Longitudinal Relationships Between School Climate, Academic Achievement, and Gaming Disorder Symptoms Among Chinese Adolescents

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Abstract

Despite growing concerns regarding the development of gaming disorder symptoms among adolescents, the longitudinal relationship between school factors and gaming disorder symptoms remains far from being fully understood. This two-year longitudinal study examined the relationship between school climate perceptions, academic achievement, and gaming disorder symptoms among three distinct demographic cohorts: preadolescents (n = 1513; 46.9% girls, M_{age} = 10.64 years, SD = 0.56), early adolescents (n = 1771; 48.3% girls, M_{age} = 13.54 years, SD = 0.70), and late adolescents (n = 2385; 50.1% girls, M_{age} = 16.41 years, SD = 0.59). A four-wave study was conducted (six months apart) using random intercept cross-lagged panel models (RI-CLPMs) to separate the within-person (state level) from the between-person (trait level) effects. The results obtained from the RI-CLPMs indicated that fluctuations in school climate perceptions negatively predicted subsequent changes in gaming disorder symptoms among preadolescents at the within-person level, but not among early and late adolescents. Fluctuations relating to gaming disorder symptoms also negatively predicted subsequent changes regarding academic achievement in late adolescents, but not in preadolescents and early adolescents. The effect of school-related factors on gaming disorder symptoms varies across different developmental stages. While preadolescents may represent a particularly susceptible subgroup in terms of being predicted by their school environment, late adolescents appear to be more vulnerable to predictors of gaming disorder symptoms. The current study also discusses the implications of school-wide programs aimed at improving school climate and preventing the development of gaming disorder symptoms during key developmental periods.

Keywords: School climate perceptions; gaming disorder symptoms; academic achievement; within-person effects; random intercept cross-lagged panel model; developmental differences

Introduction

Gaming disorder is a pattern of gaming behavior characterized by excessive and problematic video gaming, with symptoms such as impaired control to gaming, increased priority of gaming over other activities, and continuation or escalation of gaming (World Health Organization, 2020). This disorder can have negative consequences on individuals' daily life and society (e.g., Kuss & Griffiths, 2012; Reed et al., 2022). Previous literature examining the individual factors (e.g., self-control) and family-level factors (e.g., parent–child relationship) associated with gaming disorder symptoms is extensive, but the specific relationship between schooling factors (e.g., school climate perceptions) and gaming disorder symptoms is far from fully understood (Ji et al., 2022; Zhuang et al., 2023). Considering that Chinese adolescents spend most of their time in school (e.g., Yang et al., 2013) and strive for high academic achievement (e.g., Jia et al., 2009; Nie et al., 2021), school climate perceptions and academic achievement may have a subtle yet important effect on gaming disorder symptoms. However, the longitudinal relationships between school climate perceptions, academic achievement, and gaming disorder symptoms have not been sufficiently explored, and the direction of the association between these variables are unclear. Addressing this research gap informs targeted prevention and intervention programs for gaming disorder from a schooling perspective. The current study examined the longitudinal relationships between school climate perceptions, academic achievement, and gaming disorder symptoms at both within- and between-person levels through a two-year longitudinal study involving three distinct demographic cohorts: preadolescents, early adolescents, and late adolescents.

School Climate Perceptions and Gaming Disorder Symptoms

School climate refers to the *"quality and characteristics of school life"* (Cohen et al., 2009, p. 182). Students' perceptions of school climate refer to the individual cognitions and emotions they associate with the school environment (Wang & Degol, 2016). These perceptions is a pivotal factor in determining many of the individual variations that influence students' psychological development, including behavioral and mental health outcomes, as well as students' overall psychological well-being (Thapa et al., 2013; Wang & Degol, 2016).

School climate assessment encompasses two primary constructs that are inherent to the school context: *social support* and *structure* (e.g., Bear et al., 2011; Del Toro & Wang, 2022). *Social support* refers to the degree that educators, staff, and peers address students' social and emotional needs (Nie et al., 2020). This is manifested in the evident warmth, respect, acceptance, and care that is present within *teacher–student* and *student–student* interactions. Conversely, *structure* refers to how adults in a school setting establish and maintain clear

expectations and ensure consistency and fairness of school rules (Nie et al., 2020). Stage-environment fit theory (Eccles, 2004) posits that individuals' behaviors, emotions, and cognitions are shaped by the interaction between them and their environment. Congruence between students' psychological needs and school environment is crucial in bolstering their mental health and psychological development.

Previous meta-analyses, including cross-sectional studies, have reported a negative association between school climate perceptions and gaming disorder symptoms (e.g., Ji et al., 2022; Long et al., 2018). A positive school climate, marked by fruitful student relationships with peers and teachers and robust school staff support, can be a protective factor against the emergence of gaming disorder symptoms (e.g., Yu et al., 2015). Such a positive school climate meets students' core psychological needs (Yu et al., 2015), fostering greater academic involvement, richer school social interactions, and an elevated sense of psychological well-being (Thapa et al., 2013; Wang & Degol, 2016), potentially curbing excessive gaming behaviors and reducing the symptoms of gaming disorder (e.g., Ji et al., 2022; Long et al., 2018). Contrastingly, students who experience an adverse school atmosphere frequently report poor psychological well-being (Thapa et al., 2013; Wang & Degol, 2016), challenges regarding time management (e.g., Huang et al., 2020), and playing videogames to escape real-world psychological or psychiatric problems (e.g., King & Delfabbro, 2014; Melodia et al., 2022).

Symptoms of gaming disorder may predict school climate perceptions. Students with high gaming disorder symptoms may exhibit higher levels of cognitive impairment and attentional biases (Billieux et al., 2020), wherein they might view their school environment negatively and routinely report more negative perceptions concerning their school environment. Research consistently suggests that gaming disorder symptoms are associated with mental health problems (e.g., Hygen et al., 2020) and poor psychological well-being (e.g., Teng et al., 2020), which might further be associated with negative or poor school climate perceptions. Students who present intense gaming disorder symptoms are more likely to have negative perceptions of their school climate. To date, the direction of the longitudinal association between perceptions of school climate and gaming disorder symptoms has remained unclear; the current study examined this question.

Academic Achievement and Gaming Disorder Symptoms

Academic achievement is a primary way to assess individuals' educational abilities among children and youth and is widely considered a strong indicator of student success. High academic achievement is associated with good psychological health and well-being (e.g., O'Connor et al., 2019). Students with low academic achievement may experience diminished

self-esteem (e.g., Wang et al., 2021) and a reduced sense of accomplishment in their academic pursuits (e.g., Clark et al., 2014). This might lead them to seek solace and accomplishment within the virtual gaming world because videogame playing offers an escape from the harsh reality of perceived inadequacy and feelings of worthlessness (e.g., King & Delfabbro, 2014; Melodia et al., 2022). Students with poor academic performance may be marginalized, victimized, or ignored within their social circles (e.g., Riffle et al., 2021). In an attempt to distract themselves from or improve their low social status and life satisfaction, students often derive happiness and gain a sense of achievement from videogame playing (e.g., Brandtner et al., 2023; Hull et al., 2013). The intrinsically rewarding nature of game design (Cruz et al., 2017; Griffiths & Nuyens, 2017) might serve to further amplify the allure for students burdened by low academic achievement.

Excessive videogame exposure or severe symptoms of gaming disorder may also predict a decline in academic achievement. The *time displacement* hypothesis (e.g., Drummond & Sauer, 2020; Hartanto et al., 2018) posits that when individuals allocate a substantial proportion of their time to gaming activities, they inherently reduce the time available for academic endeavors, resulting in a deterioration of their academic performance. Excessive gaming may also encroach on sleep patterns, impairing students' ability to focus on learning and exerting a negative influence on their academic outcomes (e.g., Hawi et al., 2018). Problematic gaming often leads to increased isolation of students from their real-world friends and families, negatively affecting their social skills, and diminishing the strength of their social support networks (e.g., Kaptsis et al., 2016; Reed et al., 2022), which might culminate in reduced academic achievement.

The existence of longitudinal links between gaming and academic achievement has been a topic of some debate. Symptoms of gaming disorder negatively predict late achievement (e.g., Brunborg et al., 2014), whereas others have suggested that low academic achievement is a predictor of gaming disorder symptoms (e.g., Toker & Baturay, 2016). Some studies have suggested a non-significant predictive relationship between the symptoms of gaming disorder and subsequent changes in academic achievement, particularly when adjusted by early academic performance (e.g., Van Den Eijnden et al., 2018). However, most previous studies have focused on between-person relationships, leaving a research gap concerning within-person relationships, which are addressed in the current study.

