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The dynamic interplay between neuroticism, extraversion, and problematic gaming in adolescents: A 4-wave longitudinal study

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FULL-LENGTH REPORT



ABSTRACT

Background and aims: Adolescent problematic gaming is a global public health issue, and is associated with numerous negative outcomes. The Big Two personality traits, neuroticism and extraversion, have been identified as significant predictors of problematic gaming in adolescents. However, most previous studies have been cross-sectional, limiting the ability to explore their mutual influences or causality inference. This study addresses this gap by employing a longitudinal design and utilizing the Random Intercept Cross-Lagged Panel Model (RI-CLPM) to examine the bidirectional relations between the Big Two personality traits and problematic gaming at the within-person level. **Methods:** This study included 3,307 students (Mean age = 11.30, SD = 0.48, 43.6% being girls). Participants were assessed annually, completing a total of four assessments over the course of the study. **Results:** The RI-CLPM analyses revealed that neuroticism and problematic gaming significantly predict each other. Extraversion acts as a protective factor against adolescent problematic gaming, whereas problematic gaming leads to a decrease in extraversion levels. Additionally, the longitudinal relations between neuroticism and problematic gaming exhibit significant sex differences. **Discussion and conclusions:** This study provides insights into the interplay between the Big Two personality traits and problematic gaming in adolescents. These findings emphasize the need for prevention and intervention strategies that address personality traits as risk factors while recognizing how problematic gaming can influence personality, promoting a more holistic approach. The observed sex differences highlight the importance of integrating sex-specific considerations in interventions.

KEYWORDS

neuroticism, extraversion, problematic gaming, Random Intercept Cross-Lagged Panel Model

INTRODUCTION

The increasingly pervasive presence of online gaming in daily life is reshaping the landscape of adolescent socialization (Thulin, Vilhelmson, & Schwanen, 2020). As online gaming becomes increasingly embedded in the social and recreational activities of young people, facilitated by technological advancements and the expansion of online platforms, its influence extends beyond mere entertainment, raising significant concerns among educators, parents, and mental health professionals regarding its impacts on psychosocial adjustment (e.g., Chan et al., 2022; Purwaningsih & Nurmala, 2021; Rosendo-Rios, Trott, & Shukla, 2022). These concerns center on problematic gaming (e.g., Männikkö, Ruotsalainen, Miettunen, Pontes, & Käriäinen, 2020). Research has established that personality traits, particularly neuroticism and extraversion, are significant predictors of problematic gaming; however, the potential for

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problematic gaming to influence the development of these personality traits in adolescents remains largely overlooked (e.g., Chew, 2022; Gervasi et al., 2017; Şalvarlı & Griffiths, 2021). Thus, comprehensive investigations are needed to understand the dynamic interplay between neuroticism, extraversion and problematic gaming in adolescents.

Problematic gaming is characterized by excessive and compulsive gaming activities, which have been empirically observed to correlate with a variety of psychological difficulties including anxiety (e.g., Wang et al., 2017), depression (e.g., Männikkö et al., 2020), and social withdrawal (e.g., Giardina et al., 2024), attention disorders (e.g., Gao et al., 2021), sleep disturbances (Kristensen, Pallesen, King, Hysing, & Erevik, 2021) and even self-harm (e.g., Pan & Yeh, 2018) and suicidal behaviors (e.g., Erevik et al., 2022). Adding to the severity of these concerns, the most extreme cases of problematic gaming have led to the formal recognition of Internet gaming disorder (IGD) (e.g., Petry, Rehbein, Ko, & O'Brien, 2015). Defined as the uncontrollable, excessive, and compulsive use of online games that significantly impairs social and personal functioning, IGD has been included as a tentative disorder requiring additional research in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5-TR; APA., 2022). The International Classification of Diseases (ICD-11) also officially classified gaming disorder as an addictive behavior disorder (WHO, 2019). Our study uses the broader term “problematic gaming” because it encompasses a wider range of behaviors that may negatively impact an individual’s psychological and social functioning, even if they do not meet the strict diagnostic criteria for IGD in DSM-5 or ICD-11 (e.g., Ang, Chong, Chye, & Huan, 2012). This approach allows us to capture less severe cases that might still benefit from early intervention, providing a more inclusive understanding of gaming-related issues. Moreover, using “problematic gaming” offers flexibility, as it is not confined to specific diagnostic standards, making it more adaptable across different cultural contexts and individual differences (Fernandes, Maia, & Pontes, 2019).

Recent systematic reviews (Long et al., 2018; Nielsen, Favez, & Rigter, 2020) and meta-analyses (Liao, Chen, Huang, & Shen, 2022) indicate that the prevalence rates of problematic gaming among adolescents range from 3.5% to 30.4%. While these figures differ across studies, they consistently reflect a significant concern that resonates globally (Feng, Ramo, Chan, & Bourgeois, 2017; Kim, Song et al., 2022). Given the serious clinical consequences associated with problematic gaming in youth, it is essential to understand its etiological risk factors to develop effective interventions and preventive strategies. Personality traits, particularly the Big Two dimensions of neuroticism and extraversion, have been well-identified as key determinants of adolescent problematic gaming (see Gervasi et al., 2017). However, the majority of previous research has been cross-sectional in nature (see Chew, 2022; Şalvarlı & Griffiths, 2021), thereby limiting the ability to draw causal conclusions about the relation between personality traits and adolescent problematic gaming. Additionally, few studies have accounted for the directionality

and potential reciprocal dynamics between personality traits and problematic gaming, making it challenging to ascertain how Big Two personality traits and problematic gaming influence each other over time.

Early adolescence represents a dynamic period in which personality traits undergo significant development (e.g., Borghuis et al., 2017). Excessive involvement in online gaming during this critical phase may impact the developmental trajectory of personality in significant ways. For instance, the compulsive nature of problematic gaming may enhance traits like neuroticism by escalating stress and anxiety, while simultaneously stifling the growth of extraversion by limiting opportunities for real-life social interactions and engagement. Investigating the bidirectional relations between the Big Two personality traits and problematic gaming not only deepens our understanding of the co-development of adolescent personality and gaming behaviors but also aids in designing interventions that both foster sound personality development and reduce problematic gaming among adolescents. Thus, our research aims to examine the reciprocal relation between Big Two personality traits (i.e., neuroticism and extraversion) and problematic gaming by employing a longitudinal design in a sample of Chinese adolescents.

Big Two personality traits and problematic gaming

The Big Two personality traits (i.e., neuroticism and extraversion) are considered the most fundamental and widely relevant factors in describing personality (Eysenck, 1967). Neuroticism measures an individual’s emotional stability, with those high in neuroticism experiencing greater emotional distress, manifesting as heightened feelings of anxiety, worry, fear, anger, frustration, and depressed mood, and more intense emotional reactions to everyday stresses of life (Eysenck, 1990). Extraversion encompasses traits such as sociability, activity, and assertiveness, venturesome and dominant (Eysenck, 1990). Extraverts often display high levels of energy and enthusiasm in social interactions, generally maintaining a positive and optimistic outlook (Eysenck, 1990). The Interaction of Person-Affect-Cognition-Execution (Brand et al., 2019) model highlights that personality traits, as a key predisposing factor, can influence problematic gaming by impacting internal mechanisms such as emotional and cognitive responses, executive control, and the rewarding experiences associated with gaming. Personality traits may shape how individuals perceive and react to gaming stimuli, manage their impulses, and experience gratification, ultimately affecting their engagement and potential development of problematic gaming behaviors (e.g., King & Delfabbro, 2018). A comprehensive review (see Şalvarlı & Griffiths, 2021) incorporating 21 empirical studies has found that most of the research consistently shows that neuroticism is significantly positively correlated with problematic gaming, and extraversion is significantly negatively correlated, whereas some studies found no significant relations between problematic gaming and the Big Two personality traits. Additionally, a recent meta-analysis



(Akbari et al., 2021) including 25,634 young individuals revealed a modest but significant positive correlation between neuroticism and problematic gaming ($r = 0.21$, 95% CI = 0.16–0.25), and a slight yet significant negative correlation between extraversion and problematic gaming ($r = -0.12$, 95% CI = -0.16 to -0.09). Another meta-analysis found similar results, reinforcing the relations between these personality traits and problematic gaming (Chew, 2022).

