Research Square

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Cross-lagged associations and developmental trajectories of coping, self-efficacy, and college adaptation among Chinese university freshmen: a three-wave longitudinal study

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Research Article

Keywords: college adaptation, coping, general self-efficacy, cross-lagged panel model, latent growth curve model

Posted Date: November 4th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10954227/v1

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Additional Declarations: No competing interests reported.

Abstract

Background

Adjustment to college is important for students' academic performance and mental health. Previous researches have examined the effects of self-efficacy and coping on college adaptation, but their interplay and developmental trajectories over time remain unclear. Accordingly, the current study examined the prospective cross-lagged associations among general self-efficacy, positive coping, negative coping, and college adaptation, together with the developmental trajectories and coupled changes of these variables.

Methods

The Chinese College Student Adjustment Scale (CCSAS), the Chinese version of the General Self-Efficacy Scale (GSES), and the Simplified Coping Style Questionnaire (SCSQ) were administered to 766 Chinese university freshmen at three timepoints: 3 days, 1 month and 3 months after enrollment. Cross-lagged panel models and latent growth models were used to examine prospective associations and developmental linkages among college adaptation, general self-efficacy, and positive and negative coping.

Results

The results showed that (a) while only one nonreplicated early path emerged from general self-efficacy to subsequent college adaptation, college adaptation positively predicted subsequent positive coping and general self-efficacy across both intervals; (b) college adaptation increased slightly, whereas positive coping decreased slightly across the first 3 months in college; and (c) the initial levels of positive coping and college adaptation were positively associated, the rates of change of college adaptation and positive coping were positively associated.

Conclusions

These findings clarify the longitudinal relationships between self-efficacy, adaptation should not be regarded only as an outcome of self-efficacy and coping, but may also serve as an experiential source of competence beliefs and coping adjustment, notably, compared with initial positive coping, changes in positive coping were more predictive of changes in adaptation.

Introduction

College adaptation represents an important developmental task during the transition to higher education and is related to students' academic performance, mental health, and social integration[1, 2]. Successful adaptation to university life is shaped by multiple factors, including self-efficacy and coping, but most of these evidences are cross-sectional or based on single time point predictions [3–9]. Researchers suggest that adaptation, cognitive appraisal, and coping may change over the course of a transition and may interact in complex ways [10–16]. It is therefore necessary to examine the developmental trajectories of college adaptation, self-efficacy, and coping, as well as their prospective cross-lagged associations and coupled changes as these processes unfold.

Effects of self-efficacy and coping on college adaptation

Self-efficacy refers to a general belief in one's capacity to deal effectively with a range of difficulties and challenges and reflects students' overall judgment of whether they can cope [17, 18]. Cross-sectional research has linked individual resources, including self-efficacy, with college adaptation. Prospective studies by Ramos-Sánchez et al. (2007) also reveal that university-context self-efficacy at the beginning of the academic year predicts adaptation at the end of the year; moreover, Meng et al. (2015), using a four-wave longitudinal study, found in a sample of Chinese university freshmen that early social self-efficacy was associated with subsequent academic and social adaptation [4, 5]. According to social cognitive theory, self-efficacy shapes goal selection, effort, behavioral persistence, and self-regulation [18, 19]. Students with greater self-efficacy may therefore be more likely to construe transition-related difficulties as manageable challenges and to sustain their efforts [18, 19].

Coping refers to the cognitive and behavioral efforts used to manage demands appraised as taxing or potentially exceeding one's resources and captures how students respond when they encounter stress [20]. Existing studies have demonstrated positive coping to be associated with better college adaptation and negative coping with poorer adaptation; results of prospective studies further support associations between coping and subsequent college adaptation [3, 6–9]. According to the transactional theory of stress, appraisal, and coping, coping is a dynamic process in which individuals continually adjust their cognitions and behaviors after appraising environmental demands [20]. Positive coping may facilitate adaptation through problem solving, support seeking, and stress regulation, whereas negative strategies such as avoidance may delay problem resolution and impede adaptation, although their effects may vary across contexts [21, 22].

Existing evidence has documented associations among individual resources, coping, and college adaptation, but has not established causal relations [2, 3, 6]. Several prospective studies have indicated that earlier self-efficacy or coping was related to later college adaptation[4, 5, 7–9]; in particular, Meng et al. and Tao et al. found this relationship in Chinese samples [5, 8]. However, no study has tested whether college adaptation prospectively predicts subsequent self-efficacy and coping, and whether the three variables are bidirectionally related.

Alternative accounts of how college adaptation may shape self-efficacy and coping

Treating college adaptation solely as an outcome of self-efficacy and coping may overlook how adaptation experiences feed back into subsequent competence beliefs and coping responses. Moos and Schaefer's framework of life crises and transitions suggests that cognitive appraisal, coping responses, and adaptation outcomes may interact with each other during transitions [10]. Adaptation outcomes may provide information that shapes later self-efficacy and coping responses

Existing studies have shown that adaptation outcomes such as academic success and career adaptability may shape later self-efficacy [23, 24]; similar results have also been found in Chinese samples. For example, Liu et al. conducted a two-wave longitudinal study of students at elite Chinese universities during their junior and senior years and found that stress negatively predicted subsequent academic self-efficacy [25]. Within social cognitive theory, mastery experiences are among the most important sources of self-efficacy [18, 19].

Better college adaptation indicates that students have successfully managed academic, interpersonal, and daily-life demands. These successful experiences may strengthen judgments of their own coping capacity, whereas persistent adaptation difficulties and experiences of failure may undermine one’s self-efficacy [18, 19].