Developmental Differences

There may be differences in school climate perceptions, academic achievement, and gaming disorder symptoms across preadolescents (primary school students), early adolescents

(middle school students), and late adolescents (high school students). Preadolescent students perceive school climate more positively than do early and late adolescents (Bear et al., 2018). Research has also indicated a significant decrease in school climate perceptions during early adolescence (e.g., Wang & Dishion, 2012; Way et al., 2007) and during the transition from preadolescence to early adolescence (e.g., Coelho et al., 2020).

Regarding academic achievement, learning difficulty in the Chinese educational system rapidly heightens during the transition periods to early and late adolescence. Both early and late adolescents face strong pressure to gain high scores in coursework and examinations (e.g., Liu & Lu, 2011; Nie et al., 2021). Although preadolescents are exposed to videogames, preadolescents generally exhibit a lower prevalence of gaming disorder than early and late adolescents (e.g., Kuss & Griffiths, 2012; Paulus et al., 2018). Symptoms of gaming disorder exhibit an inverse-U-shaped development from preadolescence to late adolescence (Paulus et al., 2018). Given these developmental differences in school climate perceptions, academic achievement, and gaming disorder, the inter-relationships among these variables should be examined differently.

Few studies have examined the longitudinal relationships between school climate perceptions, academic achievement, and gaming disorder symptoms considering the aforementioned developmental differences. Preadolescents are becoming increasingly susceptible to a widening range of distractions, such as those provided by videogames and social media use (Kirsh, 2009; Strasburger et al., 2013). Preadolescents are possibly more affected by violent videogame exposure (e.g., Gentile et al., 2014) than adolescents, which might lead to increased aggressive behavior. For early adolescents, gaming is a stress reliever (e.g., Pine et al., 2020), yet when done excessively can hinder academic success (e.g., Borgonovi, 2016). This period is crucial for the potential onset of gaming disorder symptoms (Kuss & Griffiths, 2012), in part because of increased access to Internet-enabled computers and smartphones, which can rapidly lead to uncontrolled use (Paulus et al., 2018). Conversely, late adolescents—particularly high school students in China—remain susceptible to disruptions in academic performance because of the pressure of university entrance examinations. This vulnerability is exacerbated by the need for extensive preparation and completion of intricate academic tasks. Late adolescents might seek social fulfillment through online interactions and gaming, potentially increasing their engagement in gaming activities (Paulus et al., 2018) and increasing their risk of developing gaming disorder symptoms (e.g., Chang & Lin, 2019; Jeong et al., 2019).

Recognizing the aforementioned unique developmental characteristics is crucial when

exploring the intricate interplay between perceptions of school climate, academic achievement, and gaming disorder symptoms across preadolescents, early adolescents, and late adolescents. Owing to lack of strong theoretical framework or empirical evidence, the current study examined these developmental differences as an exploratory but not confirmatory approach. No specific hypotheses were made for examining the developmental differences.

Random Intercept Cross-Lagged Panel Models

Although previous studies have highlighted close relationships between school climate, academic achievement, and gaming disorder symptoms, they did not distinguish between within- and between-person effects. The disaggregation of within- and between-person effects is important for understanding longitudinal changes because it provides a comprehensive and accurate understanding of how and why changes occur at the individual and group levels (e.g., Curran & Bauer, 2011; Lucas, 2023). Random intercept cross-lagged panel models (RI-CLPMs) can be used to focus on both trait- and state-like components, examining both between- and within-person effects simultaneously (Hamaker et al., 2015; Usami, 2021). In the relationship between school climate perceptions and gaming disorder symptoms, the *between-person effect* helps evaluate inter-individual variances and determine whether individuals with positive school climate perceptions report less gaming disorder symptoms than those with negative school climate perceptions. Contrastingly, the *within-person effect* examines intra-individual variances and help determine whether positive school climate perceptions are associated with decreasing gaming disorder symptoms over time.

Adopting RI-CLPMs enables the separation of stable individual differences at the trait level and the within-person changes at the state level (Hamaker et al., 2015; Usami, 2021). RI-CLPMs help identify correlations among the non-observable individual-specific random intercepts that capture between-person effects. These separation of between- and within-person effects in RI-CLPM are important for longitudinal data because traditional cross-lagged panel models (CLPMs) always have a strong autoregressive coefficient that may render the cross-lagged effects unreliable (Lucas, 2023). Given the insights offered by RI-CLPMs, it is important to distinctly evaluate the between- and within-person relationships that are related to school climate perceptions (e.g., Nie et al., 2022; Teng et al., 2020) and gaming disorder symptoms (e.g., Hygen et al., 2020; Zhou et al., 2023).

Current Study

Research has demonstrated the close relationship between school factors (i.e., school climate perceptions and academic achievement) and gaming disorder symptoms. However, a longitudinal design that considers developmental differences is needed. To address these

research gaps, the current study examined the longitudinal relationships between school climate perceptions, academic achievement, and symptoms of gaming disorder. The RI-CLPM was used to examine both within- and between-person effects. The current study addressed the following questions: (i) Are there cross-lagged (within-person) effects between school climate perceptions and gaming disorder symptoms in each of the three cohorts (i.e., preadolescents, early adolescents, and late adolescents)? (ii) Are there cross-lagged (within-person) effects between academic achievement and gaming disorder symptoms among the three cohorts? It was hypothesized that school climate perceptions would negatively predict late gaming disorder symptoms at the within-person level (Hypothesis 1) and that gaming disorder symptoms would also predict late school climate perceptions at the within-person level (Hypothesis 2). It was also hypothesized that academic achievement would negatively predict late gaming disorder symptoms at the within-person level (Hypothesis 3) and that gaming disorder symptoms would also predict late academic achievement (Hypothesis 4). The current study did not formulate specific hypotheses for the developmental differences of cross-lagged effects.

Methods

Participants

This study had 5,669 participants (51.3% boys, aged 9–18 years) who are taking part in the Child and Youth Mental Health Development Project[1] (Nie et al., 2023)—an ongoing longitudinal study in Southwest China (Sichuan, Yunan, and Chongqing area). Participants were selectively clustered from 17 schools (6 primary, 6 middle, and 5 high schools; $N = 125$ classrooms). Students in the 4th, 7th, and 10th grades were invited to participate and provided oral informed consent prior to their participation. Students' parents were also consulted prior to study commencement, with written student and parental consent rates for this study being approximately 98% and 95%, respectively.

Although the Child and Youth Mental Health Development Project collected the data in the fall of 2018, the current study included the data collected from Wave 3 (fall of 2019), Wave 4 (spring of 2020), Wave 5 (fall of 2020), and Wave 6 (spring of 2021). Waves 3–6 were named Times 1 (T1) to 4 (T4) for the current study. The sample at T1 comprised 1,513 preadolescents (primary school students, 46.9% girls, $M_{age} = 10.64 \pm 0.56$ years), 1,771 early adolescents (middle school students, 48.3% girls, $M_{age} = 13.54 \pm 0.70$ years), and 2,385 late adolescents

[1] Although the datasets have been used in previous research, the question, reported analyses, findings, and conclusions made in this article do not overlap with those of any others.

(high school students, 50.1% girls, M_{age} = 16.41 ± 0.59 years). Of all the participating students, 30.8% were "left-behind children" which means children who have been left behind in rural regions while their parents move to urban areas for work. Almost 22.1% of the fathers and 18.5% of the mothers had undergraduate degrees, with more than half of the families (52.6%) having a monthly income of less than 5,000 yuan (nearly $690 [US]).

Procedure

The surveys were typically administered in a classroom setting during each school term. All school officials and teachers consented to the implementation of this study, and the survey required approximately 30 minutes to complete. Upon completion, participants were presented with a feedback report on the survey outcomes from their schools. All participants received a small token of appreciation, a notebook or pen (valued at 10 yuan), after each survey session. All surveys were administered in the classroom by trained teachers (except for T3 [i.e., Wave 5], in which students took the surveys online).

The ethics review board of Southwest University approved the project and this study was conducted in accordance with the Declaration of Helsinki. All associated schools granted permission for data collection. All participants were informed of the purpose of this project in advance and the datasets were made available for research purposes only.

