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Longitudinal Association Between Opposite-Gender Peer Relationships and Student Motivation: Testing the Random-Intercept Cross-Lagged Panel Model

Chunze Xu

xvchunze@163.com

Key Laboratory of Adolescent Cyberpsychology and Behavior (CCNU)

Gengfeng Niu

Key Laboratory of Adolescent Cyberpsychology and Behavior (CCNU)

Xiaojun Sun

Key Laboratory of Adolescent Cyberpsychology and Behavior (CCNU)

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Abstract

Background: Although the general role of the school social environment in academic motivation has been demonstrated by many researchers, less attention has been paid to the effects of peer relationships, especially opposite-gender peers, on academic motivation, and the mechanisms of interaction between the two are unclear.

Method: The present study explored the longitudinal relationship between adolescents' opposite-gender peer relationships and students' motivation through a four-wave longitudinal study of 2,380 students (52% female) using the random intercept cross-lagged panel modeling (RI-CLPM) method.

Results: The results of the study revealed gender differences: for boys, opposite-gender peer relationships were positively associated with academic motivation, whereas this effect was not significant among girls, and there was no cross-lagged effect.

Conclusion: The study aims to enlighten educators to pay attention to gender differences among adolescents by exploring the interactions between peer relationships and academic motivation, to enhance researchers' understanding and practice of the link between students' peer relationships and motivation, and to cultivate optimal social environments for students' learning.

1 Introduction

Peer relationships are central to a student's social environment in school (Kilday & Ryan, 2022). These are interpersonal relationships that students establish and develop in the process of interacting with their peers or individuals at a comparable level of psychological development (Prinstein & Giletta, 2020). This interpersonal relationship is different from the vertical relationship that students have with their parents or with older individuals who interact with each other, while peer relationships are parallel and equal. Therefore, students interact with their peers in a freer and more equal interaction process. In this process, individuals use their own skills and perspectives to influence the formation of peer relationships on the one hand; on the other hand, individuals acquire new skills and perspectives under the influence of their peers (Bukowski et al., 2014; Santos & Vaughn, 2018). Through this interaction, positive peer relationships play an important role in healthy socio-emotional and cognitive development, as well as in students' internalizing and externalizing behaviors (Bukowski et al., 2018), and increasing numbers of scholars are interested in studying adolescents' peer interactions (Bukowski et al., 2014; Santos & Vaughn, 2018).

Among numerous studies, peer relationships and motivation have often been examined jointly to determine the relationship and direction of action between the two (Bukowski et al. 2018; Tu & Chu, 2020). Motivation refers to a psychological disposition or intrinsic drive in people that stimulates individual behaviour and directs it towards a specific purpose (Bureau et al., 2021), inspiring individuals to engage in a variety of actions, such as motivation to read (Wigfield et al., 2016), motivation to achieve (Elliot & Sommet, 2023), and motivation to learn, etc. (Conradty & Bogner, 2022). Learning motivation, in particular, is an aspect that has been of interest to educational practitioners and researchers as an extension of adolescent motivation in the domain of learning (Hudig et al., 2021). For adolescents, motivation plays an important role in academic

achievement and performance, influencing their classroom performance, learning patterns, and even emotional well-being (Lee & Bong, 2021).

However, many prior studies are based on cross-sectional data and can only reveal between-person differences in whether students with good peer relationships have higher motivation to learn (Raufelder et al., 2017; Tu & Chu, 2020), failing to explore the causal relationship between peer relationships and motivation. Some longitudinal studies have also reported interactions between peer relationships and academic motivation (Gustafson et al., 1992). However, these studies often conflate between-person level and within-person level differences (Hu & Li, 2022), failing to delineate the sources of variable variance in greater detail and strip out purely within-person effects. The consequence is that, while these studies demonstrate a significant correlation between students' peer relationships and motivation in subsequent years, they can only reflect general trends at the between-person level and fail to explain the true causal relationship between variables. Therefore, when exploring longitudinal relationships between variables, the effects of between-person levels need to be separated to avoid bias in the estimates obtained (Curran & Bauer, 2011). However, the models used in the existing studies are not equipped to handle these unobserved factors well.

To address this issue, the random intercept CLPM (RI-CLPM) has entered researchers' minds as a statistical method that takes into account stable person-to-person differences as well as the effects of unobserved heterogeneity in longitudinal data over time by adding a random intercept (Hamaker et al., 2015; Mulder & Hamaker, 2020). Thus, the method is suitable for decomposing within-person and between-person effects of longitudinal associations between variables and for testing within-person effects while separating between-person effects to better explain causal relationships between variables.

At the same time, previous studies have examined peer relationships as a whole without considering the unique role of opposite-gender peer relationships. In particular, as adolescents reach adolescence and students become significantly more attentive and dependent on their peers than they are on their parents and teachers (Otake et al., 2006; Rodkin & Ryan, 2012), opposite-gender peers begin to play an important role in students' lives, which continues into early adulthood (Mehta et al., 2013). Research has shown that students' opposite-gender peer relationships not only positively affect their academic performance and overall self-esteem (Liem & Martin, 2011), but also influence the establishment and development of same-gender peer relationships (Brendgen et al., 2002), which are key factors influencing students' social adjustment in the school community. This study therefore separates opposite-gender peer relationships from peer relationships for separate consideration, as elaborated in the literature review section.

2 Literature review

2.1 Learning Motivation

Motivation is a psychological disposition or intrinsic drive of an individual that stimulates individual behavior, directs behavior to a specific end, and sustains goal-directed behavior (Bandura, 1999). In the learning environment, student motivation is essential for learning (Kim et al., 2015), as it not only maintains students' propensity to learn (Schmidt, 2014; Nawaz et al., 2015), but also contributes to the ability of

students to sustain their interest in learning throughout their learning activities (Frías et al., 2020). As a result, student motivation has become a central concern for countless educators and researchers, occupying an increasingly important place in psychological and educational research.