Feedback generated during the process of college adaptation may also influence students' subsequent coping. In a synthesis of 44 studies, Skinner and Zimmer-Gembeck found that coping changed over the course of individual development [11]. According to reinforcement theory, behavior that has been followed by favorable consequences becomes more likely to recur [26]. Thus, these outcomes associated with different coping responses during college adaptation may subsequently shape one's coping tendencies.

In summary, college adaptation may not only be influenced by prior self-efficacy and coping, as shown in studies by Meng et al. and Tao et al. [5, 8]; the success or failure of adaptation may, in turn, shape subsequent self-efficacy and coping, as suggested by Liu et al. and Skinner and Zimmer-Gembeck [11, 25] In fact, research among college students on bidirectional prediction between such resources and individual states already exists and could provide a basis for examining the mutual prediction among the focal constructs. For example, Wang & Liu (2026) examined the bidirectional relationships among self-esteem, depression, and self-efficacy, found that self-esteem and general efficacy positively predicted each other bidirectionally, and pointed out that attention to bidirectional prediction among variables helps move research from “static correlation” to “dynamic reciprocal processes,” thereby providing a more precise basis for psychological intervention and policy design in universities [27]; Marcionetti and Rossier also reported a longitudinal interrelationship between career adaptability and general self-efficacy [24], further suggesting that self-efficacy and adaptability may have a bidirectional predictive relationship. However, neither study focused on college freshmen adaptation; consequently, existing evidence can only indirectly suggest that college adaptation may reversely affect self-efficacy and coping, and direct empirical tests of this reverse and bidirectional relationship in the context of overall freshmen adaptation remain lacking, which warrants direct investigation.

Moreover, college adaptation, self-efficacy, and coping may themselves change over time, making it necessary to examine both their respective developmental trajectories and their coupled changes.

Extending prospective prediction to coupled developmental trajectories

During the first months of university, freshmen have to tackle various tasks at different stages of the transition. College adaptation is therefore not a static outcome determined at entry, but may continue to develop throughout this period [14–16]. Longitudinal studies revealed that college adaptation might change over time. For example, Larose et al. (2019) used a four-wave longitudinal design to examine the transition from high school to university [14].Nightingale et al. (2013) used a three-wave design to track the transition from about three weeks after the start of the semester to six months after enrollment. [15]. Li et al. also found that Chinese freshmen experienced unchanged academic adaptation, decreased social adaptation, and increased personal-emotional adaptation[16]. Self-efficacy and coping were likewise not entirely stable and could develop as the university environment, task demands, and stressful experiences changed. Liu et al. followed Chinese university students annually from the first through the fourth year and identified three trajectories of self-efficacy: stable-rising, stable-decreasing, and moderate-stable [12]. Conley et al. followed US university students from before entry through the fourth year and found that active-emotional coping generally declined during the first two years, whereas avoidant-emotional coping increased; changes thereafter varied by coping type and sex [13]. Rogowska et al. also found that task-oriented coping among Polish university students declined between two phases of the COVID-19 pandemic, indicating that the development of coping may depend on the particular transition phase and stress context [28].

These studies indicate that college adaptation, self-efficacy, and coping may all change over time. However, existing longitudinal evidence on these three constructs generally covers periods of six months or more [12–16, 28], leaving their development immediately after university entry less clearly understood. For example, Li et al. (2023) followed students over eight months using two waves, beginning in the second month of the semester, and found different patterns of change in academic, social, and personal-emotional adaptation [16]. With two assessments and a starting point after university entry, this design provides limited information about how changes unfold during the earliest stage of the transition. This early period warrants closer attention because studies have found that adaptation, stress responses, and perceived stress may change markedly and nonlinearly during the first three months of enrollment [29, 30]. Moreover, Moos and Schaefer's framework of life crises and transitions provides a theoretical basis for examining whether the development of college adaptation, self-efficacy, and coping is interrelated [10]. Yet longitudinal evidence beginning at university entry and following these constructs at multiple points within the first three months remains limited. Two questions therefore warrant further investigation: how overall college adaptation, general self-efficacy, and positive and negative coping each develop during this early transition, and how their changes are interrelated. Addressing these questions requires repeated assessments beginning at university entry to examine their individual developmental trajectories and co-development during this window.

The present study

The present study therefore aimed to examine the bidirectional predictive relationships among self-efficacy, coping, and college freshmen adaptation, as well as the dynamic changes in and interrelations among the three variables during the critical transition period at the beginning of the academic term. Accordingly, it addressed two research questions:

RQ1: What prospective cross-lagged associations emerge over time among general self-efficacy, positive and negative coping, and college adaptation?

RQ2: What developmental trajectories characterize general self-efficacy, positive and negative coping, and college adaptation, and how are their initial levels and rates of change related?

The current study hypothesized that general self-efficacy and coping would prospectively predict subsequent college adaptation, while college adaptation would also be prospectively associated with later self-efficacy and coping. We further hypothesized that self-efficacy, coping, and college adaptation would change across the transition period and covary over time.