Measures

School climate perceptions. The 18-item revised short Chinese version of the School Climate Questionnaire (Nie et al., 2020), derived from the Delaware School Climate Student Survey (Bear et al., 2011), was used to assess school climate. It comprises four dimensions: *teacher–student relationship* (five items; e.g., "Teachers care about their students"); *student–student relationship* (five items; e.g., "Students care about each other"); *fairness of rules* (four items; e.g., "The behavioral norms in the school are fair"); and *clear expectations* (four items; e.g., "Students know what they are supposed to do in school"). The questionnaire uses a four-point scale to rate items (1 = "strongly disagree" to 4 = "strongly agree"). The overall score on the four subscales represented the total school climate perceptions score. A higher score reflects a more favorable view of the school climate. The overall McDonald's omega coefficients (ω) for school climate perceptions were 0.96 (T1), 0.96 (T2), 0.96 (T3), and 0.97 (T4).

Gaming disorder symptoms. To assess the severity of internet gaming disorder, the Chinese version of the nine-item Internet Gaming Disorder Scale-Short Form (IGDS9-SF) was used (Pontes & Griffiths, 2015; Chinese version, Teng et al., 2020). The items are based on the nine DSM-5 criteria (e.g., "Do you feel compelled to increase your gaming engagement to achieve satisfaction or pleasure incrementally?") and are rated on a five-point Likert scale

ranging from 1 (“never”) to 5 (“very often”). Individual item scores were summed to determine a representative composite of internet gaming disorder severity with higher total scores indicating greater internet gaming disorder severity. The IGDS9-SF demonstrated excellent internal consistency across all four waves, as evidenced by McDonald’s ω coefficients of 0.91 (T1), 0.91 (T2), 0.90 (T3), and 0.91 (T4).

Academic achievement. Within the Chinese educational framework, subjects such as Chinese, Mathematics, and English are pivotal and often serve as benchmarks for gauging students’ academic proficiency (e.g., Nie et al., 2021). The current study selected Chinese, Mathematics, and English to evaluate achievement. The study also included two sources of achievement combined by their means of both self- and teacher-rated achievements.

Self-reported academic achievement. The self-assessment method used to assess students’ academic achievement required participants to evaluate their performance in Chinese, Mathematics, and English. This encompassed three questions, one example of which is “How would you assess your current performance in mathematics?” Responses were provided based on a five-point scale (1 = “very poor,” to 5 = “excellent”). The average score across the three subjects represented students’ self-assessed level of academic achievement. The internal consistency of students’ self-assessed academic performance across the four waves was adequate, with McDonald’s ω coefficients being 0.70 (T1), 0.73 (T2), 0.74 (T3), and 0.74 (T4).

Teacher-rated academic achievement. Within the Chinese school system, compared to subject-specific teachers, class advisers (“homeroom teachers”) possess the most comprehensive understanding of their students. Having these class advisers assess students’ academic performance allowed for a more accurate reflection of students’ true academic capabilities. Class advisers evaluated the academic status of each student under their care for the current term, with this assessment covering Chinese language, Mathematics, and English performance. This evaluation comprised three questions, one example of which is “How would you rate this student’s current performance in mathematics?” The scoring was based on a five-point scale (1 = “very poor,” to 5 = “excellent”). The mean scores of the three subjects constituted the teacher-rated academic performance, the internal consistency was excellent, with McDonald’s ω coefficients of 0.87 (T1), 0.91 (T2), 0.89 (T3), and 0.90 (T4).

Covariates. The demographic information was measured in T1 (Wave 3) and included participants’ age, sex (1 = boy, 0 = girl), the educational level of their parents (ranging from 1, representing primary school education, to 5, representing graduate degree), and family monthly economic incomes (ranging from 0, representing less than 3,000 ¥, to 5, representing more than 20,000 ¥). The z-scores of parents’ educational level and family monthly incomes were used

as an index of socioeconomic status (SES) and derived using the principal component analysis (Vyas & Kumaranayake, 2006).

Data Analysis Plan

Missing data. As missing data are unavoidable in longitudinal studies, two mechanisms can be used to investigate this phenomenon: data missing completely at random (MCAR) and data missing at random (MAR; Enders, 2010). The attrition rates for the current study were 5.4% (T1), 6.6% (T2), 10.9% (T3), and 22.8% for (T4), with attrition being primarily owing to students being transferred to other schools or not being present at school on the evaluation days.

Missing data were examined using MCAR or MAR[2], and a series of chi-square tests and *t*-tests were used to compare the mean differences between the completed and missing data (Little & Rubin, 2019). The results suggested that sex ($\chi^2_{[1]} = 39.58$, $p < .001$), age ($t_{[3704]} = 22.32$, $p < .001$), school climate perceptions ($t_{[5078]} = 11.09$, $p < .001$), gaming disorder symptoms ($t_{[2029]} = 5.02$, $p < .001$), self-reported achievement ($t_{[5068]} = 15.25$, $p < .001$), and teacher-rated achievement ($t_{[4513]} = 15.04$, $p < .001$) all contained data MAR (but not MCAR), which is common in longitudinal studies (Ibrahim & Molenberghs, 2009). SES ($t_{[674]} = 1.62$, $p = .106$) notably contained data MCAR. To estimate missing data, the full information maximum likelihood (FIML) method was applied, using Mplus 8.40. FIML is a statistically robust approach that estimates model parameters using the most available data, ensuring that the analysis remains as accurate and reliable as possible, even for incomplete datasets (Graham, 2009). This method enhanced the validity of the findings by minimizing the bias that might be caused by the missing data.

Measurement invariance. Confirmatory factor analysis was used to examine the longitudinal measurement invariance (i.e., configural, weak, and strong invariance) of the study variables. All variables maintained strong measurement invariance (**Table S1**).

Descriptive analyses. Descriptive statistics and correlations were calculated using SPSS Statistics 24.0 (Windows). Intraclass correlation coefficients (ICCs) were calculated for the study variables using Mplus 8.40. The ICCs for perceived school climate, academic achievement, and gaming disorder symptoms were 0.633, 0.729, and 0.551, respectively, suggesting that separate between- and within-person variances were required.

Random intercept cross-lagged panel model. Because the sample included 17 schools and 125 classrooms, the current study used maximum likelihood with robust standard errors and TYPE = COMPLEX to account for school-clustering effects. Three RI-CLPMs

[2] As the distribution of missing data was unknown, the mechanism of missing not at random could not be tested using the existing data.

(preadolescents, early adolescents, and late adolescents) were used to examine the longitudinal relationships among school climate perceptions, academic achievement, and gaming disorder symptoms[3]. To obtain more stable coefficients from the RI-CLPMs, four-step constrained models were used (Models 1–4). First, the base model with no constraints was conducted (Model 1). Second, a model that constrained the autoregressive coefficient equally across time was added (Model 2). Third, a model that constrained the cross-lagged effect equally across time was added (Model 3). Finally, a model that constrained the covariance of error invariance was added (Model 4). Model comparison used the changed comparative fit index (CFI) and Tucker–Lewis index (TLI). A change in CFI larger than 0.01 suggested significant model difference (Cheung & Rensvold, 2002).

Sensitivity analyses. A series of sensitive analyses were conducted. First, the age, sex, and SES[4] covariates were added to the RI-CLPMs as between-person variables to examine whether the results would still hold. Second, owing to gaming disorder symptoms always having sex differences, with boys always displaying a higher score of gaming disorder symptoms than girls (e.g., Borgonovi, 2016; Paulus et al., 2018), multiple-group RI-CLPMs were constructed to evaluate sex differences (between boys and girls) across the three cohorts. Each multiple-group RI-CLPM encapsulated the within-wave correlations, stability, and cross-lagged effects. The fit metrics for the models are listed in **Table S2**. Third, multiple imputations (MIs) were also used for the sensitivity analyses to examine whether the results would still hold.