Research has shown that students with high academic motivation exhibit more positive social behavioral tendencies, greater academic engagement, broader educational aspirations, and superior achievement performance (Hattie et al, 2020). In contrast, students with low motivation or no motivation tend to possess poorer learning outcomes (Al-Said, 2023), producing a number of negative learning outcomes (e.g., tardiness, leaving early, absenteeism, poor academic performance, etc.) (Lazowski & Hulleman, 2016). The importance of motivation for students cannot be overstated, and enhancing student motivation has been one of the main goals of teachers in the field of teaching and learning (Vrieling-Teunter et al., 2022); however, the factors that influence student motivation and their specific mechanisms of action remain largely unexplored.

Consequently, a comprehensive understanding of the mechanisms and processes by which the social context influences student motivation requires also consideration of the role of peer relationships, an important component of the student's social environment (Kilday & Ryan, 2022). As the centerpiece of students' social environment in school, the interaction between peer relationships and motivation is crucial and cannot be ignored. Therefore, this study focuses on the link between peer relationships and student motivation, aiming to enhance our understanding and practice of education by exploring the interplay between peer relationships and motivation to learn.

2.2 Opposite-gender peer relationships

After reviewing the extensive literature, it was found that despite the advantages that peer relationships have shown in promoting students' academic performance, well-being levels, and cognitive abilities (Bukowski et al., 2014; Santos & Vaughn, 2018), some researchers have questioned the importance of peer relationships, suggesting that peer relationships do not have a significant effect on various indicators, such as school adjustment and academic achievement (Wentzel & Caldwell, 1997; Liem & Martin, 2011). Some even suggest the opposite, suggesting that peer relationships distract students, leading to academic disengagement, lower academic motivation (Bishop, 1989; Ryan et al., 1994), and ultimately dropping out of school (Veronneau et al., 2008). Moreover, gangsterism can also occur, leading to many antisocial behaviors (e.g., adolescent bullying, peer victimization) (Tsaousis, 2016; Lee et al., 2022). Consequently, there are some discrepancies in the findings related to the impact of peer relationships, which can be both positive and negative, and which warrant further attention from researchers.

Thus, the present study suggests that the reason for this discrepancy is that previous studies have not made a careful distinction between peer relationships, but rather analyzed them as a whole, failing to clarify which part is at play. Especially after adolescents transition from childhood to adolescence, with increased contact with peers of the opposite gender, opposite-gender peer relationships begin to play an important role in adolescents' lives (Mehta & Strough, 2009), becoming the primary source role of their social identity, profoundly influencing adolescents' social adaptation and individual development (Albarello et al., 2020), and even influencing the establishment and development of same-gender peer relationships (Xiao et al.,

2022). Hence, to better understand the role of peer relationships in students, this study focuses on opposite-gender peer relationships as a separate object of study, while also laying the foundation for more clearly revealing the link between these relationships and motivation in the next section. This is not only a primary research focus of this study, but also a supplement and extension of the previous studies.

The opposite-gender peer relationship is an interpersonal relationship that is established and developed between an individual of the same age or comparable level of psychological development and the opposite gender (Liem & Martin, 2011). Specifically, it is a social and emotional bond that arises from close social interactions between individuals of the opposite gender, distinguishing it from both romantic and same-gender peer relationships as a specific type of interpersonal relationship. First, this relationship is different from opposite-gender peer relationships in that there is no element of passion, commitment, or sexual intimacy in opposite-gender peer relationships (Connolly et al., 1999), nor is there exclusivity as there is in romantic relationships (La Greca & Harrison, 2005). Second, opposite-gender peer relationships differ from same-gender peer relationships in that they can have specific effects on the individual. Research has shown that opposite-gender peers are closer, more trustworthy, more caring, and have fewer negative interactions than opposite-gender peers than same-gender peers (Hand & Furman, 2008), and can make one feel better about oneself (Baumgarte & Nelson, 2009). Other research has also found that opposite-gender peers help adolescents learn how to interact with peers with different skills, backgrounds, and interests (Poulin & Pedersen, 2007), expand their social range and sociability, and improve their ability to think flexibly, choose opinions, and care about people who are different from themselves (Smith & Inder, 1990). 1990). Such relationships can give young people the opportunity to learn from the opposite gender, as well as help individuals approach the opposite gender and enable them to develop the skills and competencies they need. Even the presence of opposite-gender peers in the peer network increases the sense of peer integration (Grygiel et al., 2022), which are benefits that are difficult for same-gender peers to provide. Thus, opposite-gender peer relationships deserve the attention of researchers as a crucial aspect of peer relationships for adolescents in late adolescence and a protective mechanism.

2.3 Opposite-gender peer relationships and learning motivation

The interaction between students' opposite-gender peer relationships and motivation has deep theoretical roots, which this study explores separately in terms of two processes: social support and socialization. First, the link between students' opposite-gender peer relationships and motivation can be explained in terms of social support. The effectiveness of social support as a key factor in building connections between adolescents and their peers has been confirmed by many researchers (Wentzel et al., 2010; Ng & Ahmad, 2018), providing a new theoretical perspective for understanding the process connecting peer relationships and motivation in this study (Shin & Johnson, 2021; Napoleon et al., 2023), especially Self-Determination Theory (SDT).

The underlying assumption of SDT is that when the social environment meets an individual's basic psychological needs for autonomy, competence, and relatedness, it enhances or maintains the individual's motivation for autonomy, at which point the individual's behaviors are more sustained, of higher quality, and ultimately produce more effective behavioral outcomes (Ryan & Deci, 2017). Therefore, peer relationships,

which are supportive social relationships in the school environment, become important for students, motivating them by meeting their psychological needs (Ryan & Deci, 2000; Wentzel, 2005), with the role of opposite-gender peer relationships cannot be ignored. As students enter adolescence, gender awareness is gradually awakening and there is a gradual bias in favour of the opposite-gender in meeting relationship needs (Bukowski et al., 2000). Research has shown that students perceive opposite-gender peers as closer, more trustworthy, more caring, and more satisfying than same-gender friends (Baumgarte & Nelson, 2009), and students with opposite-gender peers are perceived to be more desirable (Miller et al., 2009), resulting in a greater desire for opposite-gender peer relationships. Thus, opposite-gender peer relationships promote intrinsic motivation by fulfilling students' need for relationships (Ryan & La Guardia, 2000; Ryan et al., 1994). This view coincides with the attribution hypothesis proposed by psychologists Baumeister & Leary (1995) and the theory of relational motivation proposed by Ryan & Deci (2017), which is an extension and expansion of the relevant theories of Freud and Maslow. A growing body of evidence suggests that adolescents' opposite–gender peer relationships are important to their motivation in the school environment (Kilday & Ryan, 2019).