Despite previous research examining the relations between the Big Two personality traits and problematic gaming, the majority of studies have employed cross-sectional study designs (see Akbari et al., 2021; Chew, 2022; Şalvarlı & Griffiths, 2021), which carry important limitations. Primarily, cross-sectional studies can only provide snapshots of data at a single point in time, thereby constraining the ability to determine causality or the direction of the relations between variables (Savitz & Wellenius, 2023). Adolescence is a period marked by significant personality development, as individuals begin to form their own identities through exploring different roles, beliefs, and values, which contribute to their sense of self and emerging personality (e.g., Syed & Seiffge-Krenke, 2013). Furthermore, as adolescents are in the midst of shaping their identities and refining their coping mechanisms, their heightened vulnerability to external influences can make them particularly susceptible to the intense emotional experiences and virtual social interactions provided by gaming (e.g., Kim, Nam, & Keum, 2022; Macur & Pontes, 2021). Overexposure to these influences can potentially solidify specific emotional responses and behaviors (e.g., Swingle, 2016), thereby significantly impacting their ongoing personality development. Thus, problematic gaming may also significantly influence adolescent personality traits.

Theoretically, online games often feature immediate rewards and punishments, creating an environment in which players face continuous challenges, competitive pressures, and feelings of frustration, significantly increasing stress levels (e.g., Ojha et al., 2023; Przybylski, Deci, Rigby, & Ryan, 2014). Prolonged exposure to this stress exacerbates inherent anxieties, leading to heightened emotional reactions and creating a persistent feedback loop that increases sensitivity to negative feedback (e.g., Lee et al., 2015; Nesi et al., 2022; Raiha et al., 2020; Weinstein, Livny, & Weizman, 2017). Consequently, this heightened sensitivity fuels feelings of frustration and emotional instability. On the other hand, while extraversion typically promotes real-world social interactions, excessive gaming can replace these with online interactions, potentially reducing real-life social engagement (e.g., Tullett-Prado, Stavropoulos, Mueller, Sharples, & Footitt, 2021). Consequently, constant gaming can limit opportunities to develop social skills in real-world scenarios, such as navigating group dynamics or interpreting nonverbal cues (e.g., Hygen et al., 2020). Over time, this preference for gaming interactions can diminish the desire and ability to engage in social activities outside of gaming, further eroding extraverted traits and overall social confidence and competence. Overall, problematic gaming may significantly impact the formation and development

of neuroticism and extraversion in adolescents. Therefore, there may be a bidirectional relation between the Big Two personality traits and problematic gaming. However, previous cross-sectional studies inherently limit the understanding of how personality traits and problematic gaming may influence each other dynamically over time. More longitudinal research is needed to investigate these reciprocal interactions, which would allow for a clearer delineation of causality and the evolution of Big Two personality traits and problematic gaming over time.

Sex differences

When exploring the bidirectional relations between the Big Two personality traits—neuroticism and extraversion—and problematic gaming, it's important to consider potential sex differences. These relations may vary significantly between males and females, influenced by varying behavioral patterns and social expectations prevalent among different sexes. Studies suggest that females typically score higher on measures of neuroticism and extraversion than males (e.g., Lippa, 2010; Slobodskaya & Kornienko, 2021; Weisberg, DeYoung, & Hirsh, 2011). Previous research has also found that levels of problematic gaming are significantly higher among males compared to females (e.g., Fam, 2018; Stevens, Dorstyn, Delfabbro, & King, 2021).

From the perspective of gender socialization theory (Fagot, Rodgers, & Leinbach, 2000), societal expectations and cultural norms significantly shape the behavioral development of males and females, influencing how they interact with environments such as gaming. Typically, males are socialized to embody traits such as competitiveness, assertiveness, and stoicism—qualities that are often valorized in many cultures (e.g., Schrock & Schwalbe, 2009). For females, societal expectations often emphasize traits such as being quiet and submissive, which are traditionally associated with femininity (e.g., Mahalik et al., 2005). If a male exhibits high neuroticism, which includes traits such as emotional sensitivity, anxiety, and insecurity, this can clash with the traditional masculine image of emotional control and resilience (Mahalik, Burns, & Syzdek, 2007). Similarly, low extraversion, characterized by introversion and shyness, may also deviate from the expected assertive and sociable male role (Addis & Mahalik, 2003). These discrepancies between actual personality traits and socially expected ones can lead to psychological stress and internal conflict (Löckenhoff et al., 2014). For some males, problematic gaming may become an effective coping mechanism—a way to escape from the discomfort of not meeting these traditional expectations or to find a domain where they can feel competent and in control (Su, Han, Yu, Wu, & Potenza, 2020). Therefore, it seems reasonable to expect that the effect of the Big Two personality traits on problematic gaming may be more pronounced among males than females.

Given the differences in how males and females respond to the dynamics of problematic gaming, particularly in relation to reward sensitivity and craving, problematic gaming can differentially influence the development or



exacerbation of the Big Two personality traits across sexes. The higher sensitivity to gaming-related rewards observed in males can enhance the pleasure and excitement derived from gaming successes, which can lead to more frequent and intense gaming sessions as males seek out these rewarding experiences (e.g., [Dong & Potenza, 2022](#)). This pattern of behavior may gradually impact their personality traits, potentially increasing neuroticism due to the stress and frustration associated with the craving and pursuit of these gaming rewards (e.g., [Snodgrass et al., 2014](#)). Moreover, as males may become more engaged in online gaming, their extraversion could diminish over time due to reduced real-world interactions and the erosion of traditional social activities (e.g., [Uz & Cagiltay, 2015](#)). Females may not experience the same level of acute cravings or reward sensitivity from gaming. Instead, their engagement in problematic gaming might be driven more by social interactions or the narrative aspects of the games (e.g., [Lopez-Fernandez, Williams, Griffiths, & Kuss, 2019](#); [Su et al., 2020](#)). The cooperative and story-focused gaming preferred by many females may contribute to a more balanced emotional state ([Phan, Jardina, Hoyle, & Chaparro, 2012](#)), potentially reducing the likelihood of developing high levels of neuroticism. Engaging in rich, interactive game narratives can also help keep female gamers connected to a social network ([Su et al., 2020](#)), which might prevent a decrease in extraversion through regular socialization, even in a virtual setting. Consequently, the modality of engagement in gaming is pivotal for differentially influencing the Big Two personality traits across sexes. Problematic gaming may predispose males to heightened levels of neuroticism and diminished extraversion, but females are likely to experience a lesser degree of impact on these traits.

The current study

The present research aims to elucidate the complex and reciprocal relations between the Big Two personality traits (i.e., neuroticism and extraversion) and problematic gaming among Chinese adolescents through a longitudinal study design. This approach seeks to overcome the limitations of previous cross-sectional studies, which have largely been unable to determine the causal directions and the dynamic interplay between personality traits and gaming behaviors over time. Given the rapid integration of online gaming into the daily social and recreational activities of youth, understanding the interplay between problematic gaming and personality traits is crucial for developing interventions specifically tailored to mitigate the risks associated with gaming behaviors and support healthy personality development. Specifically, this study formulates two hypotheses. First, based on existing research that identifies significant positive correlations between neuroticism and problematic gaming, and negative correlations between extraversion and problematic gaming, it is hypothesized that neuroticism will significantly positively predict problematic gaming behaviors and vice versa. Meanwhile, we expect extraversion to negatively predict problematic gaming and vice versa.

Second, considering the theoretical foundations of gender role theory and the differences in gaming engagement modalities, this study hypothesized that the bidirectional relations between the Big Two personality traits and problematic gaming will be more pronounced in males than in females.