Results

Descriptive Analyses

Table 1 shows the descriptions of means (*Ms*) and standard deviations (*SD*s) for school climate perceptions, academic achievement, and gaming disorder symptoms according to sex and developmental difference. Preadolescents showed a higher level of school climate perceptions than early adolescents (ps < .001, Cohen's ds > 0.52) and late adolescents (ps < .001, Cohen's ds > 0.74). Preadolescents also showed a higher level of academic achievement (both self-reported and teacher-rated) than both early adolescents (ps < .001, Cohen's ds > 0.22) and late adolescents (ps < .001, Cohen's ds > 0.13). Early adolescents showed a higher level of gaming disorder symptoms than both preadolescents (ps < .014, Cohen's ds > 0.09) and late adolescents (ps < .001, Cohen's d > 0.12). Boys showed a higher level of gaming disorder

[3] Although the RI-CLPM included the cross-lagged effect between school climate and academic achievement, these effects were not the main interest of the present study.
[4] As SES always has a significant effect on academic achievement (e.g., Liu et al., 2022), it also served as a covariate in this model to examine whether the results remained consistent.

symptoms (ps < .001, Cohen's d > 0.63) and a lower level of teacher-rated achievement (ps < .001, Cohen's d > 0.22) than girls. No sex differences were observed regarding school climate perceptions and self-reported achievement (expect for T2).

-Insert Table 1 about here-

Table 2 shows the correlations among all the variables tested across all waves in the three samples. For preadolescents, all positive school climate perceptions related to achievement (except for T3 self-reported achievement and T2 school climate perceptions). For early and late adolescents, all the variables were significantly correlated with each other, except for teacher-rated achievement, which was not related to school climate perceptions in some waves. In all samples, both self-reported and teacher-rated achievement were significant and strongly correlated with each other (all ps < .001).

-Insert Table 2 about here-

Results of RI-CLPMs Across Three Groups

Model fit values of the RI-CLPMs across preadolescents, early adolescents, and late adolescents are shown in **Table 3**. Across all samples, the final constraint model (i.e., Model 4) exhibited a good model fit and a non-significant difference from Models 1 to 3. The study reports the results of the final constrained model for all the samples.

Preadolescents. As can be seen in **Fig. 1**, at the within-person level, the fluctuations in perceptions of school climate negatively predicted the subsequent gaming disorder symptoms (b=−.119, p < .001, 95% CI [−.172, −.065], β range from −.084 to −.088) among preadolescents. At within-person level, the fluctuations observed in academic achievement weakly predicted the subsequent gaming disorder symptoms (b= .061, p = .025, 95% CI [.016, .106], β range from 0.043 to 0.053). Fluctuations in gaming disorder symptoms had no significant predictive effect on the subsequent perceptions of school climate and academic achievement (all ps > .10). At the within-person level, there was significant stability in terms of perceptions of school climate (b= .244, p < .001, 95% CI [.173, .316], β range from .245 to .279,), academic achievement (b= .210, p < .001, 95% CI [.128, .292], β range from .189 to .229), and gaming disorder symptoms (b= .089, p = .033, 95% CI [.021, .161], β range from .089 to .095). In addition, at the between-person level, there were significant relationships between perceived school climate and gaming disorder symptoms (r = −.423, p < .001), perceived school climate and academic achievement (r = .183, p < .001), and academic achievement and gaming disorder symptoms (r = −.362, p < .001). More details about the model results can be seen in **Table S3**.

-Insert Figure 1 about here-

Early adolescents. As can be seen in **Fig. 2**, at the within-person level, the fluctuations

in perceptions of school climate positively and weakly predicted late gaming disorder symptoms (b= .073, p = .051, 95% CI [.011, .134], β range from .044 to .059) among early adolescents. There was a weak bidirectional within-person relationship between school climate perceptions and academic achievement. There was no significant cross-lagged effect between school climate perceptions and gaming disorder symptoms. At the within-person level, there was also significant stability regarding perceptions of school climate (b= .133, p < .001, 95% CI [.077, .189], β range from .132 to .159), academic achievement (b= .224, p < .001, 95% CI [.134, .313], β range from .204 to .246), and gaming disorder symptoms (b= .103, p = .007, 95% CI [.040, .166], β range from .093 to .134). At the between-person level, there was a significant relationship between perceived school climate and gaming disorder symptoms (r = −.365, p < .001), weak correlation between perceived school climate and academic achievement (r = .094, p = .061), and negative correlation between academic achievement and gaming disorder symptoms (r = −.246, p < .001). More details about the model results can be seen in **Table S4**.

-Insert Figure 2 about here-

Late adolescents. As can be seen in **Fig. 3**, at the within-person level, fluctuations in gaming disorder symptoms negatively predicted late academic achievement (b=−.067, p < .001, 95% CI [−.096, −.038], β range from −.091 to −.051) among late adolescents. There was a weak bidirectional within-person relationship between school climate perceptions and academic achievement. No other within-person cross-lagged effects were found between school climate perceptions and gaming disorder symptoms. At the within-person level, significant stability was observed regarding perceptions of school climate (b= .063, p = .023, 95% CI [.017, .109], β range from .056 to .075), academic achievement (b= .127, p = .034, 95% CI [.029, .225], β range from .100 to .125), and gaming disorder symptoms (b= .132, p < .001, 95% CI [.081, .182], β range from .118 to .156). At the between-person level, significant relationships were found between perceived school climate and gaming disorder symptoms (r = −.286, p < .001), perceived school climate and academic achievement (r = .176, p < .001), and academic achievement and gaming disorder symptoms (r = −.240, p < .001). More details about the model results can be seen in **Table S5**.

-Insert Figure 3 about here-

Sensitivity Analyses

First, all the most significant results remained consistent when the RI-CLPMs were adjusted for age, sex (1 = boy, 0 = girl), and SES (**Fig. S1–S3**). Second, owing to previous

research suggesting significant sex differences in gaming disorder, the current study also examined the sex differences in RI-CLPMs as a supply analysis (**Table S2**). When exploring the sex differences among preadolescents ($\Delta\chi^2$ = 8.79, Δdf = 9, p = .457), early adolescents ($\Delta\chi^2$ = 14.31, Δdf = 9, p = .112), and late adolescents ($\Delta\chi^2$ = 5.62, Δdf = 9, p = .777), the findings observed remained consistent in both the constrained and non-constrained models. These observations were equally evident among both the boys and girls across the preadolescents, early adolescents, and late adolescents. Third, sensitivity analyses evaluated the robustness of the results when the model dealt with missing data using MI. MIs were used to impute 200 times for the variables with missing values. RI-CLPMs were then run based on the FIML estimation. The model results were similar to the FIML estimates and remained consistent across preadolescents, early adolescents, and late adolescents (**Fig. S4–S6**). The results based on the FIML estimates did not show significant bias when using RI-CLPMs.

Discussion

Most previous studies focusing on the relationship between school climate perceptions, academic achievement, and gaming disorder symptoms used cross-sectional designs, leaving a notable gap of longitudinal research and an incomplete understanding of within-person effects. To address this issue, the current study examined the temporal dynamic relationships between school climate perceptions, academic achievement, and gaming disorder symptoms among a large sample of Chinese adolescents (i.e., preadolescents, early adolescents, and late adolescents). Using RI-CLPMs, the current study found that at the within-person level: (i) the fluctuations in school climate perceptions negatively predicted subsequent gaming disorder symptoms among preadolescents but not among early and late adolescents; (ii) early adolescents showed a weak positive prediction from school climate perceptions to subsequent gaming disorder symptoms; and (iii) only late adolescents showed a negative predictive effect of gaming disorder symptoms on subsequent academic achievement. These results remained consistent even after the covariates of age, sex, and SES were adjusted.

School Climate Perceptions and Gaming Disorder Symptoms

The results of the RI-CLPMs suggested that at the within-person level, negative school climate perceptions among preadolescents (but not early and late adolescents) predicted subsequent gaming disorder symptoms. This result supports Hypothesis 1 but not Hypothesis 2 among preadolescents. This result implies that changes in perceived school climate (at trait levels) negatively predicted subsequent changes in the symptoms of gaming disorder (at trait levels). In line with previous cross-sectional studies (e.g., Gan et al., 2022; Zhang et al., 2022),

school climate perception is a strong protective factor against the development of gaming disorder symptoms. The contribution of this result extends the effect from between-person level to within-person level. Two theoretical views can explain this finding. First, students perceive a positive school climate as providing a strong social support network, including its regard for teachers, peers, and other school staff. A positive school climate is recognized as an important resource for resisting stress and coping with problematic behaviors (e.g., Wang & Degol, 2016). When students feel supported and understood, they are more likely to adopt positive coping strategies rather than turn to problematic gaming to escape real-life problems. Second, according to self-determination theory (Deci & Ryan, 2015; Wang & Degol, 2016), a positive school environment fulfills these basic psychological needs (i.e., autonomy, competence, and belonging) by providing meaningful learning activities in school, encouraging students to participate in school engagement, and establishing positive relationships with teachers and students. When these needs are met, students are more likely to exhibit positive behaviors, reducing their dependence on symptoms of gaming disorder.

