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Research Article

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Posted Date: November 12th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10900054/v1

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Additional Declarations: No competing interests reported.

The Longitudinal Relationship Between Peer Rejection and Problematic Social Media Use Among Chinese University Students: Directional Asymmetry and Developmental Trends

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Abstract

Background: A substantial body of cross-sectional research has examined the association between peer rejection and problematic social media use (PSMU). However, the direction of cross-temporal prediction between these variables and the association between their short-term linear trends remain unclear.

Methods: This six-month longitudinal study surveyed 583 Chinese university students. Cross-lagged panel models and latent growth models were used to examine the cross-temporal predictive relationship between peer rejection and PSMU and the association between their short-term linear trends.

Results: PSMU significantly and positively predicted subsequent peer rejection across both time intervals, whereas peer rejection significantly and positively predicted

subsequent PSMU only from T2 to T3, indicating directional asymmetry and stage specificity. Across the six-month follow-up period, peer rejection showed a small increase, whereas PSMU showed a small decline. The initial levels of peer rejection and PSMU were positively associated, and a positive association was estimated between their rates of change, although the variance of the PSMU slope was not statistically significant.

Conclusions: The findings indicate a directionally asymmetric and stage-specific longitudinal association rather than a stable, symmetrical bidirectional relationship. PSMU predicted subsequent peer rejection in both intervals, whereas peer rejection predicted subsequent PSMU only from T2 to T3.

Keywords: peer rejection; problematic social media use; university students; latent growth model; cross-lagged panel model; longitudinal study

Background

With the rapid development of intelligent technologies and the widespread adoption of the mobile Internet, social media has become an important platform through which adolescents obtain information, establish social connections, and engage in interpersonal communication. It has gradually replaced some traditional forms of face-to-face communication and become one of the principal media for adolescents' everyday social interactions [1]. Social media platforms are continually updated and now offer increasingly diverse forms of interaction that can satisfy adolescents' psychological needs for belonging, self-expression, and social support. At the same

time, however, excessive and uncontrolled use has produced a growing range of maladaptive consequences [1,2]. A substantial body of research indicates that problematic social media use (PSMU) is not only closely associated with mental health problems such as anxiety and depression [3,4], but may also reduce subjective well-being and life satisfaction and increase the risks of sleep disturbance, emotional dysregulation, and impaired social functioning [4]. In addition, PSMU has been associated with lower academic engagement, poorer academic performance, and less offline social interaction [5,6], as well as with a higher likelihood of other risk behaviors, including self-harm and suicide [7]. PSMU has therefore become an important public health concern relevant to healthy adolescent development [5,6].

Problematic social media use (PSMU) is an emerging concept derived from the broader notion of social media addiction [8]. It refers to a maladaptive behavioral pattern in which excessive and poorly controlled use of social media results in impairments in psychological, behavioral, and social functioning [9]. Given that PSMU is associated with a range of maladaptive outcomes among university students [9,10], researchers have begun to examine its correlates and potential risk factors. Existing research has linked PSMU to individual, family, and social-environmental factors, among which peer rejection has been regarded as a potentially important interpersonal risk factor among university students [11,12]. When university students experience peer rejection, their offline social connectedness may be weakened, and they may use social media to regulate emotions and compensate for unmet socioemotional needs; this pattern may be associated with a higher risk of PSMU [13,14].

Peer rejection refers to a negative social experience in which individuals are persistently rejected, ignored, or excluded during interactions with peers [15,16], and it is an important interpersonal risk factor in adolescents' social adjustment [17]. Although a body of research has accumulated on the association between peer rejection and PSMU, further investigation is still needed. First, longitudinal research remains relatively scarce. Existing studies have focused primarily on whether peer rejection predicts subsequent PSMU and have paid less attention to whether PSMU prospectively predicts subsequent difficulties in offline peer relationships. Consequently, there is still insufficient evidence regarding their temporal ordering. Second, previous research has shown that both peer rejection and PSMU have developmental features and that their levels may change over time, suggesting that their longitudinal association may vary across developmental stages.

The present study sought to address these research gaps by collecting three waves of longitudinal data from Chinese university students. First, a cross-lagged panel model was used to examine the temporal ordering of peer rejection and PSMU. On this basis, latent growth models were used to investigate the short-term linear trends of the two variables and the association between their rates of change.

Direction of the relationship between peer rejection and PSMU

Current research suggests that peer rejection is associated with PSMU [8], but the direction of this relationship remains disputed. Three main perspectives have emerged.

The first perspective proposes that peer rejection positively predicts PSMU [11,18]. According to the compensatory Internet use model, when individuals encounter peer

rejection in offline social interactions, their needs for belonging and social connection remain unmet, making them more likely to turn to social media for emotional support, social recognition, and interpersonal compensation, thereby increasing their risk of PSMU [19,10]. Peer rejection is a negative social experience in which individuals are persistently rejected, ignored, or excluded during interpersonal interactions, threatening their needs for belonging and a meaningful existence [20,21]. When needs for belonging cannot be met in offline interpersonal interactions, individuals often turn to online communication in search of alternative social connections. By overcoming temporal and spatial constraints, social media makes it easier for individuals to expand their social networks and maintain interpersonal contact and to experience companionship, social support, and belonging [22]. It therefore becomes an important means of emotional compensation for individuals who experience peer rejection [23]. Research has found that greater peer rejection is associated with more frequent social media use. Peer rejection may also indirectly intensify excessive reliance on social media by increasing social anxiety and depressive affect [24]. Peer rejection is therefore regarded as a predictor of PSMU.