In order to rigorously analyze longitudinal data and capture dynamic interactions between personality traits and problematic gaming over time, our study employs an advanced statistical technique known as the Random Intercept Cross-Lagged Panel Model (RI-CLPM, e.g., [Hamaker, Kuiper, & Grasman, 2015](#)). This model represents a significant advancement over traditional cross-lagged panel models (CLPM), which do not typically distinguish between within-individual effects and between-individual differences (e.g., [Tseng, 2024](#)). Traditional CLPM often conflates these two sources of variation, potentially leading to biased estimates in interpreting the causal relations between variables over time (e.g., [Tseng, 2024](#)). The RI-CLPM addresses this limitation by incorporating random intercepts, which account for stable, between-individual differences that may influence the observed measures across time points (e.g., [Hamaker et al., 2015](#)). This feature allows for a more precise assessment of within-individual dynamics by isolating the fluctuations specific to an individual from those consistent across the population (e.g., [Tseng, 2024](#)). By employing the RI-CLPM, our study can more accurately parse out the within-person effects of the reciprocal relations between Big Two personality traits and problematic gaming over time, offering clearer insights into the nature of these longitudinal relations.

METHODS

Participants

Participants in our study were drawn from three schools adhering to the nine-year compulsory education system located in a northwestern city. With assistance from local educational authorities, these schools were invited to participate in the study, and all three agreed to take part. According to information from local education authorities, these schools showed no significant differences in major characteristics (e.g., enrollment rates, student-teacher ratios, average academic performance, or resource availability such as facilities and extracurricular programs) compared to other schools in China, and were representative of such institutions in China. At the first time point (T1), a total of 3,307 students aged 11–13 years (Mean age = 11.30, SD = 0.48) participated in the study, with 43.6% of them being girls. The research received approval from the Northwest Normal University's ethical review board, relevant local education authorities, school principals, and teachers. Prior to data collection, written informed consent was obtained from the guardians of all participating students. Participants were assessed annually, completing a total of four assessments throughout the study. Most participants in our



sample were from middle-income families compared to the overall income levels in their province, and over eighty-three percent of the participants' parents had achieved at least a high school education.

The sample sizes for the subsequent assessments were 3,126 students at the second assessment (T2), 3,105 students at the third assessment (T3), and 2,984 students at the fourth assessment (T4), corresponding to retention rates of 94.5%, 93.9%, and 90.2%, respectively. To address potential issues related to missing data, a Missing Completely at Random (MCAR) test was conducted. The normalized chi-square (χ^2/df) value from this MCAR test was 1.22 ($p < 0.05$), suggesting a potential deviation from randomness in missingness patterns (Nicholson, Deboeck, & Howard, 2017). For the statistical analysis of the model, the Full Information Maximum Likelihood (FIML) approach was employed. FIML is advantageous in that it utilizes all available information to estimate parameters, thus maximizing the use of the data. This approach is particularly effective under the assumption of missing at random data (Little & Rubin, 2002), allowing for more accurate and robust estimations even with some missing data points.

Procedure

The data collection procedure was meticulously organized to ensure uniformity and confidentiality. All four waves of data collection were conducted in regular classrooms to maintain a familiar environment and minimize disruptions. Each classroom was assigned two trained graduate research assistants who provided both verbal and written instructions on how to complete the assessments. The students were allowed to take as much time as needed to ensure they understood the questions and could answer them thoughtfully. The demographic survey, including questions about socioeconomic status (SES), was completed online by parents under the guidance of the class teacher. To maintain confidentiality, participants were reassured that all responses would be securely stored and only accessible to the research team. As a token of appreciation, each student received a small gift valued at approximately one US dollar.

Measures

All questionnaires were administered in Chinese to ensure participants' comprehension. The scales used in this study were originally developed in English and had been translated into Chinese in prior research. These translated versions have been validated, demonstrating strong reliability and validity among Chinese adolescents, as detailed in the following sections.

Big Two personality traits. Personality traits of extraversion and neuroticism were assessed using the Junior Eysenck Personality Questionnaire Revised (JEPQR-A; Francis, 1996). The JEPQR-A has demonstrated robust reliability and validity in Chinese youth, as corroborated by prior research (Tian, Jiang, & Huebner, 2019). The extraversion subscale consists of six items, such as “Do you like going out a lot?”

Similarly, the neuroticism subscale includes six items, one example being “Do you find it hard to get to sleep at night because you are worrying about things?” Responses were collected in a binary format, with “No” scored as 0 and “Yes” scored as 1. The mean score for each subscale was calculated by summing the responses, with higher scores indicating greater levels of extraversion and neuroticism, respectively. Across the four measurement points (T1 to T4), the Cronbach's alpha for the extraversion subscale ranged from 0.64 to 0.74, and for the neuroticism subscale, it ranged from 0.74 to 0.80.

Problematic gaming. Symptoms of problematic gaming were assessed using the Pathological Online Gaming Use Scale (POGU; Gentile, 2009). The POGU was developed based on the DSM-IV criteria for pathological gambling, following similar diagnostic approaches used for other disorders by considering gaming to be pathological if the gamer exhibited at least half (6) of the symptoms (Gentile, 2009). These symptoms align with DSM-IV criteria for pathological gambling and share core characteristics with other definitions of addiction, such as Brown's core facets: salience, euphoria or relief, tolerance, withdrawal symptoms, conflict, and relapse (Brown, 1991; Gentile, 2009). Earlier research has confirmed the psychometric properties of the POGU among Chinese adolescent populations (e.g., Zhao, Li, Zhou, Nie, & Zhou, 2020). The POGU is composed of 11 items designed to capture various dimensions of gaming behavior that may indicate problematic or addictive tendencies. Example items include: “Have you tried to play video games less often or for shorter periods of time, but are unsuccessful?” and “Do you need to spend more and more time and/or money on video games in order to feel the same amount of excitement”. Participants responded to each item on a three-point scale (“No,” “Sometimes,” “Yes”), scored as 0, 1, and 2, respectively. A higher average score across the items indicates more severe problematic gaming behaviors. In our study, Cronbach's alpha for the POGU ranged from 0.91 to 0.94 across the four measurement points (T1 to T4).

Covariates. At the initial data collection point (T1), detailed demographic information, including age, sex, and socioeconomic status (SES), was gathered from student participants and their parents. Students self-reported their age and sex (0 = male, 1 = female). Family socioeconomic status was assessed by having parents report their education levels and household monthly income through an online questionnaire. Parental education was measured on a scale ranging from 0 (no formal education) to 7 (doctoral degree). Household income levels were categorized on a scale from 1 (less than 1,000 RMB, ~143 USD) to 9 (over 80,000 RMB, ~11,435 USD). These scores were averaged to create an overall SES index for each family.

Data analysis

Preliminary analysis. All analyses were conducted using Mplus 8.3. Descriptive statistics, such as means and standard



deviations, were computed for all variables. Subsequently, correlational analyses were performed to examine the bivariate correlations among study variables.

RI-CLPM analysis. The RI-CLPM was constructed using the mean scores of all observed variables. The RI-CLPM aims to identify trait factors, with random intercepts accounting for consistent between-person differences (Hamaker et al., 2015). This model facilitates the analysis of how deviations from an individual’s average trait level in one construct affect deviations in another construct at the within-person level. The model estimates autoregressive and cross-lagged effects using residual scores obtained after extracting random intercepts (traits) rather than directly from observed scores. Following Mulder and Hamaker’s (2021) approach, random intercepts were modeled by regressing the observed scores onto their latent factors, with factor loadings fixed at one. This process isolates the between-person component (random intercept), and the residual variance of the observed scores represents within-person fluctuations, which are then used to estimate lagged effects between variables. At T1, the covariances among the within-person components are freely estimated, and at subsequent time points (T2, T3, and T4), all covariances among the within-person residuals are also freely estimated (Orth, Clark, Donnellan, & Robins, 2021). The RI-CLPM is tested using the Maximum Likelihood Robust (MLR) estimator to adjust for any non-normality. Controls for sex, age, and SES were applied to all observed variables at T1 and on the random intercepts. Model fit was evaluated with the chi-square statistic, Tucker-Lewis Index (TLI), Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA) and Standardized Root Mean Square Residual (SRMR). A CFI and TLI greater than 0.90, an RMSEA less than 0.08, and an SRMR less than 0.08 indicate a good model fit (Marsh, Hau, & Wen, 2004).