Methods

Sample and procedure

The research team distributed electronic survey links and QR codes through centralized college channels. Participants participated voluntarily after reading the study information and providing informed consent. Student identification numbers were used to match the longitudinal data. During data cleaning, the exclusion criteria were first applied separately to the data from each time point. Using the baseline data as the reference, the T1 and T2 data were then matched separately to the T0 data to identify students who participated at T0 and at the subsequent waves. The study protocol was approved by the Ethics Review Committee of Shenzhen Polytechnic, and all procedures complied with applicable ethical standards.

the current study used a three-wave longitudinal design. The baseline assessment was completed 3 days after university registration (T0,11 September 2024), followed by assessments 1 month (T1, 11 October 2024) and 3 months (T2, 11 December 2024) after the first measurement. The initial sampling frame comprised 998 freshmen at a university in Shenzhen, Guangdong Province, China (723 women; mean age, 18.34 years). The inclusion criteria were (1) full-time first-year university enrollment, (2) Chinese nationality, (3) residence on campus, and (4) ability to read and complete a Chinese-language questionnaire. The exclusion criteria were as follows: (1) severe mental health symptoms or substance-use problems indicated by routine mental health screening at entry; (2) failure of an attention check; (3) age younger than 15 or older than 30 years; or (4) questionnaire completion in less than 90 seconds or more than 30 minutes. Eight hundred and eighteen, 805, and 607 participants were initially recruited at T0, T1, and T2, respectively. After quality control, 766, 732, and 568 valid responses were retained.

The longitudinal baseline cohort consisted of the 766 participants with valid T0 data. Their mean age was 18.27 years (SD = 0.74); 583 (76.1%) were women and 463 (60.4%) were from urban areas. After matching by student identification number, 650 participants at T1 and 508 at T2 had usable college adaptation scores, corresponding to retention rates of 84.9% and 66.3%, respectively. In total, 459 participants completed all three waves, yielding a complete follow-up rate of 59.9%.

Participants who completed all three waves did not differ significantly from those who did not on the T0 total college adaptation score or any of its domains, positive coping, negative coping, or general self-efficacy (all $p > .05$). Descriptive statistics for the primary variables are presented in Table 1.

Measures

College adaptation

College adaptation was assessed using the Chinese College Student Adjustment Scale (CCSAS), developed by the Research Group of the College Student Mental Health Assessment System [31]. The scale comprises 60 items across seven domains: interpersonal adaptation, academic adaptation, campus-life adaptation, career-choice adaptation, emotional adaptation, self-adaptation, and satisfaction. Items are rated on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). After reverse scoring, the 60 items are summed, yielding a theoretical range of 60-300; higher scores indicate better college adaptation. The CCSAS was administered at T0, T1, and T2, with Cronbach's α values of .950, .962, and .962, respectively.

Coping style

Coping was measured using the Simplified Coping Style Questionnaire (SCSQ), developed by Xie for use with Chinese populations and informed by the Ways of Coping tradition [32, 33]. The questionnaire comprises 20 items: 12 forming the positive coping subscale and 8 forming the negative coping subscale. Items are rated on a 4-point scale (1-4), and the mean item score is calculated separately for each subscale. Higher scores indicate more frequent use of the corresponding coping style. The SCSQ was administered at all three waves. Cronbach's α values for positive coping were .891, .936, and .944 at T0, T1, and T2, respectively; the corresponding values for negative coping were .725, .775, and .822.

General self-efficacy

General self-efficacy was assessed using the Chinese version of the General Self-Efficacy Scale (GSES), developed by Schwarzer and Jerusalem and adapted by Zhang and Schwarzer [17, 34]. The scale comprises 10 items rated on a 4-point scale (1-4). Mean item scores were calculated, with higher scores indicating greater general self-efficacy. The GSES was administered at T0, T1, and T2, with Cronbach's α values of .934, .952, and .954, respectively.

Statistical analysis

Descriptive statistics, attrition comparisons, and Pearson correlation analyses were conducted in IBM SPSS Statistics 22. Cross-lagged panel models (CLPMs), longitudinal measurement-invariance tests, latent growth curve models (LGCMs), and a parallel-process latent growth curve model (PP-LGCM) were estimated in Mplus 8.3. All tests were two-sided; the significance level was set at .05, and 95% confidence intervals were reported. Sex was coded as 1 = male and 2 = female, and residence as 1 = urban and 2 = rural. First, means, standard deviations, and Pearson correlation coefficients were calculated for all study variables at the three waves to examine the temporal stability of college adaptation, positive coping, negative coping, and general self-efficacy and their basic interrelations.

Second, a cross-lagged panel model of college adaptation, positive coping, negative coping, and general self-efficacy was specified to examine their reciprocal prospective associations. The longitudinal models used full information maximum likelihood estimation to incorporate all available information from the baseline cohort rather than restricting the analyses to participants with complete data at all three waves. Four nested models were compared sequentially to identify the model that best fit the data while remaining theoretically interpretable. Model 1 (M1), the stability model, included only autoregressive paths between adjacent waves for each variable and within-wave correlations among variables. Model 2 (M2) added cross-lagged paths from positive coping, negative coping, and general self-efficacy to subsequent college adaptation, while fixing paths from college adaptation to subsequent self-efficacy and coping at zero. Model 3 (M3) instead added cross-lagged paths from college adaptation to subsequent positive coping, negative coping, and general self-efficacy, while fixing paths from the self-efficacy and coping to subsequent college adaptation at zero. Model 4 (M4), the bidirectional cross-lagged model, estimated all cross-lagged paths included in both M2 and M3. Cross-lagged coefficients were freely estimated across the two intervals. All four models used the same covariates and estimation settings and adjusted for sex, age, and residence.

