boys and girls, and attach importance to the heterogeneity of groups.

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The authors report no conflicts of interest in this work.

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