To further identify the most parsimonious model, we engaged in model comparison by systematically constraining the autoregressive and cross-lagged effects to be equal across time points. This step involves a series of nested model

comparisons to test whether the simplification of parameters affects the model fit. The analysis began with a fully unconstrained model where all parameters (autoregressive and cross-lagged effects) were estimated freely. Next, we progressively constrained the autoregressive and cross-lagged effects to be equal over time. The S-B χ^2 test was applied to compare the fit of two models, an effective method for comparing model fit across different models under conditions of non-normality (Satorra & Bentler, 2010).

Sex differences. To assess whether the effects in the final RI-CLPM varied by sex, we utilized a multiple-group model comparison approach. We applied the S-B χ^2 test to compare the fit of two models. In the first model, all lagged paths in the final RI-CLPM were freely estimated for each sex. In the second model, all lagged paths were constrained to be equal across sexes.

Ethics

Study procedures were carried out in accordance with the Declaration of Helsinki. The study was approved by the School of Psychology Research Ethics Committee at Northwest Normal University. The cognizant education authorities, school boards, and teachers at each of the participating schools also approved the implementation of this study. Additionally, all parents signed a written informed consent form allowing their child’s participation, and students provided their assent before data collection. All procedures involving human participants were in accordance with the ethical standards of the institutional and/or national research committee.

RESULTS

Descriptive statistics

Table 1 presents the means and standard deviations for all study variables. Correlational analyses indicated that neuroticism was significantly positively correlated with problematic gaming over time, whereas extraversion was

Table 1. Descriptive statistics and correlations of study variables

Variables	M	SD	1	2	3	4	5	6	7	8	9	10	11
1. T1_problematic gaming	0.28	0.15	–										
2. T2_problematic gaming	0.27	0.15	0.52	–									
3. T3_problematic gaming	0.25	0.16	0.43	0.58	–								
4. T4_problematic gaming	0.25	0.17	0.37	0.49	0.60	–							
5. T1_neuroticism	0.30	0.09	0.42	0.33	0.27	0.22	–						
6. T2_neuroticism	0.28	0.09	0.37	0.47	0.39	0.33	0.39	–					
7. T3_neuroticism	0.29	0.09	0.30	0.40	0.50	0.40	0.38	0.44	–				
8. T4_neuroticism	0.30	0.10	0.25	0.31	0.35	0.46	0.29	0.39	0.44	–			
9. T1_extraversion	0.79	0.05	–0.22	–0.14	–0.13	–0.08	–0.22	–0.21	–0.16	–0.11	–		
10. T2_extraversion	0.80	0.05	–0.22	–0.26	–0.21	–0.14	–0.20	–0.19	–0.23	–0.16	0.40	–	
11. T3_extraversion	0.79	0.05	–0.20	–0.23	–0.30	–0.24	–0.24	–0.28	–0.32	–0.22	0.37	0.45	–
12. T4_extraversion	0.79	0.06	–0.20	–0.22	–0.25	–0.30	–0.20	–0.20	–0.26	–0.30	0.34	0.40	0.48

All correlation coefficients were significant at $p < 0.001$.



significantly negatively correlated with problematic gaming over time. According to Gentile's (2009) guidelines, individuals were classified as exhibiting pathological online game use if they met at least 6 of the 11 criteria on the symptom checklist. Consistent with this approach, responses were assigned scores of "yes" = 1, "sometimes" = 0.5, and "no" = 0. The cumulative scores of the problematic gaming scale were then calculated for each time point (T1–T4). Based on these criteria, the number of participants identified as exhibiting problematic gaming behavior at T1, T2, T3, and T4 was 170, 157, 160, and 165, respectively.

RI-CLPM of neuroticism and problematic gaming

The RI-CLPM for neuroticism and problematic gaming demonstrated excellent model fit. Table 2 presents the fit indices for both constrained and unconstrained RI-CLPMs, as well as the results of the S-B χ^2 difference tests. When comparing models, we found no significant difference in fit between the model with constrained cross-lagged paths and the fully unconstrained model. However, models with constraints on autoregressive paths showed significantly worse fit compared to the fully unconstrained model.

Thus, the final model selected was the one with constrained cross-lagged paths due to its parsimony and good fit. Figure 1 presents the standardized path coefficients for the final RI-CLPM. At the between-person level, the random intercepts for neuroticism and problematic gaming were significantly correlated ($r = 0.70$, $p < 0.001$), indicating significant and stable between-person differences (see Fig. 1). This suggests significant between-person effects linking the stable variance components of these constructs. Additionally, the RI-CLPM showed that the paths from neuroticism at one time point to problematic gaming at the subsequent time point were statistically significant ($\beta_{T1 \rightarrow T2} = 0.10$, $\beta_{T2 \rightarrow T3} = 0.09$, $\beta_{T3 \rightarrow T4} = 0.09$, $ps < 0.001$). Similarly, the paths from problematic gaming at one time point to neuroticism at the subsequent time point were also statistically significant ($\beta_{T1 \rightarrow T2} = 0.16$, $\beta_{T2 \rightarrow T3} = 0.15$, $\beta_{T3 \rightarrow T4} = 0.14$, $ps < 0.001$).

RI-CLPM of extraversion and problematic gaming

The RI-CLPM for extraversion and problematic gaming demonstrated excellent model fit. Table 3 presents the fit indices for both constrained and unconstrained RI-CLPMs and the results of the S-B χ^2 difference tests. Upon comparison, models that constrained the autoregressive paths, as well as those that constrained the lagged paths from extraversion to problematic gaming, demonstrated significantly worse fit compared to the fully unconstrained model. We found no significant differences in fit between the model with constrained lagged paths from problematic gaming to extraversion and the fully unconstrained model. After comparing these models, we selected the model which constrained the lagged paths from problematic gaming to extraversion to be time-invariant, as the final model. This model demonstrated parsimony and good fit.

Figure 2 presents the standardized path coefficients for the final RI-CLPM of extraversion and problematic gaming. At the between-person level, the random intercepts for extraversion and problematic gaming were significantly correlated ($r = -0.39$, $p < 0.001$), indicating significant and stable between-person differences (see Fig. 2). Additionally, in the final RI-CLPM, the lagged effects of extraversion on problematic gaming were not constrained to be equal across time (i.e., freely estimated). The predictive effect of extraversion at T1 on problematic gaming at T2 was not statistically significant, while the effects of extraversion at T2 on problematic gaming at T3 ($\beta = -0.07$, $p < 0.001$) and extraversion at T3 on problematic gaming at T4 ($\beta = -0.09$, $p < 0.001$) were both statistically significant. The paths from problematic gaming at one time point to extraversion at the subsequent time point, fixed to be time-invariant, were also statistically significant ($\beta_{T1 \rightarrow T2} = -0.11$, $\beta_{T2 \rightarrow T3} = -0.10$, $\beta_{T3 \rightarrow T4} = -0.10$, $ps < 0.001$).

Sex difference

The multiple-group comparison revealed significant sex differences in the cross-lagged effects in the final RI-CLPM of neuroticism and problematic gaming ($\Delta S-B\chi^2/df = 5.33$, $p < 0.01$). As presented in Fig. 3, for boys, there were significant cross-lagged effects between neuroticism and problematic gaming over time. In contrast, for girls, only the predictive effect of problematic gaming on neuroticism was statistically significant, whereas the effect of neuroticism on problematic gaming was not statistically significant. Further Wald tests indicated that the effect of problematic gaming on neuroticism did not significantly differ between boys and girls (Wald $\chi^2 = 2.07$, $df = 1$, $p = 0.15$). Unsurprisingly, the predictive effect of neuroticism on problematic gaming was significantly greater in boys than in girls (Wald $\chi^2 = 10.81$, $df = 1$, $p < 0.01$).