Nested models were compared using the robust chi-square difference test, Akaike information criterion (AIC), Bayesian information criterion (BIC), comparative fit index (CFI), Tucker-Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR). CFI and TLI values of at least .90 and RMSEA and SRMR values no greater than .08 were treated as general reference criteria for acceptable fit, but the final model was not selected mechanically on the basis of any single index [35]. Lower AIC and BIC values indicate a better balance between fit and parsimony. Final model selection considered statistical fit, model parsimony, the stability of cross-lagged paths, and theoretical interpretability. Because this was an observational longitudinal study, conventional cross-lagged paths were interpreted only as prospective predictive relationships after adjustment for prior levels, or as longitudinal dynamic associations, and not as direct evidence of within-person causal effects [36].

Longitudinal measurement invariance was then tested for the four repeatedly measured constructs. Because the CCSAS contains a large number of items, the seven domain means were used as indicators; the corresponding items served as indicators for positive coping, negative coping, and general self-efficacy. Configural, metric, scalar, and strict invariance models were fitted sequentially. Following Chen, an additional set of constraints was considered not to produce a substantive deterioration in fit when the change between adjacent models met $|\Delta CFI| \leq .010$, $\Delta RMSEA \leq .015$, and $\Delta SRMR \leq .030$ for metric invariance or $\leq .010$ for scalar and strict invariance [37]. Scalar invariance was treated as the minimum requirement for comparing latent means or developmental change. Strict invariance was considered a more stringent supplementary criterion rather than a prerequisite for proceeding with growth analyses. Model fit was evaluated jointly using chi-square, CFI, TLI, RMSEA, and SRMR [37, 38].

On the basis of the longitudinal measurement-invariance results, unconditional linear LGCMs were fitted separately for college adaptation and each individual psychological factor [39]. The growth models used observed composite scores at each wave: the CCSAS total score for college adaptation, the SCSQ positive- and negative-coping item-mean scores, and the GSES item-mean score for general self-efficacy. All three loadings on the intercept factor were fixed at 1, whereas the slope-factor loadings were fixed at 0, 1, and 3 to reflect the unequally spaced assessments at T0, 1 month, and 3 months. The intercept therefore represented the initial level at T0, and the slope represented average linear change per month. The models estimated the means and variances of the intercept and slope and their covariance to test for significant average change and individual differences in initial levels and rates of change. Only psychological factors that met the requirement for scalar invariance were included in the PP-LGCM.

Finally, a PP-LGCM of positive coping and college adaptation was fitted on the basis of the longitudinal measurement-invariance and unconditional LGCM results [40]. The model simultaneously estimated the intercepts and slopes of the two developmental processes. The college adaptation intercept was regressed on the positive coping intercept; the college adaptation slope was regressed on both the positive coping intercept and slope. At the observed-score level, the within-wave residuals of positive coping and college adaptation were allowed to covary at all time points. Sex, age, and residence were specified as predictors of both intercepts and both slopes. Residual covariances between the intercept and slope growth factors were freely estimated within both the positive-coping and college-adaptation processes [41].The PP-LGCM was used to determine whether the initial levels and linear rates of change of the two constructs were related; associations between slopes were not interpreted as causal effects.

All longitudinal models used maximum likelihood estimation with robust standard errors (MLR). Missing data arising during follow-up were handled using full information maximum likelihood (FIML), which uses all available information from each participant under the missing-at-random assumption rather than deleting cases without complete three-wave data [42]. The cross-lagged model and PP-LGCM additionally adjusted for sex, age, and residence to reduce the influence of observed attrition-related factors on estimates of the primary structural paths.

Results

Common Method Bias

Data for the present study were collected using students' self-reports, which may raise concerns regarding potential common method bias. Harman's single-factor test was performed separately for the three measurement time-points [43]. In the unrotated principal-component analyses at T0, T1, and T2, the numbers of factors with eigenvalues greater than 1 were 16, 12, and 13 respectively, all exceeding 2. The variance explained by the first factor was 24.71%, 30.68%, and 31.78%, all below the conventional critical threshold of 50% [44]. Accordingly, there was no evidence that a single common-method factor dominated the data, indicating the absence of severe common method bias in this study.

Descriptive statistics and correlation analyses

Table 1 presented the means, standard deviations, and correlation matrix for college adaptation, positive coping, negative coping, and general self-efficacy at three time points (T0, T1, and T2). At each time point, college adaptation was significantly and positively correlated with positive coping ($rs = .59$-$.63$, $ps < .001$) and general self-efficacy ($rs = .57$-$.60$, $ps < .001$). College adaptation was significantly and negatively correlated with negative coping only at T0 ($r = -.15$, $p < .001$). College adaptation was generally positively correlated with positive coping ($rs = .38$-$.53$, $ps < .001$) and general self-efficacy ($rs = .41$-$.53$, $ps < .001$) across time points. All variables showed significant stability across the three time points: cross-time correlations ranged from .62 to .79 for college adaptation, .43 to .59 for positive coping, .37 to .46 for negative coping, and .49 to .60 for general self-efficacy (all $ps < .001$). Overall, college adaptation, positive coping, and general self-efficacy showed relatively stable cross-time associations and rank-order stability. Although negative coping was also stable over time, its associations with college adaptation were weaker and varied across time points. These findings provided an initial basis for testing cross-lagged and developmental-trajectory associations among the variables.