2.4 Gender differences in opposite-gender peer relations and learning motivation

Many theoretical and empirical studies have demonstrated gender differences in opposite-gender peer relationships. Sex role theory suggests that girls place more importance on social relationships, such as their relationships with opposite-gender peers (Yockey, 1978; Ogg et al., 2024). Compared to boys, girls are more focused on intimacy in their interactions with peers (Potter & Yoon, 2023) and are more susceptible to the negative effects of social adjustment (Gaughan, 2006). In addition to this, this gender difference may also be due to the fact that males and females experience different types of influences from their opposite-gender peers, respectively. For example, it has been found that male adolescents receive more support from opposite-gender peers, while female adolescents receive more support from same-gender peers (Reeder, 2003; Poulin & Pedersen, 2007). Thus, female adolescents are more susceptible to negative influences from opposite-gender peer relationships. And this is supported by relevant empirical research, which suggests that male peers increase female adolescents' risk for substance use, such as smoking (Goodwin et al., 2011), drinking alcohol (Mehta et al., 2013), and smoking marijuana (Poulin et al., 2011). Additionally, a follow-up study examining the influence of opposite-gender peers in early adolescence found that having a best friend who was of the opposite gender predicted adolescents' antisocial behavior in the following year or three, and this predictive power was more pronounced in female adolescents (Arndorfer & Stormshak, 2008). While there are indeed significant gender differences in the affective aspects of opposite-gender peer relationships, it is unclear whether there are gender differences in the association between opposite-gender peer relationships and student motivation. It is important to note that the aforementioned studies on the presence of negative influences of opposite-gender peers have typically investigated North American adolescents (e.g., Mehta et al., 2013; Poulin et al., 2011), whereas Europe, which is also part of the West, still has many differences from North America in this aspect of culture. Therefore, further validation is needed to determine whether there is cross-cultural consistency in the negative effects of the presence of opposite-gender peer relationships.

2.5 The present study

Although previous studies have investigated the cross-sectional relationship between peer relationships and motivation using literature analysis and questionnaires (e.g., Raufelder et al., 2017; Tu & Chu, 2020), they have not considered the longitudinal link between the two, which is necessary to reveal causality and may introduce confounding sources of variation (Mulder & Hamaker, 2020). Furthermore, no researchers have considered the role of opposite-gender peer relationships separately. Therefore, by using the RI-CLPM model, the present study examines the unique relationship between the quality of opposite-gender peer relationships and student motivation, focusing on adolescents during puberty. The specific model diagram is shown in Fig. 1. This study utilizes a large sample of adolescents (N = 2380), with four measurements points spaced six months apart. The aims to better understand the factors influencing student motivation and provide a theoretical and practical foundation for teachers in managing opposite-gender peer relationships, cultivate a positive opposite-gender peer ecology, and enhancing adaptive motivation in students. However, to the best of our knowledge, no previous study has used the RI-CLPM to examine the relationship between the quality of opposite-gender peer relationships and student motivation.

3 Methods

3.1 Sample and procedure

The present study was conducted in March 2024 (T1), September 2024 (T2), March 2025 (T3), June 2025 (T4) to investigate data on opposite-gender peer relationships and academic motivation based on four time points among junior high school students in public schools in Jinan, Shandong Province, China. At each time point, the research team leader led the research team to the school to distribute the questionnaires to the teachers in the school. Teachers used the questionnaires as an accompanying test, and when all students had completed the responses, the teachers returned the completed questionnaires to the research team. The school teachers first explained the research content and purpose of the survey, informing the students that participation in the study was voluntary and that the students' responses would be kept strictly confidential and used only for scientific research. The students were also informed about informed consent. At the same time, the research team obtained informed consent from the students' guardians.

In the T1 time point data collection, 2560 students agreed to complete the survey with a 95% return rate of questionnaire completion. A further 58 invalid questionnaires (with a large number of missing values in the questionnaire) were excluded through questionnaire screening. On this basis, the same cohort of children was surveyed at three subsequent time points, six months apart. The present study used Full Information Maximum Likelihood estimation (FIML) to deal with non-normality and for missing data at three time points, all adolescents who had participated in at least one measurement in its entirety were included in the present study, allowing participants with missing values to be retained (Graham, 2008). Finally, we included 2380 students, or 92.9%, in this study. Of the final data, 1143 (48%) were male and 1237 (52%) were female. The study was approved by the ethics committee of the first author's institution. The specific demographic information is shown in Table 1.

3.2 Measurements

3.2.1 Opposite-gender peer relationships

The Network of Relationships Inventory (NRI) developed by Furman & Buhrmester (1985) was used in this study to measure adolescents' opposite-gender peer relationships. The questionnaire asks participants to write the name of a 'most important friend' of the opposite gender and then answer 15 questions based on how they get along with that peer. The questionnaire was divided into five dimensions: companionship (e.g., 'How much time do you spend with this peer in your free time?'), emotional support (e.g., 'How strong are the peer's feelings for you?'), intimacy (e.g., 'Do you share your secrets and personal feelings with this peer?'), instrumental help (e.g., 'Does this peer help you with or do things for you'), and arguments and conflicts (e.g., 'How often do you and this peer fight, argue, or get angry with each other'). Each dimension consists of 3 items. The scale was scored on a 5-point scale from 1 to 5, with the mean scores of the first 4 dimensions as the support dimension (companionship, emotional support, intimacy, and instrumental help), and the mean scores of the questions in the last dimension (quarrels and conflicts) as the conflict dimension. After the reverse scoring, the two dimensions of support and conflict were used as an indicator of the quality of the friendship relationship, and the higher the scores were, the better the participant's opposite-gender peer relationships were. The validity of this scale has been well established (e.g., Rokeach & Wiener, 2017). The reliability coefficients (Cronbach's α) for this scale at time (T1), time (T2), time (T3), and time (T4) were 0.91, 0.88, 0.90, and 0.91, respectively.