Moreover, the final RI-CLPM for extraversion and problematic gaming did not show significant sex differences ($\Delta S-B\chi^2/df = 0.25$, $p = 0.78$). This suggests that the longitudinal relations between extraversion and problematic gaming operate similarly for both boys and girls.

Sensitivity analyses

Building on the foundational analysis of RI-CLPM, this research follows the recommendations of recent scholars (e.g., Tseng, 2024) by incorporating eight additional statistical models to analyze longitudinal bidirectional relations, conduct sensitivity analyses, and confirm the stability of the results. First, the Dynamic Panel Model (DPM, Allison, Williams, & Moral-Benito, 2017), the Random Intercept Auto-Regressive Moving Average Model (RI-ARMA, Asparouhov & Muthén, 2023), and the Latent Curve Model with Structured Residuals (LCM-SR, Curran, Howard, Bainter, Lane, & McGinley, 2014) were employed. These three models appropriately estimated the data, and the primary results were largely consistent with those obtained from the RI-CLPM. Additionally, five other models were attempted but either failed to converge or had issues with



Table 2. Fit statistics and model comparisons of RI-CLPMs for neuroticism and problematic gaming

Models	Freely estimated paths	Fixed time-invariant paths	S- B χ^2	df	Scaling Correction Factor for MLR	RMSEA	SRMR	CFI	TLI	S- B $\Delta\chi^2$	Δ df	Comparison model	<i>p</i>	Selected Model
M1a	All autoregressive and cross-lagged paths	None	71.65	21	1.1667	0.027	0.017	0.991	0.979					
M1b	Autoregressive paths of problematic gaming; Lagged paths from neuroticism to problematic gaming; Lagged paths from problematic gaming to neuroticism	Autoregressive paths of neuroticism	84.74	23	1.1765	0.028	0.019	0.989	0.976	12.59	2	M1b vs. M1a	0.002	M1a
M1c	Autoregressive paths of neuroticism; Lagged paths from neuroticism to problematic gaming; Lagged paths from problematic gaming to neuroticism	Autoregressive paths of problematic gaming	83.05	23	1.2387	0.028	0.019	0.990	0.977	9.67	2	M1c vs. M1a	0.008	M1a
M1d	Autoregressive paths of neuroticism; Autoregressive paths of problematic gaming; Lagged paths from problematic gaming to neuroticism	Lagged paths from neuroticism to problematic gaming	74.99	23	1.1788	0.026	0.018	0.991	0.980	3.68	2	M1d vs. M1a	0.159	M1d
M1e	Autoregressive paths of neuroticism; Autoregressive paths of problematic gaming	Lagged paths from neuroticism to problematic gaming; Lagged paths from problematic gaming to neuroticism	80.20	25	1.1823	0.026	0.020	0.990	0.980	6.22	2	M1e vs. M1d	0.072	M1e

Note. Bold indicates final selected model.



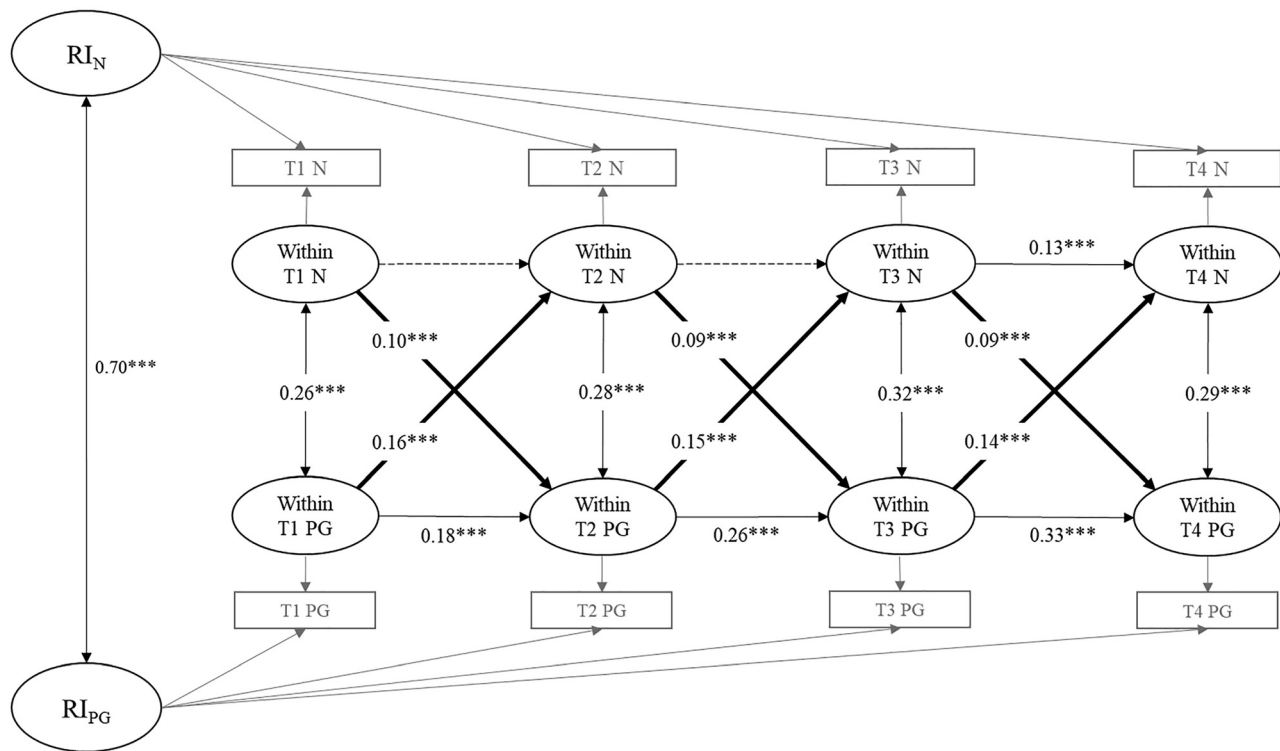


Fig. 1. Standardized path coefficients of the final RI-CLPM for neuroticism and problematic gaming. Solid lines mean the path coefficients are statistically significant, whereas dotted lines mean the path coefficients are not statistically significant. For simplicity, control variables are not presented in the figure. N = neuroticism, PG = problematic gaming; RI = random intercept.

*** $p < 0.001$

the latent variable covariance matrix not being positive definite: the General Cross-Lagged Model (GCLM, Zyphur et al., 2020), the Factor Cross-Lagged Panel Model (Factor CLPM, McArdle, 2009), the Autoregressive Latent Trajectory Model (ALT, Curran & Bollen, 2001), the Latent Change Score Model (LCS, McArdle & Hamagami, 2001), and the Stable Trait Autoregressive Trait State Model (STARTS, Kenny & Zautra, 2001). These sensitivity analyses support the robustness and stability of the findings, as consistent results across convergent models reaffirm the bidirectional relations between neuroticism and problematic gaming, as well as extraversion and problematic gaming, observed in the primary RI-CLPM analysis.

DISCUSSION

Adolescent problematic gaming has become a significant public health concern worldwide (e.g., Männikkö et al., 2020). The negative consequences associated with problematic gaming, such as academic problems, social isolation, and psychopathological symptoms, underscore the urgency of understanding the factors that contribute to problematic gaming (e.g., Ferguson, Coulson, & Barnett, 2011). The Big Two personality traits (i.e., neuroticism and extraversion) have been well-documented to play a pivotal role in shaping adolescents' susceptibility to problematic gaming (Akbari et al., 2021; Chew, 2022). However, most

previous studies have been cross-sectional, limiting the ability to infer causality or examine the directionality of relations over time, making it difficult to understand the dynamic interplay between personality traits and problematic gaming behaviors. To address this research gap, we employed a longitudinal design and utilized the RI-CLPM to examine the bidirectional relations between the Big Two personality traits and problematic gaming at the within-person level. Our analyses revealed a significant positive cross-lagged relation between neuroticism and problematic gaming. Similarly, there was a significant negative cross-lagged relation between extraversion and problematic gaming. Moreover, the longitudinal relations between neuroticism and problematic gaming exhibited significant sex differences.