Table 1. Descriptive statistics and correlations of study variables

Variables		1. CCSAS			2. POS			3. NEG			4. GSES		
		T0	T1	T2	T0	T1	T2	T0	T1	T2	T0	T1	T2
CCSAS	T0	1											
	T1	0.68***	1										
	T2	0.62***	0.79***	1									
POS	T0	0.59***	0.45***	0.38***	1								
	T1	0.45***	0.62***	0.53***	0.50***	1							
	T2	0.41***	0.52***	0.63***	0.43***	0.59***	1						
NEG	T0	-0.15***	-0.12**	-0.11*	0.21***	0.02	0.09*	1					
	T1	-0.07	-0.05	-0.03	0.12**	0.30***	0.12**	0.37***	1				
	T2	-0.02	0.02	0.05	0.13**	0.23***	0.40***	0.38***	0.46***	1			
GSES	T0	0.57***	0.46***	0.41***	0.46***	0.32***	0.34***	0.06	0.10**	0.11*	1		
	T1	0.43***	0.60***	0.48***	0.33***	0.54***	0.40***	-0.02	0.16***	0.18***	0.52***	1	
	T2	0.43***	0.53***	0.58***	0.32***	0.44***	0.49***	0.02	0.13**	0.20***	0.49***	0.60***	1
Mean		207.01	208.36	209.94	2.85	2.78	2.75	2.23	2.20	2.23	2.38	2.36	2.44
SD		30.96	32.53	31.57	0.57	0.65	0.64	0.51	0.54	0.56	0.58	0.62	0.62

Note. CCSAS = Chinese College Student Adjustment Scale; POS = positive coping; NEG = negative coping; GSES = general self-efficacy. T0 = college entry, T1 = one month, and T2 = three months. Values are Pearson correlations based on pairwise available observations. Means and SDs are based on available observations. *p < .05; **p < .01; ***p < .001.

Cross-lagged model analysis

To examine reciprocal prospective associations of positive coping, negative coping, and general self-efficacy with college adaptation, four nested cross-lagged panel models were compared. M1 included only the autoregressive stability paths for each variable. M2 tested predictive paths from the self-efficacy and coping to subsequent college adaptation, whereas M3 tested predictive paths from college adaptation to the subsequent self-efficacy and coping M4 included cross-lagged paths in both directions. Sex, age, and residence were included as covariates in all models. Table 2 presented the fit indices and comparison results for the four competing models.

As shown in Table 2, both M3 (CFI = .963, TLI = .933, RMSEA = .048, SRMR = .051) and M4 (CFI = .966, TLI = .929, RMSEA = .049, SRMR = .046) fit the data well. Relative to M3, M4 yielded a statistically significant scaled chi-square difference test, $\Delta\chi^2(6) = 12.819$, $p = .046$, and a lower AIC; however, its BIC was higher than that of M3. To estimate prospective paths in both directions, and given the statistically significant improvement in fit from M3 to M4, M4 was selected as the primary interpretive model. M3 was retained as a nested alternative model in which the six paths from self-efficacy and coping to college adaptation were constrained to zero, allowing the robustness of the main path estimates to be assessed. Comparison of paths common to both models showed that the coefficients from college adaptation to subsequent positive coping were .260 and .298 in M4 and .275 and .320 in M3. The corresponding coefficients from college adaptation to subsequent general self-efficacy were .210 and .299 in M4 and .233 and .304 in M3. All of these paths were significant in both models (all $p < .001$). Paths from college adaptation to subsequent negative coping were not significant in either model. Of the six additional reverse-direction paths in M4, only general self-efficacy at T0 prospectively predicted college adaptation at T1 ($\beta = .091$, $p < .01$); the remaining five paths were not significant. The major path-coefficient diagram for M4 is shown in Figure 2, and that for M3 in Additional file 1: Figure S1, and that for complete path-coefficient diagram for M1, M2, M3, M4 in Additional file 1: table S1.

Table 2. Fit indices for nested cross-lagged panel models

Model	Description	χ^2 (df)	CFI	TLI	RMSEA	SRMR	AIC	BIC	SABIC
M1	Autoregressive stability	257.161 (52)	0.908	0.851	0.072	0.139	25488.643	25832.090	25597.107
M2	Individual variables to adaptation	226.432 (46)	0.919	0.851	0.072	0.119	25462.997	25834.292	25580.256
M3	Adaptation to individual variables	127.608 (46)	0.963	0.933	0.048	0.051	25342.272	25713.566	25459.530
M4	Bidirectional	114.751 (40)	0.966	0.929	0.049	0.046	25338.695	25737.837	25464.748

Note. N = 766. All models adjusted for sex, age, and residence.

Developmental trajectory analyses

Longitudinal measurement invariance

Scalar invariance was supported for both the CCSAS and positive coping. For the CCSAS, changes in fit from the metric to the scalar model were ΔCFI = -.008, ΔRMSEA = .003, and ΔSRMR = .005; the corresponding changes for positive coping were ΔCFI = -.005, ΔRMSEA = .001, and ΔSRMR = .002. Strict invariance was not supported for either construct: the changes were ΔCFI = -.017, ΔRMSEA = .007, and ΔSRMR = .026 for the CCSAS, and ΔCFI = -.026, ΔRMSEA = .006, and ΔSRMR = .019 for positive coping. Subsequent growth analyses therefore proceeded on the basis that both constructs met the criterion for scalar invariance. Complete results were presented in Table 3.

Negative coping and the GSES did not meet the prespecified criterion for scalar invariance (ΔCFI = -.020 and -.013, respectively); subsequent invariance constraints for these constructs were therefore not interpreted substantively. Neither construct was included in the PP-LGCM. Detailed results were provided in Additional file 1: Table S1.