However, a weak positive within-person effect regarding the effect of perceived school climate on late gaming disorder symptoms was unexpectedly observed among early adolescents. First, it is possible that early adolescence is a period that warrants special consideration regarding the potential onset of risky behaviors such as smoking, alcohol consumption, and gaming problems (Davidson et al., 2015). Second, it is a period when early adolescents start to develop a sense of independence and autonomy (Zimmer-Gembeck & Collins, 2006), while their self-control is not well developed (e.g., Davidson et al., 2015). A positive school climate encourages high autonomy (e.g., Jia et al., 2009) that may positively link to problematic gaming behaviors. As autonomy increases over time, problematic gaming behaviors may also increase. Third, peer relationships play a critical role in shaping adolescents' perception of school climate. Compared to late adolescents, early adolescents are in the early developmental stage of forming a deeper and more mature understanding about healthy gaming behaviors, values, and the purposes of socialization among peers. It is possible that they perceive more invitations and approval from friends to play videogames together as indicators of positive peer relationships, despite the increased risk of gaming disorder symptoms. However, this unexpectedly positive within-person effect between school climate perceptions and gaming disorder symptoms among early adolescents had a relatively weak effect size. Caution is advised in drawing a definitive conclusion from this finding.

No cross-lagged effect was found between perceived school climate and gaming disorder symptoms among late adolescents at the within-person level. This result is consistent with those

of previous studies (e.g., Hygen et al., 2020; Kojima et al., 2021; Takahashi et al., 2022) that used RI-CLPMs, which found no within-person effect of gaming disorder symptoms among adolescents. This fact can likely be attributed to the following reasons. First, compared to preadolescents and early adolescents, late adolescents view their school in a more complex manner and exhibit a greater stability of gaming disorder symptoms over time. Even substantial changes in school climate may not significantly predict the changes in symptoms of gaming disorder. Second, Chinese students, especially high school students, are often forbidden from bringing smartphones into school but will often go home after school to play with their smartphones and use computers. This may create a problem whereby even though the school climate has become more positive, students are at greater risk of developing increased symptoms of gaming disorder at home. For example, family climate may also predict the development of gaming disorder symptoms (e.g., Zhou et al., 2023) at the within-person level. A third reason may be that changes in school climate tend to take longer (e.g., more than one or two years) to take effect, and slight fluctuations in school climate, six months apart, may not be sufficient to prompt significant fluctuations or changes in symptoms of gaming disorder.

The lack of an observable within-person effect does not mean that creating a positive school climate is unimportant. Similar to the results obtained in previous studies (e.g., Gan et al., 2022; Yu et al., 2015), the current study found a strong negative between-person relationship between school climate perceptions and gaming disorder symptoms among all adolescents, indicating that adolescents with positive school climate perceptions tended to have a lower prevalence of gaming disorders or fewer symptoms at the between-person level. This is because a positive school climate fulfills students' basic psychological needs, matches the current stage of student development, helps further reduce depression and anxiety, and enhances overall well-being (Wang & Degol, 2016). In line with the observed between-person effects, school-wide programs targeting at promoting positive school climate may still be useful to prevent the development of gaming disorder and other problems.

Academic Achievement and Gaming Disorder Symptoms

The findings of the RI-CLPMs suggested that among high school students, fluctuations in gaming disorder symptoms (at trait levels) negatively predicted subsequent fluctuations in academic achievement (at trait levels), but not inversely. This result supports Hypothesis 4 but not Hypothesis 3 among late adolescents. This result coincides with the view that late adolescents are particularly vulnerable to the negative effects of gaming disorder symptoms (e.g., Paulus et al., 2018; Teng et al., 2020). This result is also consistent with the time displacement hypothesis (e.g., Drummond & Sauer, 2020; Hartanto et al., 2018), which posits

that excessive gaming leads to a decline in achievement. This may be the case because for all high school students with academic tasks and high levels of academic pressure, the time invested in learning is positively proportional to their degree of academic achievement. However, excessive gaming may lead to students not having enough time to spend on learning (Drummond & Sauer, 2020). Students with intense gaming disorder symptoms may have difficulty concentrating while working (their thoughts may revolve around videogames, leading to inefficient learning). As mentioned above, in the Chinese context, high school students face tremendous pressure from their parents to advance to university level education, and the development of gaming disorder symptoms causes them to lose valuable learning time and energy during this important period, leading to a decline in their levels of academic achievement.

This result was not observed among preadolescents and early adolescents. Preadolescents' level of achievement improved, weakly predicting a subsequent increase in the symptoms of gaming disorders at the within-person level (**Fig. 1**). The relationship between academic achievement and gaming among preadolescents appears to differ from that observed among high school students. First, for elementary school students, grade enhancement serves as a reward. For example, elementary school students may be allowed by their parents to play videogames as a reward for achieving good grades, increasing their exposure and resulting in problematic gaming. Second, after experiencing academic stress, elementary school students may seek to relax and de-stress through gaming, especially if they believe they have "earned" the time off. Parental supervision may be diminished for primary school children with good grades. When elementary school children's grades improve, parents may perceive their children as being able to manage themselves, and they may reduce their supervision of their children's playtime. However, when including SES as a covariate, this effect became non-significant. Caution should be exercised when explaining the weak positive effect between academic achievement and symptoms of gaming disorder at the within-person level.

Developmental Perspectives

Preadolescents, early adolescents, and late adolescents showed intra-individual cross-lagged effects in different models, illustrating the importance of different developmental stages when theorizing the relationship between school factors and gaming disorder symptoms. First, according to the theory of cognitive development (Smetana & Villalobos, 2009) in preadolescence, students' cognition and thinking are intuitive and concrete, and they tend to learn about and understand the world through direct observation. They may be more susceptible to the external environment, as characterized by factors including the school environment and

parental guidance. Students may be more likely to form healthy gaming habits when the school environment is positive, emphasizing the importance of learning and healthy behaviors. When children transition to adolescence, their cognitive abilities and self-control increase significantly, and they begin to develop a sense of independence and autonomy. Even if the school environment is favorable, if a student has developed a problematic gaming habit, it may be more challenging to change this behavior. The symptoms of gaming disorders may create distractions and affect students' learning efficiency and performance in late adolescence.

Second, preadolescents and adolescents may possess different values. Preadolescents (primary school students) are still forming their values and are more likely to accept and imitate the values of adults, especially their parents and teachers. A school environment that emphasizes the importance of academic achievement and moderate gaming habits may have profound effects to them. However, for adolescents, especially high school students, more stable values have already been formed (Pöge, 2020), with more apparent plans and goals for the future. If these goals are tied to academic performance, students may choose to focus more on their studies and resist the temptation to play videogames. If they lose interest or confidence in their studies, problematic gaming may become more prevalent as a means of escaping reality, leading to a further decline in academic achievement.

Limitations and Future Directions

The current study had some limitations. First, the current study relied mainly on self-reported data, which may have been affected by the shared method variance. The RI-CLPM used in the current study partially mitigated these effects by adjusting for the initial correlations and covariation. Future research should examine how school factors are linked to the development of gaming disorder symptoms and consider using various data collection approaches (e.g., parent ratings of school climate and test records of academic achievement). Second, this study lacked any measures for gaming with friends, which may explain the unexpectedly weak positive within-person effect between perceived school climate and gaming disorder symptoms among early adolescents. Early adolescents with many friends at school likely also have many friends to play videogames with. Future studies could collect these data and try to explain the unexpected within-person effect between school climate and gaming disorder symptoms. Third, this study (while longitudinal) only lasted two years, which may have limited its potential to fully explore the broad extent of the developmental effects of school factors associated with the onset of symptoms of gaming disorder. Future studies should extend the duration to elucidate the relevant transition patterns from late childhood to early adolescence. Fourth, this study examined only two school factors (school climate perceptions

and academic achievement) linked to the development of gaming disorder symptoms. As suggested by the stage-environment fit theory (Eccles, 2004; Wang & Degol, 2016), school context may also interact with personal traits (e.g., self-control) and school engagement, affecting the relationship with symptoms of gaming disorder. Future research should investigate the moderators and mediators between these variables, and the long-term relationship between other school factors and symptoms of gaming disorder. Finally, this study was conducted in Southwest China, where students typically spend extended hours in school and educators hold strong authority to monitor daily student activities, including students' smartphone use and screen time in schools. Future researchers should compare the cultural dynamics of China with those of other regions when assessing the preventive effect of schools on gaming disorder symptoms.