Neuroticism and problematic gaming

Our study suggests that neuroticism may predict increases in problematic gaming over time, and similarly, problematic gaming might also predict increases in neuroticism among young people. Adolescents high in neuroticism are often overwhelmed by intense emotions such as anxiety, sadness, and frustration, which might make coping effectively challenging (Evans et al., 2016; Gomez, Holmberg, Bounds, Fullarton, & Gomez, 1999). Online games may provide an appealing escape, offering a virtual environment where these emotional discomforts could be temporarily set aside (Calleja, 2010). For adolescents with high neuroticism,

Table 3. Fit statistics and model comparisons of RI-CLPMs for extraversion and problematic gaming

Models	Freely estimated paths	Fixed time-invariant paths	S-B χ^2	df	Scaling Correction Factor for MLR	RMSEA	SRMR	CFI	TLI	S-B $\Delta\chi^2$	Δ df	Comparison model	<i>p</i>	Selected Model
M2a	All autoregressive and cross-lagged paths	None	71.07	21	1.1622	0.027	0.019	0.991	0.976					
M2b	Autoregressive paths of problematic gaming; Lagged paths from extraversion to problematic gaming; Lagged paths from problematic gaming to extraversion	Autoregressive paths of extraversion	98.83	23	1.1576	0.032	0.040	0.986	0.967	28.67	2	M1b vs. M1a	0.000	M1a
M2c	Autoregressive paths of extraversion; Lagged paths from extraversion to problematic gaming; Lagged paths from problematic gaming to extraversion	Autoregressive paths of problematic gaming	83.76	23	1.2384	0.028	0.022	0.988	0.974	10.37	2	M1c vs. M1a	0.006	M1a
M2d	Autoregressive paths of extraversion; Autoregressive paths of problematic gaming; Lagged paths from extraversion to problematic gaming	Lagged paths from problematic gaming to extraversion	72.99	23	1.1680	0.026	0.019	0.991	0.979	2.16	2	M1d vs. M1a	0.34	M1d
M2e	Autoregressive paths of neuroticism; Autoregressive paths of problematic gaming	Lagged paths from neuroticism to problematic gaming; Lagged paths from problematic gaming to neuroticism	80.20	25	1.1823	0.026	0.020	0.990	0.980	6.22	2	M1e vs. M1d	0.072	M1d

Note. Bold indicates final selected model.



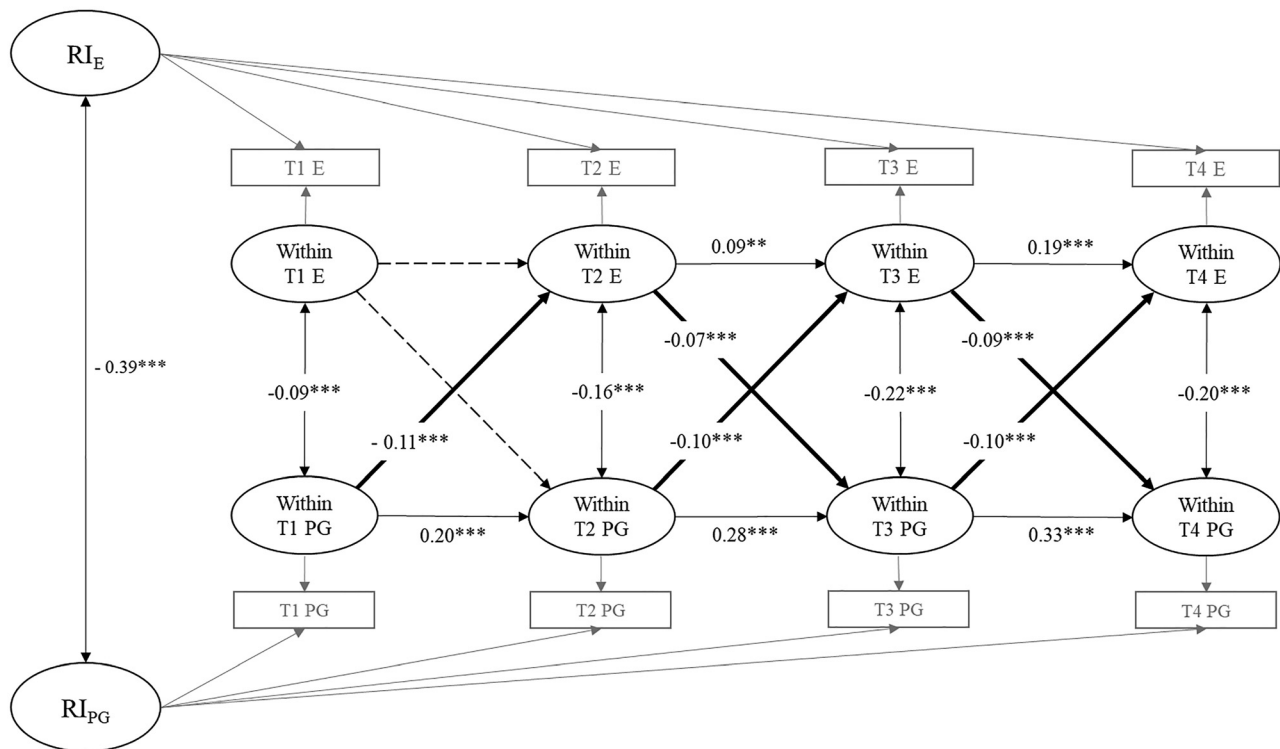


Fig. 2. Standardized path coefficients of the final RI-CLPM for extraversion and problematic gaming. Solid lines mean the path coefficients are statistically significant, whereas dotted lines mean the path coefficients are not statistically significant. For simplicity, control variables are not presented in the figure. E = extraversion, PG = problematic gaming; RI = random intercept.

** $p < 0.01$, *** $p < 0.001$

gaming could become a refuge from real-life challenges, potentially serving as a coping mechanism to manage their emotional turbulence (Dieris-Hirche et al., 2020). This cycle could perpetuate as gaming becomes a habitual response to emotional distress. The immediate rewards and temporary escape from reality provided by gaming might lead to increased usage and, potentially, problematic gaming behaviors. Additionally, the increase in problematic gaming might exacerbate neuroticism in adolescents through several psychological mechanisms. As adolescents spend more time gaming, they might face prolonged exposure to interpersonal stress, which could act as a catalyst for their inherent anxieties (e.g., Ojha et al., 2023; Przybylski et al., 2014), possibly leading to heightened emotional reactivity. The constant exposure to the immediate rewards and punishments in games could create a feedback loop that might increase sensitivity to negative feedback (e.g., Lee et al., 2015; Nesi et al., 2022; Raiha et al., 2020; Weinstein et al., 2017), further fueling feelings of frustration and emotional instability.

Moreover, our findings suggest that significant sex differences may exist in the bidirectional relations between neuroticism and problematic gaming. Specifically, in boys, there seems to be a significant bidirectional relation between neuroticism and problematic gaming. In contrast, for girls, neuroticism does not significantly predict problematic gaming, although problematic gaming does seem to have a significant effect on increasing neuroticism, with

this effect being similar to that observed in boys. The societal expectations placed on boys to exhibit emotional control and resilience can intensify the internal conflict experienced by those with high neuroticism (Löckenhoff et al., 2014; Mahalik et al., 2007). This conflict might drive boys to engage in problematic gaming as a means of coping with emotional sensitivity and anxiety, potentially creating a cycle of dependency on gaming for emotional regulation (Chumbley & Griffiths, 2006). The immediate rewards and sense of control provided by gaming offer a stark contrast to the emotional challenges faced in their everyday lives, making gaming an appealing, albeit maladaptive, coping mechanism (Desai, Zhao, & Szafron, 2016). On the other hand, boys are often more engaged in competitive and immersive gaming environments (e.g., Su et al., 2020). However, this constant exposure to competitive stress and the drive to achieve high performance may intensify boys' emotional reactions (Wang et al., 2022). Failures and negative feedback within these games can exacerbate feelings of frustration and anxiety, leading to increased emotional instability (Villani et al., 2018). Moreover, the immediate rewards and perceived control offered by gaming are especially attractive to boys, while the emotional toll of constant competition and the pressure to perform well can deepen their neurotic tendencies (e.g., Su et al., 2020), thus creating a vicious cycle that perpetuates both problematic gaming behaviors and heightened neuroticism among boys.