The second perspective proposes that PSMU prospectively predicts subsequent peer rejection among university students [25]. According to the I-PACE model, individuals with PSMU often have difficulty effectively controlling their urges to use social media and invest substantial time, attention, and emotional resources in online social activities. This investment may compete with resources needed for face-to-face interaction and the maintenance of offline relationships and may therefore coincide

with less frequent or lower-quality participation in offline peer interactions [26,27]. When individuals remain absent from offline social settings, their peers' sense of identification and closeness may gradually decline, potentially developing into peer indifference or even active rejection [25]. At the same time, the pervasive demand to remain constantly online and the pressure of social comparison on social media may be associated with greater interpersonal sensitivity and excessive attention to others' evaluations and social feedback [28]. In offline interactions, they may consequently be more likely to display inappropriate behaviors such as avoidance, indifference, or conflict, increasing the likelihood of being ignored or rejected [29]. Research indicates that higher levels of PSMU are associated with stronger peer rejection.

The third perspective proposes that peer rejection and PSMU may show a reciprocal prospective association. On the one hand, individuals who experience peer rejection often report impaired offline social connections and chronically unmet belonging needs and may therefore use social media to obtain emotional support and interpersonal connection. During social media use, likes, comments, and immediate interactive feedback may temporarily alleviate negative emotions and social pain associated with rejection, reinforcing social media use and increasing the risk of PSMU [19,11]. On the other hand, prolonged PSMU may be associated with greater investment in online interaction and fewer opportunities for face-to-face social contact. This pattern may coincide with continuing losses in offline social skills, peer support, and social capital [27], thereby increasing the risk of being rejected by peers again [13]. In addition, according to the Social Skills Deficit Hypothesis, individuals who experience persistent

peer rejection generally lack effective interpersonal communication skills and offline social support, making them more likely to rely on online environments to satisfy unmet belonging needs and gradually develop compulsive and compensatory patterns of social media use [30,19]. As PSMU becomes more severe, offline social participation may decrease, opportunities to develop social skills may remain restricted, and interpersonal relationship quality may deteriorate, a pattern consistent with a potentially self-reinforcing association among peer rejection, PSMU, and offline social withdrawal [27,13].

Previous studies have largely relied on cross-sectional data and have generally indicated that peer rejection is positively associated with PSMU. Nevertheless, the temporal ordering of the two remains unclear, and additional longitudinal studies are needed. The present study therefore used a three-wave cross-lagged panel model to examine their cross-temporal predictive relationship and to evaluate whether the predictive pattern was symmetric across directions and intervals.

Developmental patterns of peer rejection and PSMU

Emerging adulthood theory suggests that university students are in an important developmental transition from late adolescence to early adulthood. This stage generally spans the ages of 18 to 29 years and is characterized by concentrated identity exploration, the restructuring of interpersonal relationships, and lifestyle transitions, as well as considerable instability and developmental plasticity [31]. As individuals gradually leave their previous family and secondary-school peer environments, enter

university, and establish new social networks, their peer relationships and patterns of Internet use continually adjust in response to changing developmental tasks and social contexts. Peer rejection and PSMU are therefore not static individual characteristics but show clear temporal dynamics and developmental features.

Regarding the developmental trend of peer rejection, longitudinal research spanning childhood and adolescence has found that peer victimization generally declines with age, although some individuals follow persistent trajectories of peer rejection [32,33]. More recent trajectory research has further shown that peer rejection does not follow the same pattern of change for all individuals. Some individuals remain at a low level over time, some show persistently high or gradually increasing levels, and others experience a gradual decline in rejection as they grow older and their social environments improve [32,34,33]. For example, using latent class growth analysis, Xiao et al. [34] identified four developmental trajectories of peer rejection among left-behind children in China: stable-low and declining, moderate and declining, high and declining, and persistently increasing. These findings indicate that peer rejection shows both a degree of stability and marked individual heterogeneity.

Regarding the developmental trend of PSMU, findings vary across countries and cultural contexts, but generally indicate that its development is dynamic. A two-year longitudinal study of adolescent students in Estonia used a latent growth model and found that changes in PSMU increased in parallel with changes in depressive symptoms, indicating that PSMU has developmental features during adolescence [35]. Another four-wave longitudinal study of Dutch secondary-school students identified

four distinct developmental trajectories. PSMU increased during early adolescence in the high-risk trajectory group and subsequently declined slightly while remaining at a high level, whereas most adolescents maintained stable low levels of PSMU [36]. Current longitudinal research on PSMU trajectories has focused mainly on children and adolescents, and there remains insufficient empirical evidence concerning developmental patterns among university students, particularly those in emerging adulthood. Longer-term longitudinal studies are therefore needed [13].

In summary, previous research has separately described the developmental characteristics of peer rejection and PSMU and documented a significant association between them. However, existing studies have mainly focused on cross-sectional relationships or examined the developmental patterns of the two variables separately. Insufficient attention has been paid to whether their changes are related. The present study therefore used latent growth models to examine their short-term linear trends and the association between their growth factors.

Objectives of the present study

Previous cross-sectional research has been unable to establish the temporal ordering of peer rejection and PSMU among university students. The limited longitudinal research has generally collected data at only two time points and has not examined in depth the short-term linear trends of the two variables or the association between their changes. Accordingly, the present study focused on two core research questions: (a) What are the cross-temporal predictive patterns between peer rejection and PSMU across three measurement occasions? (b) What short-term linear trends do

peer rejection and PSMU show, and are their initial levels and rates of change related? Cross-lagged panel analysis was used to examine temporal prediction, and latent growth models were used to characterize short-term linear trends and associations between growth factors. The study thus extends evidence on directional asymmetry, stage specificity, and coordinated change while providing a more precise empirical basis for university prevention efforts.