Table 3. Longitudinal measurement invariance for adaptation and positive coping

Construct	Model	CFI	TLI	RMSEA	SRMR	ΔCFI	ΔRMSEA	ΔSRMR
CCSAS	Configural	.960	.949	.056	.034	—	—	—
CCSAS	Metric	.958	.950	.055	.045	−.002	−.001	.011
CCSAS	Scalar	.950	.945	.058	.050	−.008	.003	.005
CCSAS	Strict	.933	.931	.065	.076	−.017	.007	.026
Positive coping	Configural	.932	.923	.042	.042	—	—	—
Positive coping	Metric	.931	.925	.041	.043	−.001	−.001	.001
Positive coping	Scalar	.926	.922	.042	.045	−.005	.001	.002
Positive coping	Strict	.900	.899	.048	.064	−.026	.006	.019

Note. N = 766. CCSAS invariance was tested using the seven domain means as indicators; positive coping was tested at the item level. Changes in fit indices are relative to the preceding model. Scalar invariance was supported for both constructs; strict invariance was not supported.

Unconditional latent growth curve models

The unconditional linear LGCM for college adaptation fit the data well, $\chi^2(1) = 0.119$, $p = .730$, CFI = 1.000, RMSEA = .000, SRMR = .003. The mean intercept was 207.10 (SE = 1.08, $p < .001$), and the mean linear slope per month was 0.85 (SE = 0.36, $p = .019$). Both the intercept variance (702.11, $p < .001$) and slope variance (81.68, $p < .001$) were significant, indicating a small overall increase in college adaptation and individual differences in both initial levels and rates of change.

For positive coping, the unconditional linear LGCM yielded $\chi^2(1) = 3.808$, $p = .051$, CFI = .989, RMSEA = .061, and SRMR = .018. The mean intercept was 2.83 (SE = .02, $p < .001$), and the mean linear slope per month was -.03 (SE = .01, $p < .001$). Both the intercept variance (.20, $p < .001$) and slope variance (.033, $p < .001$) were significant. Slope variances were not significant for negative coping or general self-efficacy. Growth-model results for the other individual psychological factors are reported in Additional file 1: Table S2.

Table 4. Unconditional growth models for adaptation and positive coping

Variable	χ² (df)	p	CFI	RMSEA	SRMR	Intercept M (SE)	Slope M (SE)	Var(I)	Var(S)
CCSAS	0.119 (1)	.730	1.000	.000	.003	207.10 (1.08)***	0.85 (0.36)*	702.11***	81.68***
Positive coping	3.808 (1)	.051	.989	.061	.018	2.83 (0.02)***	−0.03 (0.01)***	0.20***	.033***

Note. N = 766. Slope loadings were fixed at 0, 1, and 3, so the slope represents average monthly change. MLR estimation with FIML was used. *p < .05; ***p < .001.

Parallel-process latent growth curve model

The initially PP-LGCM yielded a negative residual variance at T2 (−247.564, SE = 95.996, 95% CI [−435.717, −59.411]), despite excellent overall model fit. We therefore examined a series of more parsimonious residual structures: M1 freely estimated residual variances for both measures at all three waves; M2 constrained the adaptation residual variances to equality across waves while freely estimating those for positive coping; M3 applied the equality constraint only to positive coping; and M4 constrained the residual variances of each measure to equality across waves. We compared model admissibility, fit, parsimony, and the stability of key path estimates. M1 was inadmissible, M3 still produced a negative variance, and although M4 was admissible, its SRMR was relatively high (.085). Among the admissible models, M2 showed the best fit (CFI = .971, TLI = .927, RMSEA = .066, SRMR = .056) and was therefore selected as the primary model. Because this specification was selected after examining the data, the findings should be interpreted as exploratory. In the M2 exploratory model, after adjustment for sex, age, and residence, the positive coping intercept was positively associated with the college adaptation intercept (B = 49.164, SE = 3.166, β = .796, p < .001), but was not significantly associated with the college adaptation slope (B = −1.220, SE = 1.487, β = −.128, p = .412). The slopes of positive coping and college adaptation were positively associated (B = 27.365, SE = 8.701, β = .930, p = .002), suggesting that participants whose positive coping declined less, remained more stable, or increased relatively more showed more favorable changes in adaptation. Core structural estimates are presented in Table 5 and Figure 3, complete covariate paths in Additional file 1: Table S4, and the full residual-structure model comparison in Additional file 1: Table S5.

Table 5. Structural estimates from the parallel-process growth model

Parameter	B	SE	β	95% CI for B	p
Positive coping intercept → CCSAS intercept	49.164	3.166	.796	[42.958, 55.371]	< .001
Positive coping intercept → CCSAS slope	-1.220	1.487	−.128	[-4.135, 1.695]	.412
Positive coping slope → CCSAS slope	27.365	8.701	.930	[10.311, 44.419]	.002

Note. N = 766. CCSAS = Chinese College Student Adjustment Scale. B, SE, and 95% CI are unstandardized; β values are STDYX standardized. p values test B, as do the significance marks in Figure S2. For the slope-to-slope path, the separate standardized Wald test gives p = .016; it should not be substituted for the unstandardized test p = .002 without identifying the change of test. Complete covariate paths are reported in Table S4.