3.2.2 Learning motivation

The Motivation Scale from the Learning Motivation Strategies Inventory developed by Pintrich & De Groot (1990) was used to measure adolescents' motivation to learn. The Motivation Scale consists of three subscales: self-efficacy (9 items), intrinsic value (9 items), and test anxiety (4 items), with a total of 22 items rated on a 7-point scale, where 1 = not at all true of me to 7 = very true of me. This questionnaire is suitable for measuring the motivation of students who are in the adolescent stage of their lives, and has been widely validated in many (For example, Duncan & McKeachie, 2005; Kim & Jang, 2015; Tabatabaei et al. 2017). The reliability coefficients (Cronbach's α) of this scale were 0.81, 0.82, 0.84, and 0.84 at time (T1), time (T2), time (T3), and time (T4), respectively.

3.3 Data analysis

Firstly, CFA was used to test the measurement models of opposite-gender peer relationships and learning motivation involved in this study in order to verify that the data were a good fit. Since χ^2 values are likely to be significant in large sample data, CFA models are only acceptable when χ^2 values are not significant (Byrne, 2011). Therefore, we used CFI, RMSEA, and SRMR as model fit goodness-of-fit indicators for the measurement model. The details are shown in Table 5.

Subsequently, in order to analyse the longitudinal interactions between variables, this study used the RI-CLPM, eschewing the use of the traditional CLPM model, which has been challenged by many researchers as conflating interpersonal variability and failing to delineate sources of variation, rendering the findings

inaccurate (Usami, 2020). In contrast, the RI-CLPM used in this study is a further revision of the traditional model that predicts longitudinal outcomes of the study variables by introducing the latent variable of the random intercept of the RI-CLPM. Specifically, in the present study there were two random intercept latent variables (one for opposite-gender peer relationships and the other for academic motivation), and by analyzing the residuals of these variables, it was investigated whether changes in one variable within an individual were correlated with changes in the other (which included autoregressive and cross-lagged effects). The stability of within-individual effects and between-individuals between variables can be better separated to express a more rigorous causal link between variables (Hamaker et al., 2015; Mulder & Hamaker, 2020), to the effect of enhancing inferences about bidirectional causal relationships between analyzed variables. Therefore, this study used the RI-CLPM model as the analytical method.

For model fit index selection, comparative fit indices (CFI, TLI ≥ 0.95) and root mean square (RMSEA ≤ 0.06) were used as model fit indices in this study (Hu & Bentler, 1999; Iacobucci, 2009). All analyses in this study were performed in Mplus 8.0.

4 Results

The correlation statistics between the variables are shown in Table 2. First, the present study conducted RI-CLPM model fitting, which showed that the RI-CLPM model estimating adolescents' opposite-gender peer relationships and motivation was well-fitted with $\chi^2_{(9)} = 149$, CFI = 0.99, TLI = 0.99, SRMR = 0.01, and RMSEA = 0.01. The standardized path coefficients for the random intercept cross-lagged panel model are shown in Figure 2 and Table 3.

Second, in order to explore the role of gender differences in the moderating role between adolescents' opposite-gender peer relationships and motivational interrelationships, this study conducted a multi-group analysis in the RI-CLPM model. We performed multiple group analyses of the unconstrained model by gender. The configural model fitted the data well with CFI = 0.99, SRMR = 0.01, RMSEA = 0.00 (Boys: CFI = 0.99, SRMR = 0.03, RMSEA = 0.00. Girls: CFI = 1.00, SRMR = 0.02, RMSEA = 0.00). The standardized path coefficients for males and females are given in Figure 3 and Table 4. Specifically, there was a significant correlation between opposite-gender peer relationships and motivation at the between-person level for boys ($r = 0.34$, $p < 0.001$) and girls ($r = 0.35$, $p < 0.001$). This suggests that adolescents with good opposite-gender peer relationships at the four time points from T1 to T4 will have higher levels of motivation. And after controlling for between-person differences, we found a longitudinal transmission effect of the results, suggesting that opposite-gender peer relationships between boys and girls predicted changes in academic motivation across time, and that academic motivation also predicted changes in opposite-gender peer relationships across time. However, the cross-lagged effect was different between boys and girls, i.e., there were gender differences. Specifically, for boys, this effect is consistent with the estimated effect for the overall sample, i.e., there is a significant longitudinal effect of boys' opposite-gender peer relationships on academic motivation. That is, if when boys have good opposite-gender peer relationships at one point in time (e.g., T1), then at the next point in time (e.g., T2) they are predicted to have higher levels of academic motivation than usual, reflecting consistency across time. For girls, on the other hand, this effect was not

statistically significant. That is, opposite-gender peer relationships for girls did not predict academic motivation across time.

To validate this effect, this study conducted a multi-group analysis to compare the difference between the overall unconstrained model (free estimation model) and the constrained model (model in which the cross-lagged path coefficients are constrained to be the same across gender groups) by means of a chi-square test of variance. The results show that fitting a multi-group RI-CLPM that is not constrained to be gender-grouped reveals χ^2 (18) = 363.46, CFI = 0.98, TLI = 0.97, RMSEA = 0.04, SRMR = 0.03. Next, we constrained the lagged paths to be invariant between groups, obtaining χ^2 (30) = 558.67, CFI = 0.97, TLI = 0.98, RMSEA = 0.05, SRMR = 0.03. The chi-square test of difference between the two nested models was $\Delta\chi^2$ (12) = 195.21, $p < 0.001$, which indicates that the model results were significantly different by gender, suggesting significant gender differences in the cross-regression paths. Specifically, there were significant gender differences in the prediction of T2 academic motivation by T1 opposite-gender peers relationships ($\Delta\chi^2$ = 5.62, $\Delta df = 1$, $p < .05$)) for boys ($\beta = .06$, $p < .05$) and girls ($\beta = .02$, $p > .05$); and in the prediction of T3 academic motivation by T2 opposite-gender peers relationships ($\Delta\chi^2 = 4.06$, $\Delta df = 1$, $p < .05$), boys ($\beta = .06$, $p < .05$), and girls ($\beta = .01$, $p > .05$); significant gender differences in the predictive effect of T3 opposite-gender peer relationships on T4 academic motivation ($\Delta\chi^2 = 6.24$, $\Delta df = 1$, $p < .05$), boys ($\beta = .05$, $p < .05$), and girls (β =.01, $p > .05$), and non-significant gender differences in other paths with ps > .05, consistent with the findings.