Methods

Participants and procedure

The present study was based on a longitudinal survey of social media use among university students. Using cluster sampling, a total of 692 students were recruited from four universities in China. All participants completed questionnaires in September 2025 (T1), December 2025 (T2), and March 2026 (T3).

At the second wave of data collection, some students were lost to follow-up because they had not provided their student identification numbers or had withdrawn from university, transferred to another institution, or for other reasons. The attrition rate was 8.67%, and 632 valid questionnaires were obtained. Independent-samples t tests compared the baseline data of participants who dropped out before the second wave with those who remained. The two groups did not differ significantly in peer rejection or PSMU ($t = 0.384$, $p > 0.05$; $t = -0.827$, $p = 0.408$). Similarly, 583 valid questionnaires were obtained at the third wave, representing an attrition rate of 7.75% from the second to the third wave. The t-test results again showed no significant differences between the

two groups in peer rejection or PSMU ($t = 0.517$, $p > 0.05$; $t = -1.214$, $p > 0.05$). These results indicated that there was no systematic attrition in the present study. The final sample comprised 583 participants who completed all three waves. Their mean age was 18.91 ± 0.81 years; 16.1% were male and 83.9% were female. Median monthly household income was USD 887. Regarding parental education, 87.5% of fathers and 90.9% of mothers had an educational level below higher education, whereas 12.5% of fathers and 9.1% of mothers had received higher education.

The study followed the principles of the Research Ethics Committee of Henan University of Engineering and was approved by the principals of the participating institutions. Before the study began, participants were informed of its purpose, the voluntary nature of participation, and the procedures for withdrawal, and written informed consent was obtained from all participants. After completing each questionnaire, participants received an appropriate small gift as a token of appreciation.

Measures

Data were collected using self-report scales. All peer-rejection and PSMU items were rated on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree), and negatively scored items were reverse-coded before analysis. Participants also provided demographic information in all three surveys.

Peer rejection

Peer rejection was assessed using the Social Exclusion Scale developed by Thau et al. [37]. The wording of the items was modified slightly by specifying peers as the agents

of exclusion and making the descriptions as applicable as possible to adolescents. In the pilot administration, the scale had an alpha coefficient of 0.88, indicating high reliability. Cronbach's alpha coefficients across the three waves were 0.90 at T1, 0.93 at T2, and 0.96 at T3, indicating good stability. The scale consists of six items, with higher scores indicating greater perceived peer rejection. An example item is, “I sometimes feel that my peers may ignore me.”

Problematic social media use

PSMU was measured using the Social Media Use Questionnaire (SMUQ) developed by Xanidis and Brignell. The questionnaire contains nine items covering withdrawal reactions and compulsive use. An example item is, “I find it difficult not to use social media.” All items are rated on a five-point scale and summed, with higher total scores indicating more severe PSMU. In the present study, Cronbach's alpha coefficients across the three waves were 0.82, 0.84, and 0.86, respectively[38].

Data analysis

SPSS 26.0 and Mplus 8.3 were used for data analysis. First, descriptive statistics and correlation coefficients were calculated to examine the stability of peer rejection and PSMU and the associations between them at different time points among Chinese university students.

Second, a cross-lagged panel model of peer rejection and PSMU was constructed to examine their cross-temporal predictive relationship. In the cross-lagged analysis,

the fit of the hypothesized model was assessed and three nested models (M1-M3; see Figure 1) were evaluated. Model 1, the baseline model, assumed significant autoregressive relationships for peer rejection and PSMU. Model 2 freely estimated the cross-temporal paths from peer rejection at T1 and T2 on PSMU while fixing the path coefficients from PSMU to peer rejection at zero. Model 3 freely estimated the cross-temporal paths from PSMU at T1 and T2 on peer rejection while fixing the path coefficients from peer rejection to PSMU at zero. Model 4 was the full cross-lagged model containing all paths included in the first three models; comparison with Models 1, 2, and 3 was used to identify the optimal model.

Third, following the approach of Muthen and Muthen [39], parallel-process latent growth modeling was conducted in two steps: (a) separate unconditional latent growth models were fitted to the three-wave peer-rejection and PSMU data to determine whether the two variables showed short-term linear change patterns and whether there were significant individual differences in their initial levels and rates of change; and (b) the two processes were analyzed jointly by constructing a parallel-process latent growth model based on the latent growth models of peer rejection and PSMU to examine the relationship between changes in the two variables.

Mplus was used to fit the models, and all parameters were estimated using full-information maximum likelihood. The model-fit indices and acceptable cutoff values used were chi-square, df, CFI > 0.900, TLI > 0.950, RMSEA < 0.100, and SRMR < 0.08. Because chi-square is relatively sensitive to sample size, it was not used as the sole criterion for evaluating model fit.