Discussion

The present study aimed to examine the longitudinal associations among general self-efficacy, positive and negative coping, and college adjustment, as well as their developmental trajectories during the early college transition period among first-year university freshmen. Results indicated that, after controlling for the prior levels of the corresponding variables, college adjustment predicted higher subsequent levels of both general self-efficacy and positive coping across both time intervals. Only general self-efficacy at entry predicted college adjustment 1 month later; neither positive nor negative coping significantly predicted subsequent adjustment across either interval. Over the first three months following enrollment, college adjustment showed a slight overall increase, while positive coping decreased slightly on the whole. Significant individual differences were observed in both the initial levels and rates of change of the two constructs. The rate of change of positive coping was positively correlated with that of college adjustment, and the initial level of positive coping was positively correlated with that of college adjustment. By contrast, initial positive coping was not significantly associated with the slope of college adjustment. Because the residual structure of the parallel process model is data-driven, this result constitutes exploratory evidence and should be interpreted with caution.

Prospective associations of general self-efficacy and coping with college adaptation

The finding that general self-efficacy at entry predicted college adaptation 1 month later is consistent with prior research linking self-efficacy to better college adjustment and with longitudinal evidence that social self-efficacy predicts a successful first-year transition [4, 5]. The present finding therefore adds short-term prospective evidence that freshmen' broader confidence in managing difficulties is relevant to adaptation during the initial month after enrollment, after accounting for prior adaptation. This result suggests that general self-efficacy is an early prospective indicator of college adaptation. However, we failed to find the same predictive path over the second interval, which may indicate a phase-specific effect of self-efficacy on college adaptation. Longitudinal research suggests that the predictive contribution of self-efficacy and other individual resources to college adaptation may vary across phases of the transition, and that the influence of early self-efficacy on subsequent adaptation may increasingly operate through more proximal processes such as social support [5]. Universities could therefore consider general self-efficacy as one indicator in early screening for adaptation difficulties and as a potential intervention target to support students during their initial transition. Future research should examine whether proximal factors, such as social support, mediate or moderate the association between general self-efficacy and college adaptation beyond the first month after enrollment.

After controlling for prior college adaptation and self-efficacy, neither positive nor negative coping significantly predicted subsequent overall college adaptation across either interval. This pattern diverged from studies that framed coping as an antecedent of adaptation [7–9].

One possible explanation concerns baseline adjustment: these studies used prospective mediation models without controlling for prior levels of the same adaptation outcome [7–9]. whereas the current CLPM assessed coping's additional predictive contribution beyond prior adaptation and self-efficacy. Earlier associations may therefore partly reflect pre-existing differences in adaptation, potentially explaining the nonsignificant additional contribution of coping observed here. Future studies should replicate these baseline-adjusted analyses to clarify whether coping prospectively predicts college adjustment.

Prospective associations of college adaptation with general self-efficacy and coping

College adaptation predicted subsequent general self-efficacy across both intervals, whereas the reverse path was significant only during the first month after entry, indicating reciprocal prospective prediction during this initial period. This pattern is consistent with longitudinal findings in related domains [23, 24]. From a social cognitive perspective, the prospective association from adaptation to self-efficacy is theoretically plausible, as Bandura identified mastery experiences as an important source of self-efficacy [18]. Better college adaptation may reflect successful management of academic, interpersonal, and campus-life demands [1, 31]; these experiences may strengthen students' confidence in their ability to manage difficulties [18, 19]. College adaptation may thus serve as an experiential source of general self-efficacy during the transition. For university mental health services, these findings suggest the value of providing proactive adaptation support from the start of university, helping students manage transition demands while supporting the development of self-efficacy. Given the reciprocal prospective associations observed during the first month, future research should test whether a mutually reinforcing process operates during the earliest stage of transition, whereby successful adaptation strengthens self-efficacy, which in turn supports further gains in adaptation.

College adaptation significantly and positively predicted positive coping across both intervals, indicating that students with better adaptation subsequently used positive coping more frequently. Previous research has commonly examined coping as an antecedent of college adaptation, while reverse-direction longitudinal evidence was rare [3, 6–9]. A longitudinal COVID-19 study observed that task-, emotion-, and avoidance-oriented coping changed alongside perceived stress across two pandemic waves [28]. Moos and Schaefer's framework proposes that adaptation outcomes can feed back into subsequent appraisals and coping

[10]. Reinforcement theory likewise proposes that responses followed by favorable outcomes are more likely to recur [26].From these perspectives, successful adaptation experiences may reinforce problem solving, action planning, and support seeking through feedback such as successful task completion, a sense of control, and effective support. The present findings are therefore consistent with the possibility that positive coping can develop through learning from adaptation experiences. Future research should directly test this proposed feedback mechanism.

Together with the findings for general self-efficacy, these results provide early-transition evidence consistent with the view that adaptation experiences may inform subsequent competence beliefs and coping responses. College adaptation may thus represent a potential intervention target for supporting their development. University programs could provide support for academic, social, emotional, and institutional adjustment from entry while incorporating positive coping skills training. Program evaluations could assess changes in general self-efficacy and positive coping alongside college adaptation and student satisfaction.

Developmental trajectories of college adaptation and positive coping

College adaptation among Chinese university freshmen increased slightly during the first 3 months after entry, broadly consistent with a six-month longitudinal survey of 294 domestic and international students entering a midwestern U.S. state university, which found increasing adjustment over time among domestic and international student sojourners [29]. Moos and Schaefer's transition framework proposed that adaptation changes through continuing interactions between the person and the environment [10]. One possible explanation is that, as students become more familiar with course requirements and campus resources and establish daily routines and peer relationships, their overall adaptation may improve. The findings indicated that the first three months after university entry were an important window for timely academic, interpersonal, and campus-integration assistance.