5 Discussion

As mentioned earlier, understanding the link between adolescent peer relationships and motivation is crucial for both students and teachers, which has prompted extensive research in this area (Raufelder et al., 2017; Tu & Chu, 2020; Hu & Li, 2022). Especially over the last two decades, research in this area has expanded significantly. However, prior studies have conflated between-person and within-person levels of peer relationships and student motivation, potentially overestimating the strength of their link (e.g., Umemoto & Inagaki, 2022; Li et al., 2023), while failing to account for consistency across time. Therefore, the present study examines the relationship between adolescents' opposite-gender peer relationships and motivation using nearly two years of longitudinal data, employing the RI-CLPM model to separate between-person influences and elucidate within-person interactions. This approach not only clarifies the longitudinal relationship between adolescent peer relationships and motivation but also provides insights into how educators can create an optimal social and developmental environment for student learning. By understanding how peer relationships contribute to student motivation and academic development, educators can enhance their practices.

The results of the present study suggest, on the one hand, that after isolating between-person influences, adolescents' opposite-gender peer relationships are associated with longitudinal, unidirectional cross-lagged effects on academic motivation at the within-person level. Specifically, adolescents' opposite-gender peer relationships at one measurement time point (e.g., T1) predicted academic motivation levels at the next measurement time point (e.g., T2, T3). That is, students with positive opposite-gender peer

relationships at one time point in time exhibited higher levels of academic motivation six months later, demonstrating cross-temporal consistency. These findings provide support for the notion that peer relationships promote academic motivation, offering longitudinal evidence of the cause-and-effect link and complementing previous research (Raufelder et al. 2017; Tu & Chu, 2020) On the other hand, within-person results suggest that adolescents' academic motivation does not predict changes in their opposite-gender peer relationships. This aligns with previous research indicating that social support remains consistent over time (Wentzel et al., 2010; Ng & Ahmad, 2018). According to Self-determination theory, fulfilling an individual's basic psychological needs for autonomy, competence, and belonging enhances intrinsic motivation. In the case of students who possess a lack of intrinsic motivation to learn, they can gain a sense of autonomy by experiencing both a sense of psychological freedom to engage in activities based on their own will and choices, a sense of control over their environment and the development of their abilities, and a sense of competence and belonging by connecting with others and experiencing the feeling of loving and caring for others and being loved and cared for, which will fulfill the need for competence and belonging, and ultimately enhance one's own intrinsic motivation levels and obtaining higher levels of motivation to learn (Ryan & Deci, 2017). And it is possible that both same-gender and opposite-gender peer relationships, and possibly both, are involved in this process. Therefore, changes in adolescents' academic motivation do not necessarily predict their opposite-gender peer relationships, and other factors need to be taken into account (Ryan & Deci, 2000).

In contrast, the present study focused on how opposite-gender peer relationships exhibit different gender patterns in their impact on academic motivation, revealing notable differences between boys and girls. Specifically, the present study found that, on the one hand, at the within-person level, although students of different genders did not show a significant correlation in the effect of academic motivation on opposite-gender peer relationships, the cross-lagged effect of adolescents' opposite-gender peer relationships on students' motivation was more pronounced among boys than among girls. On the other hand, at the between-person level, opposite-gender peer relationships were significantly and positively correlated with academic motivation in both boys and girls. That is, although for adolescents, students (both boys and girls) who have good opposite-gender peer relationships show higher levels of academic motivation in the school community. However, for females, within-individual changes in opposite-gender peer relationships did not significantly predict changes in academic motivation, showing a lack of temporal consistency. Such a conclusion can be explained from the following perspective: The social support theory points that intimate relationships between people are the essence of social support, which is a general term for the emotions felt or the help actually received by an individual in social life, and can help the individual to regulate and adapt, to generate optimism in life and to alleviate his or her psychological problems, such as anxiety and depression, thereby relieving stress and enhancing motivation toward life (Yang, 2021; Menescardi & Estevan, 2021). Whereas, in the school social environment, for students, peers are the main source of social support (Rautanen et al., 2022), influencing the formation and development of motivation to learn. However, adolescents of different genders receive social support from different sources, showing significant gender differences. Specifically, boys receive more support from opposite-gender peers and are closer to their opposite-gender peers. Girls, on the other hand, receive more support from and are closer to same-gender peers (Reeder, 2003; Poulin & Pedersen, 2007). This may have led to the fact that boys would be more

significantly influenced in terms of opposite-gender peer relationships and more likely to promote higher levels of academic motivation.

This is despite the fact that adults, especially parents of students, are often overly concerned about students' peer relationships, especially students' peer relationships with the opposite-gender peers, believing that their interactions will be too close and hinder students' learning process and school engagement (Weymouth et al., 2019). However, this study reveals that opposite-gender peers can enhance students' motivation to learn through social support and socialization. Also, for promoting adolescents' motivation to learn in the school social environment there should be different interventions based on gender. Specifically, for male adolescents, educators should provide appropriate guidance and positive interventions for boys' opposite-gender peer relationships. Within a moderate range, students should be guided to create a positive opposite-gender peer interaction environment to help them obtain good social support and socialization beliefs, and to enhance learning motivation; for female adolescents, since a change in a single factor does not lead to a change in the other factor, the intervention for girls' learning motivation should be based on the two aspects of peer relationships and learning motivation (Endedijk et al., 2021). Teachers should utilize the "invisible hand" to guide students' opposite-gender peer relationships and cultivate a positive peer ecology, which promotes cooperation and a positive learning atmosphere between students and their peers, and facilitates the development of motivation in a positive direction (Endedijk et al., 2021; Kilday & Ryan, 2022). At the same time, significant autoregressive paths suggest that both good opposite-gender peer relationships and positive academic motivation predict the development of students' opposite-gender peer relationships and academic motivation long into the future, i.e., increased academic motivation predicts increased future academic motivation, as does opposite-gender peer relationships. This effect has very long-term implications and deserves the attention of researchers and educators.