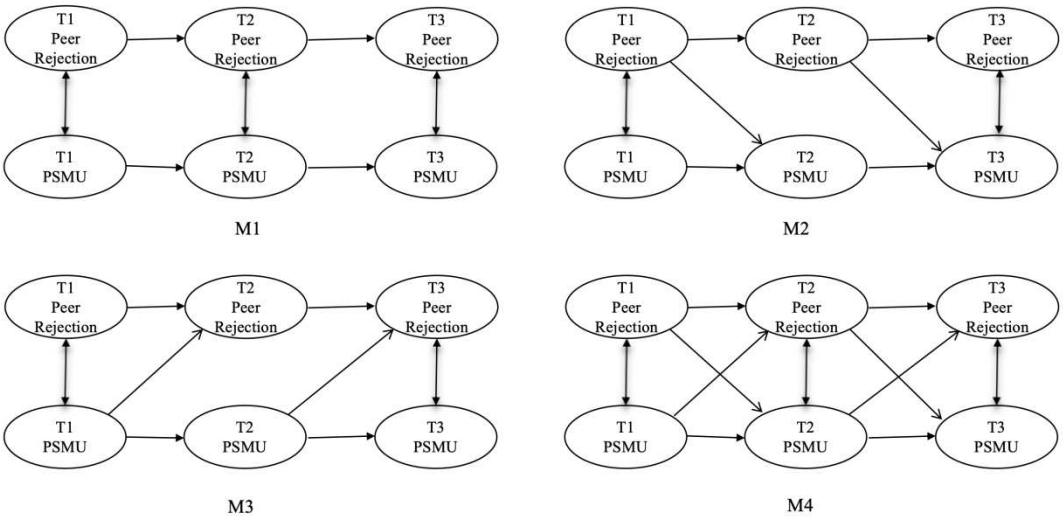


Figure 1. Nested models of peer rejection and PSMU

Note. PSMU = problematic social media use.

Results

Common method bias

Because the data were collected through student self-reports, common method bias may have been introduced. Harman's single-factor test was conducted separately for each of the three waves. At every wave, at least two factors had eigenvalues greater than 1, and the first factor accounted for 36.59%, 38.90%, and 44.56% of the variance, respectively. All values were below the 50% cutoff, indicating that the present study did not have significant common method bias.

Descriptive statistics and correlations

Table 1 presents the means, standard deviations, and correlation matrix for peer rejection and PSMU among university students at the three time points. From T1 to T3, peer rejection and PSMU were significantly positively correlated ($r = 0.21–0.40$, $p <$

0.001). Peer-rejection scores across the three time points ($r = 0.42–0.60$, $p < 0.001$) and PSMU scores across the three time points ($r = 0.53–0.56$, $p < 0.001$) were also significantly positively correlated. These results indicate consistent concurrent associations and temporal stability for peer rejection and PSMU among university students, supporting the use of cross-lagged panel analysis and latent growth modeling.

Table 1. Descriptive statistics and bivariate correlations

Variable	**Mean (SD)**	**1**	**2**	**3**	**4**	**5**	**6**
1. T1 peer rejection	12.88 (4.37)	1.000					
2. T2 peer rejection	13.84 (4.45)	0.45***	1.000				
3. T3 peer rejection	13.46 (4.66)	0.42***	0.60***	1.000			
4.T1 problematic social media use	28.31 (5.86)	0.40***	0.26***	0.28***	1.000		
5.T2 problematic social media use	28.44 (5.48)	0.22***	0.34***	0.29***	0.55***	1.000	
6.T3 problematic social media use	27.77 (5.60)	0.21***	0.27***	0.40***	0.53***	0.56***	1.000

Note. PR = peer rejection; PSMU = problematic social media use; T1, T2, and T3 represent the first, second, and third measurement occasions, respectively. **$p < 0.01$; ***$p < 0.001$.

Cross-lagged panel model

To examine the cross-temporal predictive relationship between peer rejection and PSMU among university students, a cross-lagged analysis was conducted using the three-wave data. Before analyzing the relationships between the variables, the fit indices of the four models were compared (see Table 2).

As shown in Table 2, M4 fitted the data better than M1, M2, and M3. The chi-square differences between M4 and M1 ($\Delta\chi^2 = 20.07$, $\Delta df = 4$, $p < 0.001$), M4 and M2 ($\Delta\chi^2 = 12.59$, $\Delta df = 2$, $p < 0.01$), and M4 and M3 ($\Delta\chi^2 = 6.02$, $\Delta df = 2$, $p < 0.05$) were all significant. These results indicate that M4 was the optimal model among the four competing models.

Table 2. Fit indices for the nested models

Model	χ^2	df	CFI	TLI	SRMR	RMSEA	Model comparison	$\Delta\chi^2$	Δdf	p
M1	81.56	8	0.90	0.83	0.08	0.13	M4 vs. M1	17.46	4	<0.01
M2	72.77	6	0.91	0.79	0.07	0.14	M4 vs. M2	8.67	2	<0.05
M3	72.06	6	0.91	0.80	0.06	0.14	M4 vs. M3	7.96	2	<0.05
M4	64.10	4	0.92	0.82	0.05	0.15	—	—	—	

Note. *p < 0.05; **p < 0.01; ***p < 0.001.

In addition, the final model examining the association between peer rejection and PSMU among university students (Figure 2) demonstrated a marginally acceptable fit to the data (CFI = 0.92, TLI = 0.82, SRMR = 0.05, RMSEA = 0.10). As shown in Figure 2, both peer rejection and PSMU exhibited high stability from T1 to T3, with standardized autoregressive path coefficients of 0.41–0.57 ($p < 0.001$) and 0.53–0.55 (p

< 0.001), respectively. Regarding the cross-lagged predictive paths, peer rejection at T1 did not predict PSMU at T2 (β = -0.01, p > 0.05), whereas PSMU at T1 significantly predicted peer rejection at T2 (β = 0.10, p < 0.05). Peer rejection at T2 significantly predicted PSMU at T3 (β = 0.09, p < 0.05), and PSMU at T2 significantly predicted peer rejection at T3 (β = 0.09, p < 0.05).

In summary, the cross-lagged panel analysis indicated an asymmetric and stage-specific cross-temporal predictive relationship: PSMU predicted subsequent peer rejection across both intervals, whereas peer rejection predicted subsequent PSMU only from T2 to T3. Both variables also showed substantial temporal stability.