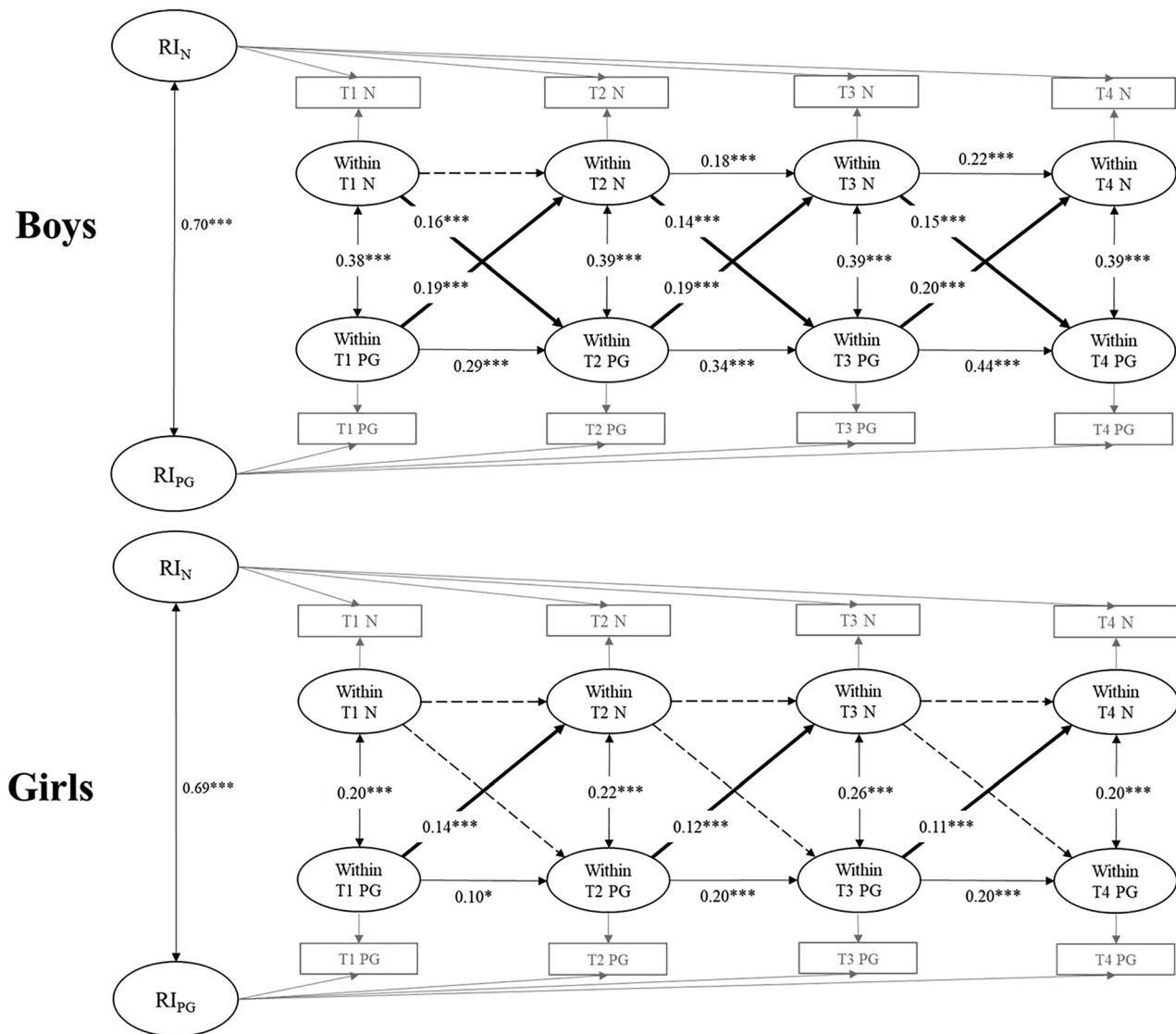


Fig. 3. Standardized path coefficients of the final RI-CLPM for neuroticism and problematic gaming in boys (upper half) and girls (lower half). Solid lines mean the path coefficients are significant, whereas dotted lines mean the path coefficients are not significant. For simplicity, control variables are not presented in the figure. N = neuroticism, PG = problematic gaming; RI = random intercept.

* $p < 0.05$, *** $p < 0.001$

Our findings indicate that, in contrast to boys, neuroticism does not significantly predict problematic gaming in girls. Several factors may explain this difference. For instance, girls are generally socialized to seek and value social support more than boys (Belle, 1991). This means that girls might be more likely to turn to friends, family, or other social networks when dealing with emotional distress rather than relying solely on gaming as a coping mechanism (e.g., Liang, Zhou, Yuan, Shao, & Bian, 2016). The availability of these social supports can mitigate the need to use gaming as a primary way to manage negative emotions, thereby reducing the likelihood that neuroticism will lead to problematic gaming. Additionally, the societal expectations and norms for emotional expression in girls might also play a role. Girls are often encouraged to express their emotions and seek help (e.g., Deng, Chang, Yang, Huo, & Zhou, 2016),

which may help them process and manage their feelings more effectively without resorting to gaming. These sex differences underscore the importance of understanding how boys and girls interact with gaming environments and cope with emotional distress. By recognizing these patterns, we can develop more effective, sex-sensitive interventions that address the specific needs of each group, thereby promoting healthier gaming habits and better mental health outcomes for adolescents.

Extraversion and problematic gaming

Our study suggests that problematic gaming might contribute to diminishing extraversion in youth over time. Adolescents who engage heavily in gaming might reduce their real-world social interactions, which may lead to social

isolation (e.g., Nawaz, Nadeem, Rao, Fatima, & Shoaib, 2020). This reduced face-to-face engagement may limit their social skills and confidence, making them less inclined to participate in social activities. As they might prioritize gaming over spending time with friends and family, their social networks could weaken, potentially reducing the positive reinforcement from real-world interactions and thereby possibly diminishing their extraversion (Dieris-Hirche et al., 2020). Additionally, the negative emotional consequences commonly associated with problematic gaming, such as increased stress, anxiety, and depression (e.g., Männikkö et al., 2020), might further diminish extraversion in adolescents (Klimstra, Akse, Hale III, Raaijmakers, & Meeus, 2010; Morken, Wichstrøm, Steinsbekk, & Viddal, 2024). These negative emotions could make social interactions seem more daunting and less enjoyable, potentially reducing their motivation to engage with others (e.g., Elmer & Stadtfeld, 2020). As problematic gaming continues to exacerbate these negative emotional states, adolescents may find themselves increasingly overwhelmed by their emotions, leading to a further decline in extraversion.

Preliminary results from our study also indicate that higher levels of extraversion may act as a protective factor, thus reducing the likelihood of adolescents becoming addicted to online gaming. Extraversion, characterized by sociability, assertiveness, and a tendency to engage with others (Eysenck, 1990), might encourage the formation of strong social networks (e.g., William, Ling, & Woon, 2016). These networks could provide support, companionship, and a sense of belonging, possibly making extraverts less likely to turn to gaming as their primary means of social interaction and emotional support (de Hessele, Rozgonjuk, Sindermann, Pontes, & Montag, 2021). The real-life community and connections they cultivate could act as a buffer against the lure of online gaming, providing them with a robust emotional foundation. Moreover, extraverts tend to participate in a wide range of activities which might provide numerous sources of satisfaction and accomplishment (Lu & Hu, 2005). The stimulation derived from these activities could fulfill their need for novelty and engagement, possibly making gaming just one of many interests rather than an all-consuming pastime. Additionally, extraverts' effective communication and assertiveness in social situations could lead to better stress management and conflict resolution skills (Sims, 2017). These abilities might help them navigate emotional challenges without resorting to gaming for escape. By actively engaging in diverse face-to-face social activities and maintaining strong interpersonal relationships, extraverts may achieve emotional regulation and fulfillment in ways that naturally protect against the risks of problematic gaming.