It is worth noting that the present study has some limitations. First, the evaluation of opposite-gender peer relationships and academic motivation used in this study was based solely on adolescents' self-reports, and the findings may be subjective and self-biased, lacking objective evaluations from third parties such as others (e.g., parents and teachers), which may lead to bias between the questionnaire results and the actual situation. This reveals that the researcher can use more objective evaluation indicators in the future, such as considering both students' self-reported situations and incorporating third-party reports from significant others (e.g., peers) when evaluating students' peer relationships, and consider them in a comprehensive manner to further fit the real situation of students in the school environment, thus enhancing the reliability of the study. Second, further validation is needed to determine whether the gender differences exhibited in the results of this study are cross-culturally consistent. Particularly in the current research context of collectivist culture, female adolescents tend to face greater social evaluative pressures and different socially expected roles than males (Senzaki et al., 2022), factors that may lead to discrepancies in findings across cultural contexts. Therefore, more research is needed to understand the developmental process of adolescents' opposite-gender peer relationships and academic motivation, and to explore the heterogeneity across different sociocultural contexts. Finally, the participants in this study were mainly concentrated in mid-adolescence and the time interval was 6 months, which may be too short a lag time to detect the long-term dynamic process of the interaction of opposite-gender peer relationships on academic motivation throughout adolescence.

Declarations

Ethics Approval

This study received review and approval from the Research Ethics Committee of Shandong Normal University (Approval No.: 202486) on February 1, 2024. All procedures involving human subjects were conducted in compliance with relevant guidelines and regulations, including the Declaration of Helsinki. The scope of approval encompasses all questionnaire surveys conducted within the study.

Informed consent

All participants in the survey signed written informed consent forms. These forms were collected during the survey period, which ran from March 2024 to June 2025. Prior to the formal distribution of the questionnaire, each participant was presented with an informed consent statement. Participants were informed that participation in this study was voluntary, that their responses would be kept strictly confidential, and that the data would be used solely for scientific research purposes. Participants retained the right to withdraw at any time during the completion process without facing any consequences. The research team committed to maintaining the anonymity of all responses, securely storing coded data, and publishing only aggregated results. This study did not involve vulnerable populations, and all collected data underwent complete anonymization.

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Compliance with Ethical Standards

Ethical Approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committees and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflict of Interests: No conflict of interest exits in the submission of this manuscript, and manuscript is approved by all authors for publication.

Informed Consent: Informed consent was obtained from all individual participants included in the study.

Authors contribution

Chunze Xu: Conceptualization, Formal analysis, Methodology, Writing – original draft. Gengfeng Niu: Conceptualization, Data curation, Formal analysis, Methodology. Xiaojun Sun: Funding acquisition, Supervision, Validation, Writing – review and editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability statement

Data will be made available on request.

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Tables

Table 1 Basic demographic information about the participants

Variable	Level	Percentage (%)
Gender		
	Male	48.02
	Female	51.93
Grade		
	1	30.68
	2	55.70
	3	13.62
Mother’s education		
	Undergraduate	42.3
	College and below	55.6
	Master’s Degree and above	2.1
Father’s education		
	Undergraduate	74.83
	College and below	23.61
	Master’s Degree and above	1.56
Ranking of grades in the class		
	1-25%	6.76
	26-50%	21.53
	51-75%	64.75
	76-100%	6.96
Location		
	City	59.06
	Suburb	28.87
	Rural	12.07

Table 2 Correlations between the variables entered into the RI-CLPM of all participants.

	WOP T1	WOP T2	WOP T3	WOP T4	WSM T1	WSM T2	WSM T3	WSM T4
WOP T1	-							
WOP T2	0.582*	-						
WOP T3	0.501*	0.560*	-					
WOP T4	0.473*	0.533*	0.592*	-				
WSM T1	0.254*	0.190*	0.153*	0.181*	-			
WSM T2	0.211*	0.245*	0.171*	0.202*	0.620*	-		
WSM T3	0.224*	0.241*	0.213*	0.210*	0.551*	0.630*	-	
WSM T4	0.203*	0.232*	0.190*	0.242*	0.503*	0.591*	0.612*	-

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Within Opposite-gender Peer Relationships (WOP) and Within Student Motivation (WSM)

Table 3 Standardized Parameter Estimates From RI-CLPM.

Parameter	*Estimate*	*SE.*	*p*
Autoregressive parameters			
WOP T1→WOP T2	.19	.02	< .001
WOP T2→WOP T3	.17	.01	< .001
WOP T3→WOP T4	.19	.02	< .001
WSM T1→WSM T2	.17	.01	< .001
WSM T2→WSM T3	.15	.02	< .001
WSM T3→WSM T4	.16	.02	< .001
Cross-lagged parameters			
WOP T1→WSM T2	.03	.01	< .05
WOP T2→WSM T3	.03	.02	< .05
WOP T3→WSM T4	.03	.02	< .05
WSM T1→WOP T2	-.01	.02	.07
WSM T2→WOP T3	-.01	.01	.06
WSM T3→WOP T4	-.01	.02	.06

Note: Within Opposite-gender Peer Relationships (WOP) and Within Student Motivation (WSM).

Table 4 Standardized Parameter Estimates from Multiple Group RI-CLPMs.