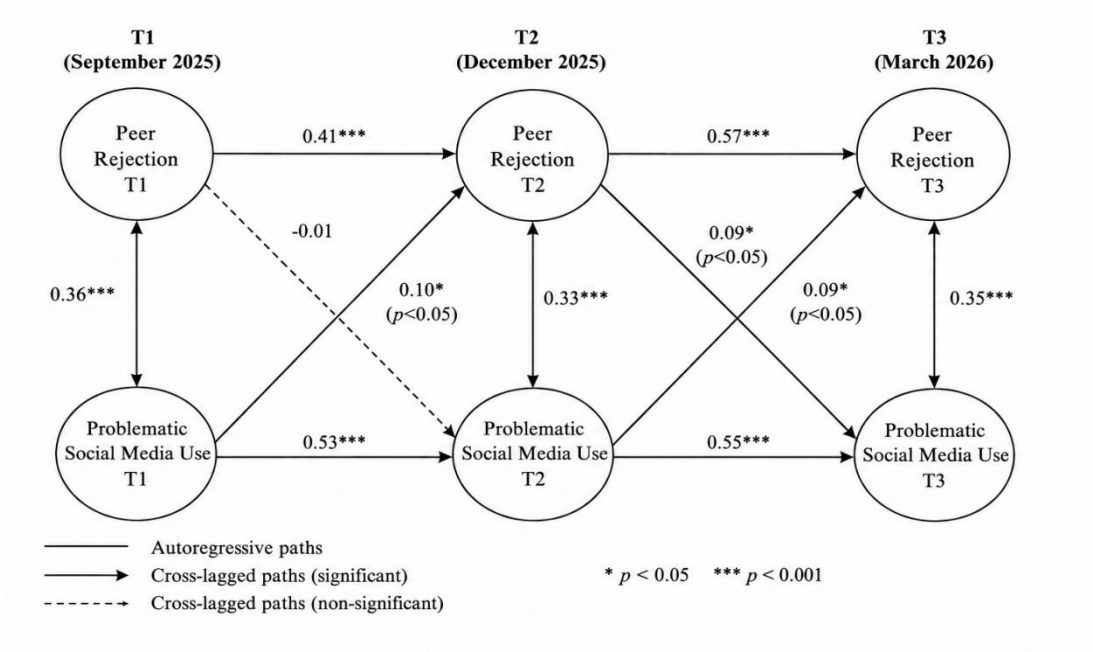


Figure 2. Cross-lagged panel model of peer rejection and problematic social media use

Short-term linear trends of peer rejection and PSMU

Unconditional linear latent growth model of peer rejection

To examine the trend of change in peer rejection among university students, an unconditional linear latent growth model was constructed (see Figure 3a). In the model, the intercept represented the initial value of peer rejection at the first measurement occasion, with all factor loadings fixed at 1, whereas the slope represented the linear rate of change in peer rejection. Because the three measurement intervals were equal, the slope-factor loadings were set at 0, 1, and 2. Thus, the intercept represented participants' initial level of peer rejection when they entered university, and the slope represented the amount of change in peer rejection at each measurement occasion.

The results indicated that the unconditional linear model showed broadly acceptable fit (CFI = 0.96, TLI = 0.86, RMSEA = 0.08, SRMR = 0.05). In the unconditional linear latent growth model of peer rejection, the intercept was 13.14 (SE = 0.17, $p < 0.001$), representing the initial level of peer rejection, and was significantly greater than zero. The slope was 0.22 (SE = 0.10, $p < 0.05$), reflecting a small short-term linear increase across the six-month, three-wave observation period. Both the intercept-factor variance ($\sigma^2 = 8.65$, SE = 1.36, $p < 0.001$) and the slope-factor variance ($\sigma^2 = 1.98$, SE = 0.71, $p < 0.01$) were significantly different from zero, indicating significant individual differences in the initial level of peer rejection and its rate of change. In addition, the intercept and slope growth factors were not significantly correlated ($r = -0.06$, $p > 0.05$); thus, the initial level of peer rejection was not significantly associated with its rate of change (see Table 3 for details).

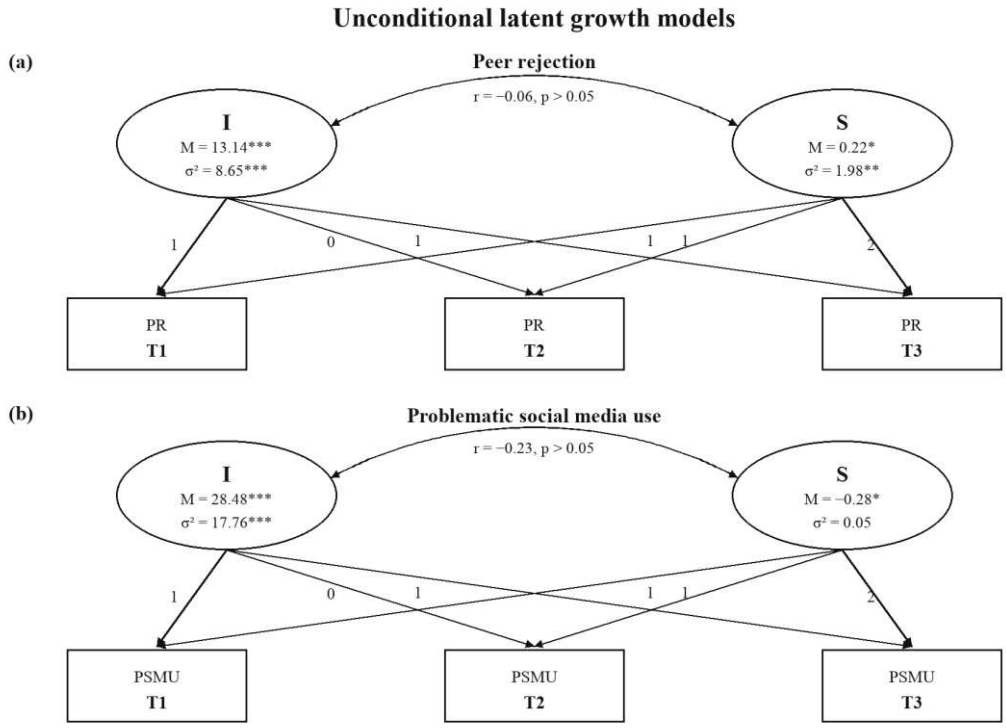


Figure 3. Unconditional latent growth models of peer rejection and problematic social media use