Implications for Practice

The results provide important insights and implications for creating developmentally sensitive school-based practical strategies and policies aimed at preventing and addressing gaming disorder and related online risk behaviors among school-age children. The current study found that negative school climate perceptions significantly predicted increased gaming disorder symptoms at the trait level across all three stages of adolescence. This underscores the necessity of prioritizing the fostering of a positive school climate to reduce online risk behaviors and problematic gaming from elementary school through to high school settings. Particularly noteworthy was the significant association between positive school climate and decreased gaming disorder symptoms also observed among preadolescents not only at the trait level but also at the state level. This finding emphasizes the pivotal role of the school climate in early prevention efforts targeting gaming disorder among elementary school students. Some school-wide practices, such as Positive Behavioral Intervention and Support (PBIS) and universal social and emotional learning (SEL) programs have shown efficacy in promoting a positive school climate (e.g., Mahoney et al., 2021), particularly in elementary schools, by enhancing students' relationships with peers and adults, improving behavioral management skills, and fostering self-awareness across different school environments.

The findings also indicated that gaming disorder symptoms predicted decreased in academic achievement at trait level (between-person) across all three stages of adolescence, with this predictive effect also persisting at the state (within-person) level among late adolescents. This suggests that students' heightened risk of gaming disorder symptoms could serve as an early indicator for their declines in academic performance, particularly for late adolescents. Therefore, it is important to assess and monitor students' online risk behaviors,

including gaming, as preventative measures integrated with other school-based intervention data and instruction to maximize student achievement and support students' social, emotional, and behavioral needs. For late adolescents exhibiting gaming disorder symptoms, providing targeted school-based support is crucial to mitigate the negative impact of these symptoms on academic performance. Equally important is to support both adolescents and their family members in accessing intervention resources and programs with holistic treatment approaches. In addition, psychological support and educational interventions should be provided to support students who experiencing declining grades and those exhibiting problematic gaming behavior, especially for Chinese high school adolescents strive for high academic achievement (Jia et al., 2009; Nie et al., 2021).

Conclusion

The longitudinal relationships between school climate perceptions, academic achievement, and gaming disorder symptoms have not been sufficiently explored, and the direction of the associations between these variables is unclear. To address these research gaps, a four-wave longitudinal design employing RI-CLPMs was employed to investigate the longitudinal link between school climate perceptions, academic achievement, and gaming disorder symptoms across three developmental stages (i.e., preadolescence, early adolescence, and late adolescence). At the within-person level, the results showed a series of intricate dynamics. Among preadolescents, more favorable school climate perceptions were linked to decreases in gaming disorder symptoms, a pattern that did not appear among early or late adolescents. Among late adolescents, gaming disorder symptoms negatively predicted subsequent academic achievement, an effect that was not observed among preadolescents and early adolescents. These results offer important insights into how school-related factors have varying effects on the onset and development of gaming disorder symptoms across different developmental stages. Preadolescents appear to be particularly vulnerable to the school environment, whereas late adolescents appear to be more susceptible to the developmental ramifications of gaming. The current study enriches the existing literature by indicating a potential shift from the view of gaming disorder symptoms being shaped by ecological factors to instead being a shaping force in adolescent development. This shift in perspective highlights the urgent need for developmentally sensitive and school-based intervention strategies aimed at both preventing gaming disorder and alleviating its negative impacts on educational outcomes.

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Table 1 Descriptive statistics of study variables according to sex and developmental differences.

Variables	Sample size		Total		Boy		Girl		Pre-AD		Early-AD		Late-AD	
	n_{total}	n_{boys}	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
PSC														
T1	5401	2746	3.28	0.55	3.29	0.58	3.27	0.52	3.53	0.55	3.24	0.57	3.15	0.48
T2	5327	2712	3.28	0.53	3.28	0.54	3.28	0.51	3.56	0.55	3.24	0.52	3.12	0.44
T3	5063	2566	3.28	0.51	3.28	0.53	3.28	0.49	3.54	0.56	3.23	0.49	3.13	0.42
T4	4416	2178	3.30	0.52	3.31	0.53	3.29	0.51	3.55	0.53	3.23	0.48	3.13	0.45
S-AA														
T1	5391	2739	2.94	0.84	2.92	0.89	2.96	0.79	3.38	0.86	2.93	0.84	2.66	0.71
T2	5317	2707	2.86	0.85	2.82	0.90	2.89	0.78	3.32	0.87	2.79	0.83	2.60	0.71
T3	5057	2563	2.86	0.87	2.83	0.92	2.88	0.80	3.38	0.87	2.75	0.80	2.56	0.73
T4	4386	2162	2.95	0.82	2.96	0.88	2.94	0.76	3.36	0.84	2.81	0.78	2.72	0.70
T-AA														
T1	4800	2415	3.04	0.93	2.92	0.96	3.15	0.89	3.26	0.99	2.98	1.01	2.91	0.78
T2	5320	2706	3.05	0.97	2.92	0.99	3.19	0.92	3.21	0.99	2.97	1.08	3.02	0.84
T3	5273	2696	3.07	0.93	2.96	0.95	3.19	0.89	3.34	0.99	2.96	0.99	2.99	0.80
T4	4763	2398	3.21	0.97	3.10	0.99	3.32	0.93	3.39	0.99	2.97	1.03	3.27	0.86
GDS														
T1	5374	2731	1.70	0.79	1.96	0.88	1.44	0.60	1.69	0.74	1.76	0.84	1.67	0.79
T2	5290	2690	1.70	0.76	1.96	0.82	1.44	0.59	1.67	0.75	1.80	0.81	1.65	0.74
T3	5050	2558	1.61	0.72	1.84	0.78	1.38	0.55	1.58	0.74	1.71	0.74	1.56	0.67
T4	4379	2168	1.60	0.74	1.82	0.81	1.38	0.57	1.60	0.74	1.69	0.77	1.52	0.69

Note. PSC, perceptions of school climate; *S-AA,* self-reported academic achievement; *T-AA,* teacher-rated academic achievement; *GDS,* gaming disorder symptoms; *AD,* adolescents; *T1 to T4,* Time 1 to Time 4.

Table 2 Correlations among the main study variables across T1 to T4 in preadolescents, early adolescents, and late adolescents.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Preadolescents (n = 1513)																
1. School climate perceptions (T1)	–															
2. School climate perceptions (T2)	.604**	–														
3. School climate perceptions (T3)	.571**	.640**	–													
4. School climate perceptions (T4)	.537**	.613**	.722**	–												
5. Gaming disorder symptoms (T1)	-.324**	-.239**	-.253**	-.221**	–											
6. Gaming disorder symptoms (T2)	-.243**	-.266**	-.279**	-.214**	.469**	–										
7. Gaming disorder symptoms (T3)	-.217**	-.239**	-.251**	-.225**	.417**	.553**	–									
8. Gaming disorder symptoms (T4)	-.239**	-.266**	-.312**	-.306**	.431**	.570**	.562**	–								
9. Self-reported achievement (T1)	.141**	.065*	.130**	.097**	-.235**	-.166**	-.161**	-.177**	–							
10. Self-reported achievement (T2)	.092**	.090**	.118**	.057*	-.198**	-.195**	-.175**	-.192**	.704**	–						
11. Self-reported achievement (T3)	.079**	.038	.121**	.060*	-.179**	-.133**	-.179**	-.171**	.695**	.712**	–					
12. Self-reported achievement (T4)	.098**	.083**	.124**	.118**	-.158**	-.160**	-.167**	-.198**	.686**	.685**	.760**	–				
13. Teacher-rated achievement (T1)	.124**	.098**	.124**	.084**	-.221**	-.199**	-.185**	-.194**	.592**	.578**	.543**	.547**	–			
14. Teacher-rated achievement (T2)	.067*	.098**	.107**	.051*	-.196**	-.220**	-.173**	-.199**	.581**	.600**	.535**	.544**	.768**	–		
15. Teacher-rated achievement (T3)	.121**	.094**	.113**	.076**	-.208**	-.156**	-.138**	-.146**	.561**	.548**	.533**	.553**	.663**	.664**	–	
16. Teacher-rated achievement (T4)	.128**	.107**	.125**	.090**	-.235**	-.200**	-.199**	-.198**	.556**	.526**	.508**	.560**	.695**	.666**	.721**	–