Parameter	*Boy*			*Gril*		
	Estimate	*SE.*	*p*	*Estimate*	*SE.*	*p*
Autoregressive parameters						
WOP T1→WOP T2	.17	.02	< .001	.19	.02	< .001
WOP T2→WOP T3	.17	.03	< .001	.20	.01	< .001
WOP T3→WOP T4	.18	.03	< .001	.18	.02	< .001
WSM T1→WSM T2	.10	.03	< .001	.21	.01	< .001
WSM T2→WSM T3	.09	.03	< .001	.19	.03	< .001
WSM T3→WSM T4	.09	.02	< .001	.20	.02	< .001
Cross-lagged parameters						
WOP T1→WSM T2	.06	.02	< .05	.02	.02	.50
WOP T2→WSM T3	.06	.03	< .05	.01	.01	.48
WOP T3→WSM T4	.05	.02	< .05	.01	.02	.45
WSM T1→WOP T2	.01	.02	.25	-.03	.02	.06
WSM T2→WOP T3	.02	.02	.31	-.04	.01	.06
WSM T3→WOP T4	.01	.02	.29	-.03	.02	.06

Note: Within Opposite-gender Peer Relationships (WOP) and Within Student Motivation (WSM).

Table 5 Results of the CFA measurements of the two scales at four time points.

Measurements	*α*	*CFI*	*TLI*	*RMSEA*	*p*
T1					
1.1 Opposite-gender peer relationships	.91	.98	.93	.04	< .001
1.2 Learning motivation	.81	.95	.92	.03	< .001
1.2.1 Self-efficacy	.86	.92	.90	.04	< .001
1.2.2 Intrinsic value	.84	.93	.91	.05	< .001
1.2.3 Test anxiety	.85	.90	.92	.05	< .001
T2					
2.1 Opposite-gender peer relationships	.88	.99	.95	.03	< .001
2.2 Learning motivation	.82	.97	.89	.03	< .001
2.2.1 Self-efficacy	.86	.95	.90	.04	< .001
2.2.2 Intrinsic value	.88	.92	.89	.04	< .001
2.2.3 Test anxiety	.83	.94	.91	.03	< .001
T3					
3.1 Opposite-gender peer relationships	.90	.93	.92	.05	< .001
3.2 Learning motivation	.84	.94	.91	.05	< .001
3.2.1 Self-efficacy	.89	.89	.90	.04	< .001
3.2.2 Intrinsic value	.81	.95	.92	.03	< .001
3.2.3 Test anxiety	.85	.93	.88	.03	< .001
T4					
4.1 Opposite-gender peer relationships	.91	.93	.92	.04	< .001
4.2 Learning motivation	.84	.93	.90	.03	< .001
4.2.1 Self-efficacy	.81	.90	.91	.03	< .001
4.2.2 Intrinsic value	.87	.92	.92	.05	< .001
4.2.3 Test anxiety	.88	.90	.91	.03	< .001

Figures

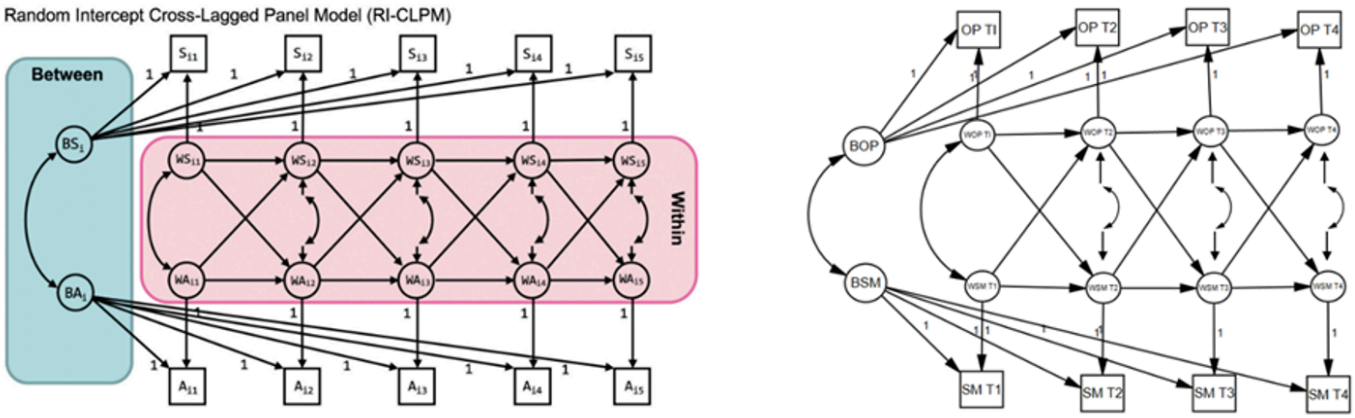


Figure 1

Random Intercept Cross-Lagged Panel Model (RI-CLPM) (left figure), Random Intercept Cross-Lagged Panel Model (RI-CLPM) for Opposite-sex Peer Relationships (OP) and Student Motivation (SM) (right figure).