Note. I = intercept; S = slope; PR = peer rejection; PSMU = problematic social media use. T1, T2, and T3 = Time 1, Time 2, and Time 3. Values inside I and S are estimated factor means and variances. *p < 0.05; **p < 0.01; ***p < 0.001.

Unconditional linear latent growth model of PSMU

To examine the trend of change in PSMU among university students, an unconditional linear latent growth model was likewise constructed (see Figure 3b). The unconditional linear model fitted the data well (CFI = 0.99, TLI = 0.98, RMSEA = 0.08, SRMR = 0.02).

In the unconditional linear latent growth model of PSMU, the intercept, representing the initial level of PSMU, was 28.48 (SE = 0.23, $p < 0.001$) and was significantly greater than zero. The slope, representing linear change in PSMU across the three waves, was -0.28 (SE = 0.11, $p < 0.05$), indicating a small short-term decline across the six-month observation period. The variance of the intercept factor was significant ($\sigma^2 = 17.76$, SE = 2.33, $p < 0.001$), indicating significant individual differences in initial PSMU. In contrast, the variance of the slope factor was not significant ($\sigma^2 = 0.05$, SE = 1.09, $p > 0.05$); therefore, the data did not support significant individual differences in rates of change. The intercept and slope growth factors were not significantly correlated ($r = -0.23$, $p > 0.05$; see Table 3), and no conclusion about lower initial levels being associated with faster subsequent change is warranted.

Table 3. Unconditional latent growth model estimates and fit indices

Model	**χ^2/df**	**CFI**	**TLI**	**SRMR**	**RMSEA**	**Intercept**	**Slope**	**Intercept variance (slope variance)**
Peer rejection	9.94	0.96	0.86	0.05	0.08	13.14***	0.22*	8.65*** (1.98**)
Problematic social media use (PSMU)	4.59	0.99	0.98	0.02	0.08	28.48***	-0.28*	17.76*** (0.05)

Note. *p < 0.05; **p < 0.01; ***p < 0.001.

Parallel-process latent growth model

In the preceding section, a cross-lagged panel model was used to examine the cross-temporal predictive relationship between peer rejection and PSMU. A parallel-process latent growth model was then constructed to examine the latent growth processes of the two variables and the association between their growth factors.

First, the intercept and slope factors of peer rejection were used to predict the intercept and slope factors of PSMU. The model showed good fit (CFI = 0.98, TLI = 0.95, RMSEA = 0.08, SRMR = 0.02); the specific model results are presented in Figure 4. The intercept factor of peer rejection was significantly and positively associated with the intercept factor of PSMU ($\beta = 0.71$, SE = 0.10, $p < 0.001$), indicating that higher initial peer rejection corresponded to higher initial PSMU. A significant positive path was also estimated from the peer-rejection slope to the PSMU slope ($\beta = 0.62$, SE = 0.20, $p < 0.01$). However, because the variance of the PSMU slope was not statistically significant, this slope-to-slope association should be interpreted cautiously and should not be taken as evidence that students differed significantly in their PSMU rates of change. The intercept and slope factors of peer rejection were negatively correlated, but this correlation did not reach statistical significance ($r = -0.04$, $p > 0.05$). The intercept and slope factors of PSMU were positively correlated, but this correlation was likewise nonsignificant ($r = 0.04$, $p > 0.05$). Accordingly, the results do not support an association between either variable's initial level and its subsequent rate of change, nor do they support the conclusion that students with lower initial levels changed more rapidly.

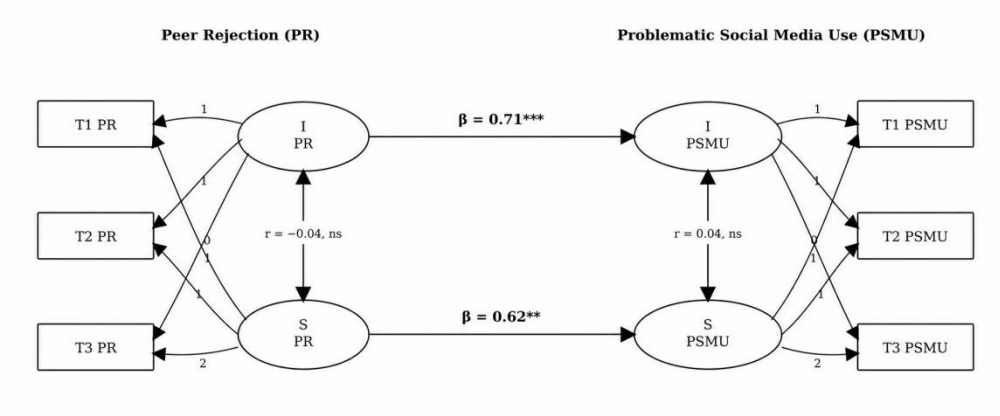


Figure 4. Parallel-process latent growth model of peer rejection predicting PSMU

Note. I = intercept factor; S = slope factor; PR = peer rejection; PSMU = problematic social media use; T1-T3 = Time 1-Time 3. The intercept factor loadings were fixed at 1, and the linear slope factor loadings were fixed at 0, 1, and 2. Standardized estimates are reported. Model fit: CFI = 0.98, TLI = 0.95, RMSEA = 0.08, and SRMR = 0.02. **p < 0.01; ***p < 0.001; ns = nonsignificant.