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Early adolescents (n = 1771)																
1. School climate perceptions (T1)	–															
2. School climate perceptions (T2)	.579**	–														
3. School climate perceptions (T3)	.573**	.632**	–													
4. School climate perceptions (T4)	.538**	.562**	.673**	–												
5. Gaming disorder symptoms (T1)	-.175**	-.175**	-.212**	-.172**	–											
6. Gaming disorder symptoms (T2)	-.112**	-.210**	-.192**	-.190**	.495**	–										
7. Gaming disorder symptoms (T3)	-.189**	-.207**	-.250**	-.233**	.534**	.615**	–									
8. Gaming disorder symptoms (T4)	-.185**	-.200**	-.219**	-.242**	.463**	.549**	.673**	–								
9. Self-reported achievement (T1)	.101**	.076**	.052*	.069*	-.101**	-.111**	-.095**	-.088**	–							

10. Self-reported achievement (T2)	.089**	.129**	.103**	.108**	-.162**	-.195**	-.181**	-.148**	.677**	–						
11. Self-reported achievement (T3)	.077**	.111**	.116**	.093**	-.133**	-.154**	-.165**	-.126**	.686**	.748**	–					
12. Self-reported achievement (T4)	.065*	.119**	.093**	.133**	-.125**	-.139**	-.153**	-.141**	.636**	.682**	.726**	–				
13. Teacher-rated achievement (T1)	.034	.043	.044	.036	-.140**	-.128**	-.157**	-.099**	.542**	.535**	.545**	.500**	–			
14. Teacher-rated achievement (T2)	.055*	.076**	.092**	.074**	-.108**	-.140**	-.154**	-.118**	.552**	.589**	.607**	.544**	.777**	–		
15. Teacher-rated achievement (T3)	.019	.069**	.057*	.032	-.124**	-.145**	-.124**	-.116**	.505**	.530**	.574**	.514**	.697**	.685**	–	
16. Teacher-rated achievement (T4)	-.040	.028	.043	.020	-.114**	-.116**	-.091**	-.046	.453**	.516**	.507**	.516**	.620**	.595**	.694**	–

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
							Late adolescents (n = 2385)									
1. School climate perceptions (T1)	–															
2. School climate perceptions (T2)	.562**	–														
3. School climate perceptions (T3)	.512**	.588**	–													
4. School climate perceptions (T4)	.498**	.558**	.566**	–												
5. Gaming disorder symptoms (T1)	-.205**	-.185**	-.180**	-.143**	–											
6. Gaming disorder symptoms (T2)	-.145**	-.161**	-.175**	-.171**	.588**	–										
7. Gaming disorder symptoms (T3)	-.120**	-.146**	-.191**	-.154**	.542**	.641**	–									
8. Gaming disorder symptoms (T4)	-.115**	-.146**	-.171**	-.190**	.514**	.556**	.612**	–								
9. Self-reported achievement (T1)	.197**	.166**	.127**	.163**	-.161**	-.116**	-.108**	-.105**	–							
10. Self-reported achievement (T2)	.125**	.152**	.100**	.137**	-.168**	-.123**	-.100**	-.108**	.560**	–						
11. Self-reported achievement (T3)	.092**	.089**	.127**	.119**	-.133**	-.117**	-.139**	-.124**	.484**	.572**	–					
12. Self-reported achievement (T4)	.077**	.116**	.113**	.187**	-.084**	-.094**	-.092**	-.117**	.444**	.526**	.564**	–				
13. Teacher-rated achievement (T1)	.084**	.117**	.078**	.088**	-.162**	-.100**	-.116**	-.111**	.376**	.308**	.304**	.248**	–			
14. Teacher-rated achievement (T2)	.069**	.084**	.064**	.095**	-.194**	-.136**	-.187**	-.120**	.315**	.367**	.334**	.276**	.622**	–		
15. Teacher-rated achievement (T3)	.035	.071**	.083**	.081**	-.139**	-.108**	-.141**	-.094**	.297**	.349**	.393**	.296**	.584**	.651**	–	
16. Teacher-rated achievement (T4)	.023	.025	.055*	.091**	-.101**	-.088**	-.111**	-.067*	.304**	.255**	.274**	.365**	.522**	.523**	.528**	–

Note. T1 to T4, Time 1 to Time 4. Correlations at -.05 to .05 are suggested as not significant.

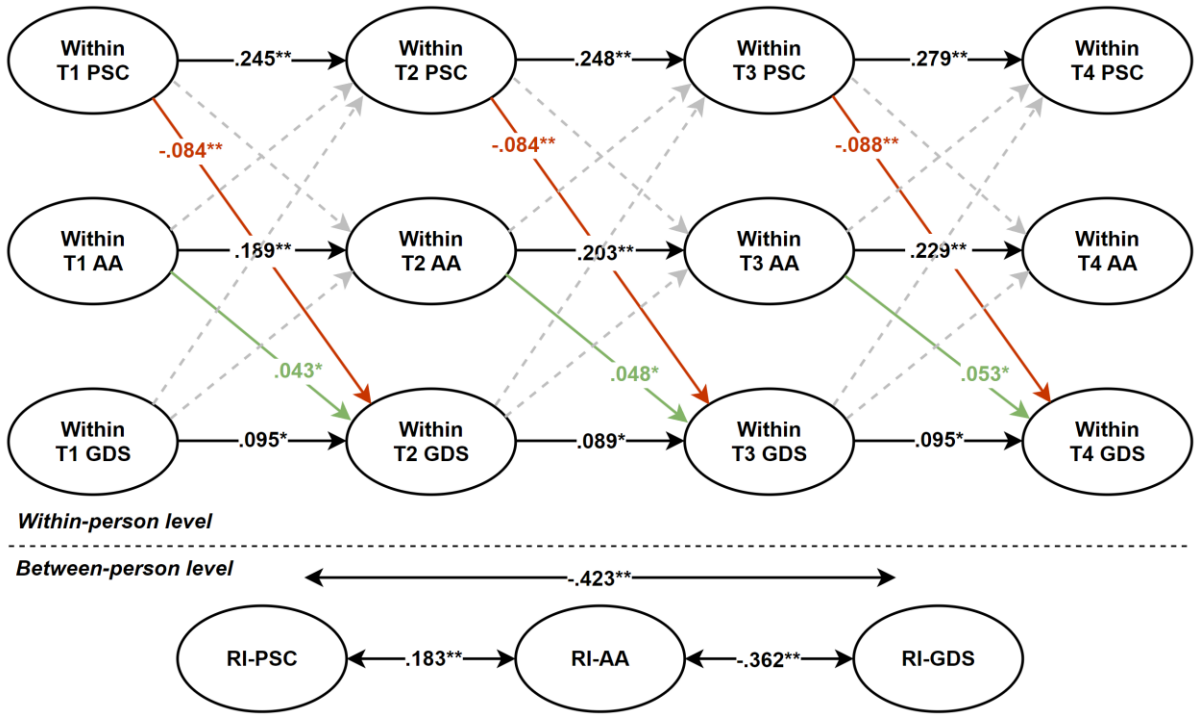
*p < .05, **p < .01.

Table 3 Model comparison test for the random intercept cross-lagged panel models.

Models	χ^2 (*df*)	ΔCFI	ΔTLI	RMSEA [90% CI]	CFI	TLI	SRMR
Preadolescent sample (*n* = 1513)							
Model 1	37.77 (21)	-	-	0.023 [0.010, 0.035]	0.997	0.989	0.024
Model 2	64.02 (27)	0.005	0.008	0.030 [0.021, 0.040]	0.992	0.981	0.047
Model 3	75.26 (39)	-0.001	-0.006	0.025 [0.016, 0.033]	0.993	0.987	0.049
Model 4	92.80 (48)	0.002	0.000	0.025 [0.017, 0.032]	0.991	0.987	0.044
Early adolescent sample (*n* = 1771)							
Model 1	26.59 (21)	-	-	0.012 [0.001, 0.025]	0.999	0.997	0.018
Model 2	47.27 (27)	0.002	0.005	0.021 [0.010, 0.031]	0.997	0.992	0.024
Model 3	57.01 (39)	0.000	-0.003	0.016 [0.005, 0.025]	0.997	0.995	0.025
Model 4	62.64 (48)	-0.001	-0.002	0.013 [0.001, 0.021]	0.998	0.997	0.024
Late adolescent sample (*n* = 2385)							
Model 1	20.00 (21)	-	-	0.000 [0.000, 0.016]	1.000	1.000	0.018
Model 2	38.73 (27)	0.002	0.005	0.013 [0.000, 0.022]	0.998	0.995	0.029
Model 3	62.29 (39)	0.002	0.002	0.016 [0.008, 0.023]	0.996	0.993	0.031
Model 4	84.19 (48)	0.002	0.002	0.018 [0.011, 0.024]	0.994	0.991	0.033

Note. Model 1: the base model with no constraints; Model 2: the model constrains the autoregressive coefficient equally across time; Model 3: the model constrains the cross-lagged effect equally across time; and Model 4: the model constrains the covariance of error invariance. *df*, degrees of freedom; *RMSEA*, root mean square error of approximation; *CFI*, comparative fit index; *TLI*, Tucker-Lewis Index; *CI*, confidence interval; *SRMR*, standardized root mean square residual.