Strengths, limitations, and future directions

Our study has several notable strengths. By employing a four-wave longitudinal design with one-year intervals, our research offers robust evidence for the bidirectional

relationships between the Big Two personality traits (neuroticism and extraversion) and problematic gaming. This design allows for examining changes over time and establishing temporal precedence, which is crucial for understanding causality. Focusing on bidirectional relations enables a comprehensive understanding of how personality traits and problematic gaming influence each other, highlighting their dynamic interplay. Additionally, the large and diverse sample enhances the generalizability of our findings across different demographic groups, thereby increasing the relevance and applicability of the results to a wider adolescent population.

Despite these strengths, our study also has some limitations. One significant limitation is the use of the POGU scale to measure problematic gaming. The POGU is based on the DSM-IV criteria for pathological gambling, which, despite providing valuable insights, may not fully align with the most current diagnostic standards for gaming disorder as outlined in the DSM-5 and ICD-11. The outdated basis of the POGU implies that it may not accurately capture the latest conceptualization of gaming disorder, potentially affecting the validity of our findings. Additionally, the POGU shares core features with Brown's (1991) components model of addiction, which focuses on aspects such as salience, euphoria, and withdrawal symptoms. While these features are important in assessing addictive behaviors, using older criteria may lead to an overemphasis on certain dimensions of gaming behavior while overlooking other dimensions now considered significant, such as gaming despite harms, conflict/interference due to gaming, or impaired control, as per the DSM-5 and ICD-11. The reliance on an outdated diagnostic framework can also introduce potential biases in identifying and categorizing problematic gaming behaviors, particularly in the context of a rapidly evolving digital environment. This discrepancy may also limit the generalizability and accuracy of the findings. As such, caution is warranted in interpreting the results. To address these concerns, future research should employ more contemporary assessment tools aligning with the latest diagnostic criteria for gaming disorder. This would improve the overall precision and relevance of findings, enhancing our understanding of the interplay between personality traits and gaming behaviors.

Moreover, the reliance on self-reported data in this study can introduce bias, as participants may underreport or overreport their gaming behaviors and personality traits, with social desirability and recall bias potentially affecting the accuracy of the responses. Relying solely on self-reported questionnaires limits the depth of our data. Incorporating other methods, such as behavioral observations or parent/teacher reports, could provide a more comprehensive understanding of participants' behaviors and traits. Additionally, the study was conducted within a Chinese cultural context, which may limit the generalizability of the findings to other cultural settings. Cultural differences in gaming behaviors and personality expression should be considered when interpreting the results. Expanding research to different cultural contexts would help identify cultural



factors that influence the relation between personality traits and gaming behaviors, with comparative studies offering insights into how cultural norms and values shape these dynamics.

Another limitation is that our study focused solely on the Big Two personality traits—neuroticism and extraversion. Future research could explore the role of other personality dimensions, such as conscientiousness, agreeableness, and openness to experience, in relation to problematic gaming. Furthermore, our study did not collect data on general gaming engagement among participants. The absence of this information limits our ability to contextualize the prevalence of gaming within the sample, which could have provided valuable insight into the broader landscape of adolescent gaming behavior. We recommend that future research include data on general gaming engagement to provide a more comprehensive understanding of adolescents' gaming habits.

Implications

The findings from this study not only deepen our theoretical understanding of how personality traits and problematic gaming influence each other but also provide practical guidance for educators, parents, and mental health professionals working to support the healthy personality development of adolescents and mitigate the risks of problematic gaming. Firstly, the risk effect of neuroticism on adolescent problematic gaming underscores the need for targeted interventions focused on emotional regulation and stress management for adolescents exhibiting high levels of neuroticism. Research has demonstrated that mindfulness-based interventions (Armstrong & Rimes, 2016; Hanley, de Vibe, Solhaug, Gonzalez-Pons, & Garland, 2019) can significantly reduce levels of neuroticism. By fostering emotional regulation and enhancing self-awareness, mindfulness practices provide adolescents with healthier alternatives for managing stress and anxiety (Meiklejohn et al., 2012). When integrated into school mental health education curricula, these programs can teach coping strategies that help students manage their emotions more effectively and reduce their reliance on gaming as a coping mechanism (Sharma, Bhargav, Kumar, Digambhar, & Mani, 2021). Similarly, the protective role of extraversion against problematic gaming suggests that promoting social activities and encouraging face-to-face interactions can serve as protective factors. Schools and communities should create opportunities for adolescents to participate in sports, clubs, and other group activities that foster social connections and provide alternative sources of engagement and satisfaction outside of gaming (King & Delfabbro, 2014).

Moreover, the significant sex differences in the longitudinal relations between neuroticism and problematic gaming suggest that interventions should be tailored to address these differences. For boys, who exhibit a stronger bidirectional relation between neuroticism and problematic gaming, interventions should focus on providing alternative ways to achieve a sense of competence and control (Zhou, Zhang, &

Gong, 2023). Encouraging boys to engage in various activities, such as team sports and community service, can help them build skills, gain confidence, and experience emotional fulfillment, while also providing physical and emotional benefits. These activities offer healthy avenues for developing a sense of competence and control, thereby reducing their reliance on gaming to meet these needs (Liu, Wang, Zhai, Luo, & Xin, 2023). For girls, who show a significant impact of problematic gaming on neuroticism but not the reverse, interventions should emphasize maintaining social support networks and engaging in cooperative, narrative-driven activities that provide emotional engagement without the high stress associated with competitive gaming (Su et al., 2020). Enhancing girls' access to supportive social environments and teaching effective coping strategies can help reduce the negative emotional impacts of problematic gaming.

Our research also found that problematic gaming has a significant impact on youth personality development. Therefore, it is crucial to reduce or prevent problematic gaming in adolescents to promote healthy personality development. Limiting screen time, setting clear boundaries for gaming sessions, and encouraging breaks can help prevent excessive gaming. Parents and caregivers should monitor gaming behavior and foster open communication about the potential risks of excessive gaming (Pornnoppadol et al., 2020). Providing adolescents with diverse recreational options and promoting a healthy lifestyle, including regular physical activity, can divert their attention from gaming and reduce the likelihood of developing problematic habits (Pornnoppadol et al., 2020). Additionally, schools can play a critical role by integrating digital literacy and responsible gaming education into their curricula (Bonnaire, Serehen, & Phan, 2019). Teaching students about the potential dangers of excessive gaming and equipping them with skills to balance their online and offline activities can foster healthier gaming practices (Walther, Hanewinkel, & Morgenstern, 2014). Overall, our study underscores the importance of a holistic approach to addressing problematic gaming, one that considers the individual's personality traits, emotional needs, and social environment. By implementing targeted interventions and promoting healthy, balanced lifestyles, we can reduce the risks associated with problematic gaming and support the well-being of adolescents.

CONCLUSIONS

This longitudinal study provides critical insights into the bidirectional relations between the Big Two personality traits—neuroticism and extraversion—and problematic gaming among adolescents. By employing the RI-CLPM, we were able to examine these relations at the within-person level, addressing the limitations of previous cross-sectional studies. Our findings reveal that adolescent neuroticism and problematic gaming mutually predict each other, suggesting a reinforcing cycle. In contrast, extraversion serves as a protective factor, reducing the risk of problematic gaming,



while engagement in problematic gaming negatively impacts extraversion over time. Importantly, the study highlights significant sex differences in the longitudinal relations between neuroticism and problematic gaming. These results underscore the necessity of incorporating personality assessments into interventions aimed at reducing problematic gaming. By targeting neuroticism and fostering extraversion, such interventions could potentially break the cycle of problematic gaming and support healthier development among adolescents.

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