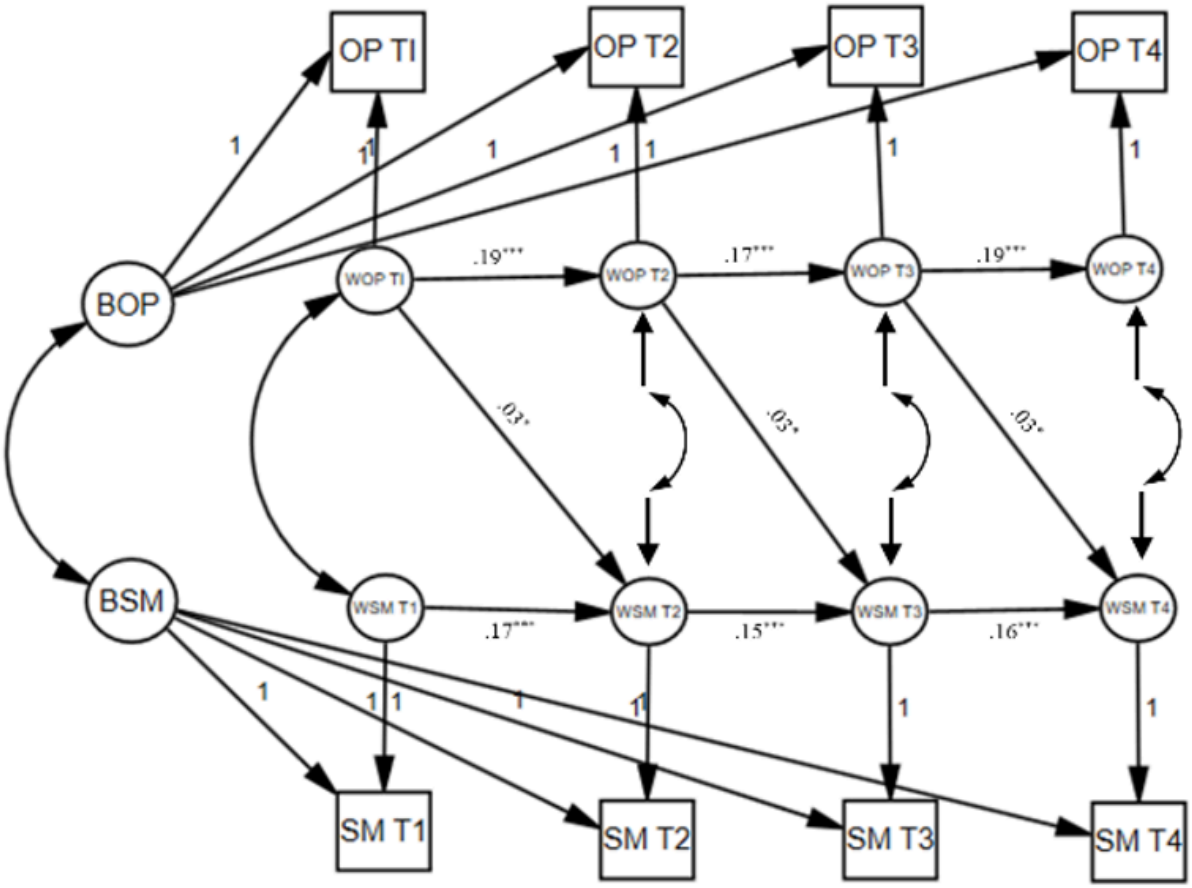


Figure 2

Results from Random Intercept Cross-Lagged Panel Models.

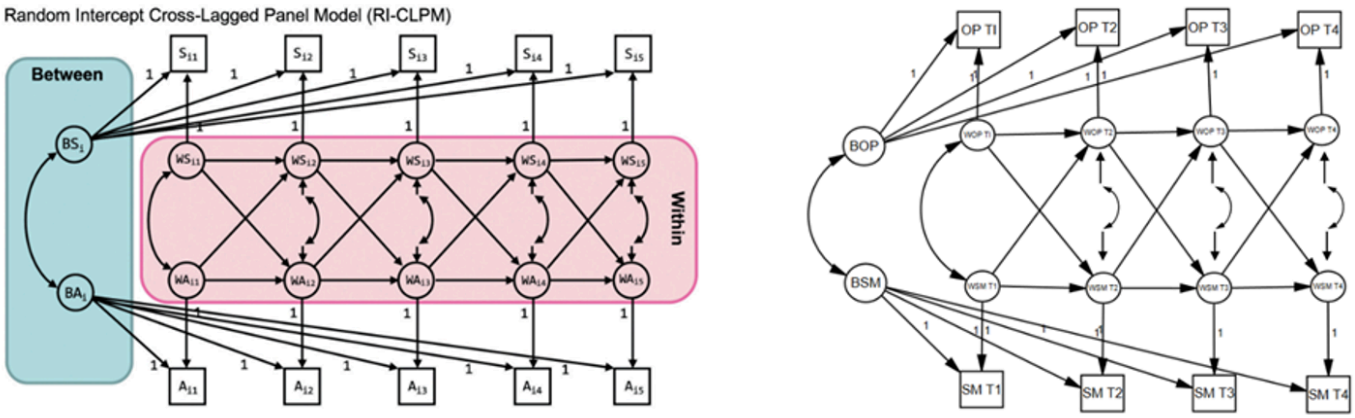


Figure 3

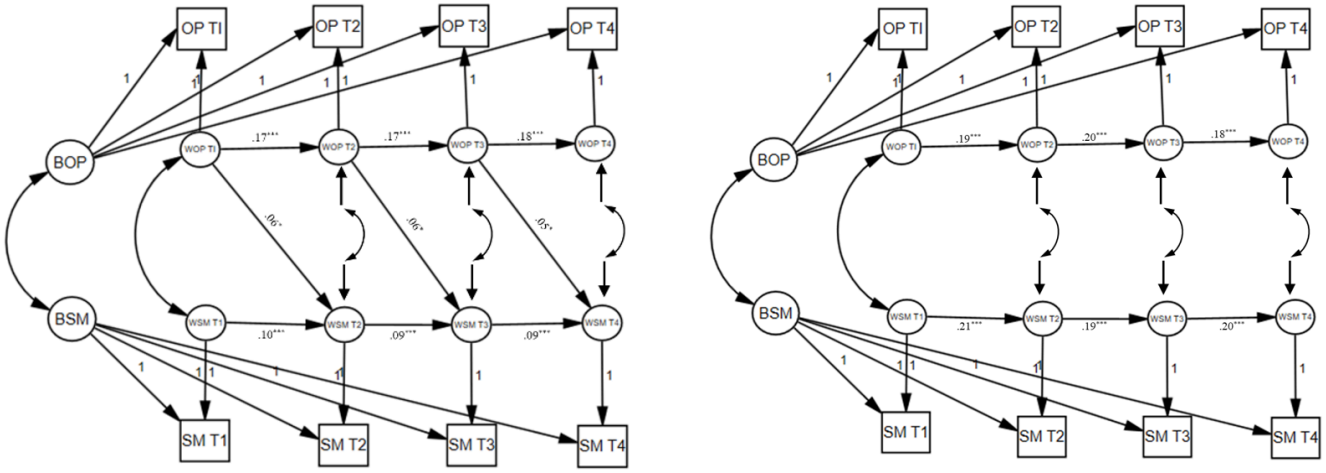


Figure 3

Multigroup Random Intercept Cross-Lagged Panel Model for Boys(left figure) and Girls(right figure).