Discussion

Asymmetric cross-temporal prediction between peer rejection and PSMU

The present study used a three-wave cross-lagged panel model to examine cross-temporal prediction between peer rejection and PSMU among Chinese university students. The results showed that PSMU significantly predicted subsequent peer rejection during both intervals, whereas peer rejection significantly predicted PSMU only from T2 to T3. Thus, the two variables did not exhibit a stable and symmetrical

422 bidirectional relationship throughout the follow-up period. Instead, the relatively
423 consistent direction was from PSMU to subsequent peer rejection, whereas the reverse
424 pathway was stage-specific. This pattern mainly supports the second perspective
425 reviewed in the literature and provides only limited support for a reciprocal-association
426 perspective.

427 The present study found that peer rejection significantly predicted subsequent
428 PSMU only during part of the follow-up period, whereas PSMU consistently and
429 positively predicted subsequent peer rejection, indicating an asymmetric
430 cross-temporal predictive pattern that differed across stages. During the earliest stage
431 of university entry, reliance on social media for general adjustment and maintenance of
432 pre-existing relationships may have reduced the specificity of peer rejection as a
433 predictor of subsequent PSMU. As peer networks became more stable and group
434 boundaries more clearly defined, repeated or accumulated rejection experiences may
435 have more strongly frustrated belonging needs and encouraged compensatory
436 social-media engagement. This stage-dependent process may help explain why the peer
437 rejection-to-PSMU path emerged only from T2 to T3 [19,11]. By contrast, PSMU may
438 show stronger behavioral inertia. Persistent problematic use may repeatedly consume
439 time and psychological resources needed for offline interaction and may be associated
440 with social comparison, interpersonal withdrawal, and poorer offline adjustment. This
441 provides a plausible explanation for why PSMU predicted subsequent peer rejection in
442 both intervals [27,40,41]. These findings suggest that the predictive association from peer

443 rejection to PSMU is more contextual and stage-specific, whereas the association from
444 PSMU to later peer rejection may be more consistent across intervals.

445 These findings have implications for the timing of university prevention efforts.
446 PSMU may be treated as an early risk indicator for subsequent difficulties in peer
447 relationships and should therefore be monitored across the follow-up period.
448 Peer-support interventions may be particularly relevant when peer networks have
449 begun to stabilize and rejection experiences become more salient. A coordinated
450 approach that monitors both problematic online engagement and offline peer
451 relationships is therefore warranted, with priority given to reducing PSMU-related risks
452 while strengthening peer support during periods of peer-network reorganization.

453 **Developmental trend of peer rejection**

454 The present study found that peer rejection among Chinese university students showed
455 a small overall increase during the six-month follow-up period and that there were
456 significant individual differences in both its initial level and rate of change. These
457 findings indicate a short-term linear change in the present sample, together with
458 individual heterogeneity in starting levels and rates of change; they should not be
459 generalized to the entire university period. This pattern may be related to the continuing
460 restructuring of peer relationships after students enter university. After entering
461 university, students need to rebuild peer networks in dormitories, classes, student
462 associations, and other settings. As interactions deepen, group boundaries,
463 interpersonal status, and peer evaluations also become more clearly defined. For

students who have difficulty with interpersonal adjustment or lack stable peer support, latent interpersonal alienation during the early stage may gradually accumulate through repeated interactions and manifest as higher levels of peer rejection. Existing longitudinal research likewise indicates that peer rejection or peer victimization has dynamic developmental features and may follow different trajectories, including stable-low, declining, increasing, or persistently high patterns [42,43,34,44,45].

These results reflect the complex restructuring of peer relationships faced by Chinese university students during the transition from secondary school to university. As university life progresses, new social networks can provide belonging and support for most students but may also gradually reveal the interpersonal marginalization of some students. The small increase observed within the six-month period may therefore reflect a process in which peer relationships move from initial formation toward relative stability and differentiation after university entry. The findings provide short-term longitudinal evidence on changes in peer relationships within the present sample, while longer follow-up is required before conclusions can be drawn about trajectories across the whole university period.

Developmental trend of PSMU

The present study found that PSMU among Chinese university students showed a small overall decline during the six-month observation period. This finding describes a short-term average linear trend in the present sample and does not imply that PSMU declines throughout the university period. It is inconsistent with some longitudinal

research reporting increases in PSMU over time. One possible explanation is that PSMU is associated with multiple factors, including peer relationships, motives for use, emotional states, and situational conditions [13]. More specifically, at the beginning of the follow-up period, students may rely more heavily on social media to obtain information, maintain pre-existing relationships, and cope with the stress of adapting to a new environment. As they become familiar with campus life and develop offline peer networks, their compensatory reliance on social media may decline slightly. Taken together, these conditions may help explain the small average decline observed from the beginning of the academic year to the end of the first semester [10].