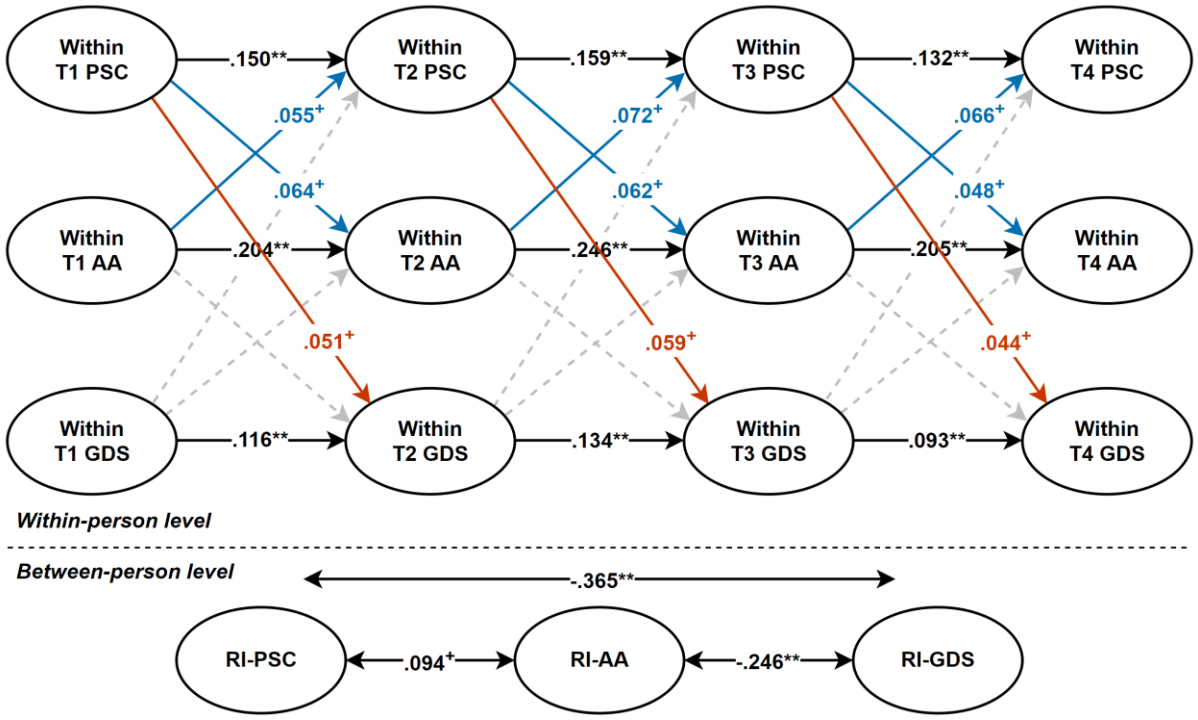
Fig. 1 RI-CLPM of school climate perceptions, academic achievement, and gaming disorder symptoms in preadolescents.



Note. *PSC,* perceptions of school climate; *AA,* academic achievement; *GDS,* gaming disorder symptoms; *RI-PSC,* random intercept of perceptions of school climate; *RI-AA,* random intercept of academic achievement; *RI-GDS,* random intercept of gaming disorder symptoms. All estimated effect is the standardized coefficient. The correlations among study variables at the within-person level are not shown. Dashed lines indicate nonsignificant coefficients. See the online article for the color version of this figure.

* $p < .05$, ** $p < .01$.

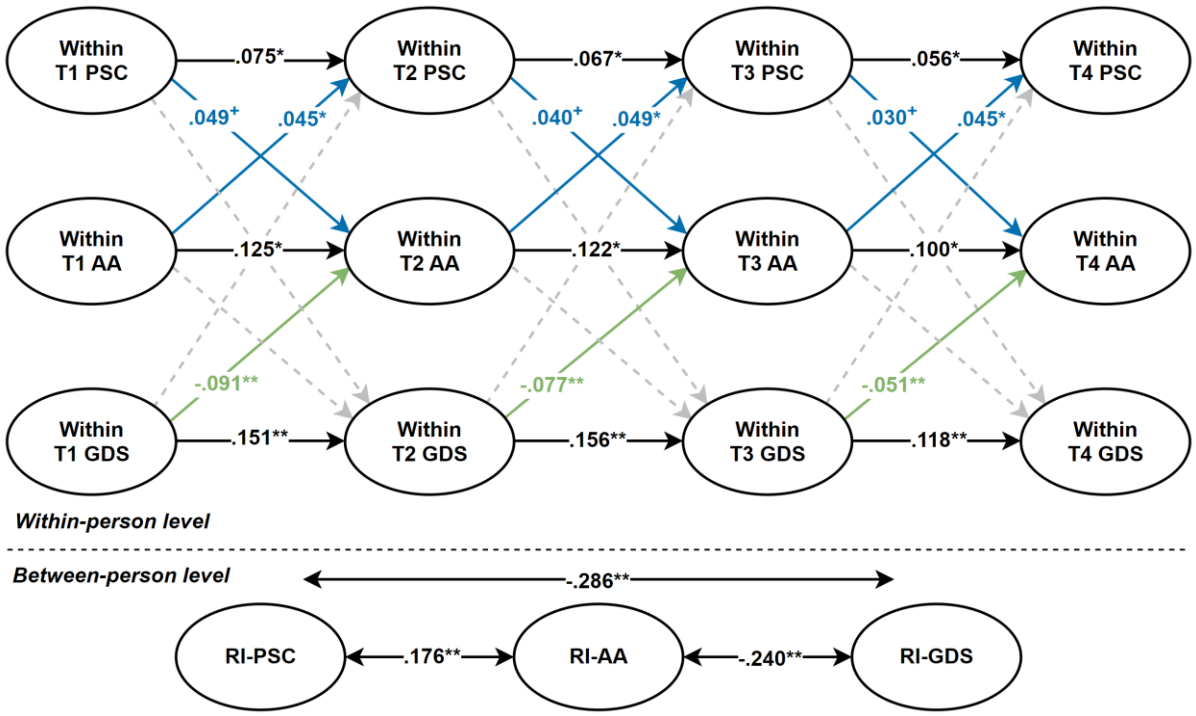
Fig. 2 RI-CLPM school climate perceptions, academic achievement, and gaming disorder symptoms in early adolescents.



Note. *PSC,* perceptions of school climate; *AA,* academic achievement; *GDS,* gaming disorder symptoms; *RI-PSC,* random intercept of perceptions of school climate; *RI-AA,* random intercept of academic achievement; *RI-GDS,* random intercept of gaming disorder symptoms. All estimated effect is the standardized coefficient. The correlations among study variables at the within-person level are not shown. Dashed lines indicate nonsignificant coefficients. See the online article for the color version of this figure.

$^{+}p < .090$, * $p < .05$, ** $p < .01$.

Fig. 3 RI-CLPM of school climate perceptions, academic achievement, and gaming disorder symptoms in late adolescents.



Note. *PSC,* perceptions of school climate; *AA,* academic achievement; *GDS,* gaming disorder symptoms; *RI-PSC,* random intercept of perceptions of school climate; *RI-AA,* random intercept of academic achievement; *RI-GDS,* random intercept of gaming disorder symptoms. All estimated effect is the standardized coefficient. The correlations among study variables at the within-person level are not shown. Dashed lines indicate nonsignificant coefficients. See the online article for the color version of this figure.

$^{+}p < .090$, * $p < .05$, ** $p < .01$.