Developmental association between peer rejection and PSMU

The present study found that the initial level of peer rejection was significantly and positively associated with the initial level of PSMU and that a significant positive path was estimated from the peer-rejection slope to the PSMU slope. These findings suggest an association between the two variables in their initial states and a degree of synchrony in their short-term changes. However, because the variance of the PSMU slope was not statistically significant, the slope-to-slope association should be interpreted cautiously and cannot be taken as evidence of significant between-student differences in PSMU change rates. Three explanations may help interpret this pattern. First, according to the compensatory Internet use model and the I-PACE model, peer rejection is a negative interpersonal experience that may frustrate the need to belong and co-occur with loneliness and anxiety. Under these circumstances, individuals may be more likely to use social media for interpersonal connection and emotional

compensation. Repeated immediate feedback may further reinforce their use expectancies, making students with higher or more rapidly increasing peer rejection more likely to maintain or develop higher levels of PSMU [19,26,11]. Second, from a developmental transactional perspective, peer relationships and online behavior are not independent but may interact across development. Increasing peer rejection may coincide with reduced offline interaction and greater reliance on online communication. PSMU may, in turn, be associated with less time for offline interaction, greater social comparison, and interpersonal withdrawal. These processes are consistent with a potentially reciprocal association under some conditions, but they should not be interpreted as a stable bidirectional cycle because the cross-lagged pattern in the present study was directionally asymmetric and stage-specific [27]. Finally, the synchronous changes in the two variables may reflect shared developmental risk factors. University, particularly the initial stage of entry, is an important period of peer-network restructuring and social adjustment. Factors such as loneliness, low school belonging, emotion-regulation difficulties, and limited social support may be associated with both peer rejection and PSMU and thus with coordinated changes in the two variables [13]. The present study therefore suggests that peer rejection and PSMU may follow interrelated short-term developmental processes involving frustrated interpersonal needs, online compensation, and shared risk factors. Its contribution lies in distinguishing the relative consistency of the two directional paths, integrating cross-temporal prediction with average short-term trends, and identifying stage-specific priorities for prevention. These conclusions remain bounded by the

six-month follow-up, the nonsignificant PSMU slope variance, and the use of a traditional cross-lagged panel model.

Limitations and future directions

Despite its important findings, the present study has several limitations.

First, the present study used a traditional cross-lagged panel model to examine the longitudinal relationship between peer rejection and PSMU. This model cannot fully distinguish stable between-person differences from within-person change. The results can therefore be interpreted only as cross-temporal prediction and do not warrant causal inference. In addition, the slope variance of PSMU was not significant; the relevant paths and associations between rates of change should therefore be interpreted cautiously. Future studies could include more measurement occasions and use approaches such as random-intercept cross-lagged panel models to further test within-person associations.

Second, the present study included only three measurement occasions over six months. It can therefore reflect only short-term linear change during a specific observation period, rather than the developmental trajectory across the entire university period, and cannot readily identify potential nonlinear changes or semester-stage differences. Future research could follow students from university entry to graduation and include at least four to six measurement occasions to examine the long-term development of the two variables and their dynamic relationship more comprehensively.

549 Third, the present study relied primarily on self-report scales. Peer rejection therefore
550 reflected mainly students' perceived experiences of rejection and may have been
551 associated with factors such as negative affect and rejection sensitivity. In addition, the
552 high proportion of women in the sample may limit the generalizability of the findings.
553 Future studies should use multi-regional samples with more balanced gender and
554 year-level distributions, combine multiple data sources such as behavioral observation
555 and qualitative interviews, and examine potential mechanisms including social anxiety,
556 fear of missing out, emotion regulation, and social support.

557

558 **Conclusions**

559 Using cross-lagged panel models and latent growth models, the present study examined
560 the longitudinal association and short-term linear trends of peer rejection and PSMU
561 among Chinese university students. The main conclusions were as follows: (a) PSMU
562 significantly predicted subsequent peer rejection across both time intervals, whereas
563 peer rejection predicted subsequent PSMU only from T2 to T3, indicating directional
564 asymmetry and stage specificity rather than a stable, symmetrical bidirectional
565 relationship; (b) during the six-month follow-up period, peer rejection showed a small
566 average increase, with significant individual differences in both its initial level and rate
567 of change, whereas PSMU showed a small average decline, with significant individual
568 differences in its initial level but no statistically significant individual differences in its
569 rate of change; and (c) the initial levels of peer rejection and PSMU were positively

associated, and a positive path was estimated between their slopes, although the latter finding should be interpreted cautiously because the PSMU slope variance was not significant. Overall, the evidence supports a directionally asymmetric and stage-specific longitudinal association, not a stable, symmetrical reciprocal process. The findings suggest that PSMU should be monitored as an early risk indicator for subsequent peer-relationship difficulties, while peer support may be particularly important during stages of peer-network stabilization and reorganization.

List of abbreviations

CFI, comparative fit index; CLPM, cross-lagged panel model; FIML, full-information maximum likelihood; I-PACE, Interaction of Person-Affect-Cognition-Execution; LGM, latent growth model; PSMU, problematic social media use; RMSEA, root mean square error of approximation; SE, standard error; SMUQ, Social Media Use Questionnaire; SRMR, standardized root mean square residual; TLI, Tucker-Lewis index; T1-T3, Time 1-Time 3.

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of Henan University of Engineering (No. 64/2025). All participants provided written informed consent before participating in the study.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analysed during the current study are not publicly available because they contain information that could compromise participants' privacy, but are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

This study was supported by the Key Scientific Research Project of Higher Education Institutions in Henan Province, “Research on the Construction of an Evaluation Index System for College Students' Innovation Vitality in the Context of Artificial Intelligence” (Grant No. 25B190001).

This study was supported by the General Project of the Henan Provincial Educational Science Planning Program, “AI-Empowered Pathways for Enhancing Mental Health Education for University Students” (Grant No. 2025YB0265).

606 **Authors' contributions**

607 PW contributed to the study methodology, formal analysis, investigation, preparation
608 of the original draft, and visualization. XJ reviewed and revised the manuscript. AH
609 organized and analyzed the data. All authors read and approved the final manuscript.

610 **Acknowledgements**

611 We thank the school administrators, teachers, and students who cooperated with the
612 data-collection process.

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