Positive coping decreased slightly during the first 3 months after entry, consistent with longitudinal evidence of an early decline in active coping during the university years [13]. Coping develops in response to changing stressors and regulatory demands [11]. One possible interpretation is that, as academic and campus routines became more familiar, fewer situations may call for deliberate coping efforts. A similar pattern has been observed in longitudinal mixed-method research conducted in another adjustment context: Compared with the early phase, 149 participants exposed to the novel context showed reduced use of coping strategies as they gradually adapted to the situation[45].

The coupled-development analysis showed a strong positive association between the initial levels of positive coping and college adaptation and the rate of change in positive coping was also positively associated with that of adaptation.This association between initial levels is consistent

with earlier research linking active or engagement coping with college adjustment, including academic and psychological adaptation [6, 9]. It indicates that positive coping and adaptation were already closely aligned at the beginning of the university transition, underscoring the value of considering these two processes together from entry. A positive association between changes in positive coping and changes in quality of life has also been reported [46]. Together, these findings suggest that positive coping may be understood as a dynamic resource whose development is linked to adaptation. The present study thus adds a developmental perspective by showing that the association between positive coping and college adaptation extends from their initial levels to their trajectories of change. Future intervention studies could test whether strengthening positive coping also improves adaptation, while further longitudinal research could examine whether changes in positive coping provide useful early indicators of adaptation difficulties.

Implications

By integrating prospective prediction with developmental processes, the current study advanced understanding of the relationship between self-efficacy, coping and college adaptation. The findings extended the conventional unidirectional view of general self-efficacy and coping solely as antecedents of adaptation, suggesting that college adaptation may also provide longitudinal information about later competence beliefs and positive coping [10, 11, 18–20, 26]This perspective highlights the potential value of adaptation support within university mental health promotion and skills development programs. The positive covariation between changes in positive coping and adaptation further underscores the value of following both processes throughout the transition. Universities could therefore combine assessments of students' abilities and resources at entry with repeated assessments of positive coping and adaptation. Future research should evaluate whether incorporating these changes into monitoring systems improves the early identification of adaptation difficulties and helps guide timely support.

Limitations

The findings should be interpreted in light of several limitations. First, the sample was drawn from one university, and approximately three-quarters of participants were women, which limits the generalizability of the findings. Second, a conventional CLPM cannot separate stable between-person differences from within-person change. Even after controlling for prior levels, cross-lagged coefficients may contain both sources of variation [36]. The paths in the current study can therefore be interpreted only as prospective prediction. Future studies could use random-intercept cross-lagged panel models together with more intensive follow-up or randomized controlled interventions to examine within-person temporal ordering and mechanisms involving mastery experiences, perceived control, and outcome feedback. Third, in the unconditional PP-LGCM, the residual variance of adaptation at T2 was negative, indicating a Heywood case. Although this problem was resolved by adopting a parsimonious specification in which residual variances were constrained to be equal across time [47], this choice constitutes a data-driven model modification, and the relevant results should therefore be treated only as exploratory evidence. A Heywood case may arise from sampling fluctuations, empirical identification problems, or model misspecification [48].Although missing data were handled using full information maximum likelihood (FIML), substantial attrition reduced the information available for estimation and may have increased the risk of improper solutions [49, 50]. In addition, the three-wave design limited our ability to examine nonlinear trajectories and evaluate the adequacy of the assumed linear growth form [51]. Future research should improve participant retention, include more measurement occasions, and schedule assessments according to theoretically expected patterns of change to better evaluate growth forms, residual structures, and the stability of cross-process relationships.

Conclusion

College adaptation predicted subsequent general self-efficacy and positive coping, while only baseline general self-efficacy predicted college adaptation one month later, among a sample of Chinese university freshmen. Besides, college adaptation was found to increase slightly and positive coping to decrease slightly during the first 3 months after entry. These findings suggested that college adaptation is not only an outcome of the transition but also an important longitudinal source of information for understanding subsequent competence beliefs and positive coping.

Abbreviations

AIC, Akaike information criterion; BIC, Bayesian information criterion; CCSAS, Chinese College Student Adjustment Scale; CFI, comparative fit index; CLPM, cross-lagged panel model; FIML, full information maximum likelihood; GSES, General Self-Efficacy Scale; LGCM, latent growth curve model; MLR, maximum likelihood estimation with robust standard errors; PP-LGCM, parallel-process latent growth curve model; RMSEA, root mean square error of approximation; SCSQ, Simplified Coping Style Questionnaire; SRMR, standardized root mean square residual; TLI, Tucker–Lewis index.

Declarations

Ethics approval and consent to participate

The study was approved by the Ethics Review Committee of Shenzhen Polytechnic (NO 8/2024). Electronic informed consent was obtained from all participants before data collection. All procedures were performed in accordance with applicable ethical standards.

Consent for publication

Not applicable.

Availability of data and materials

The data that support the findings of this study are available on request from the corresponding author Yang. The data are not publicly available because they contain information that could compromise the privacy of the research participants.

Competing interests

The authors declare no competing interests.

Funding

This study was supported by the Fundamental Research Funds for the Central Universities Special Grant Project "Dose-effect Relationship and Intervention of Exercise for Promoting Adolescent Mental Health" (Project Number: 2024TZJK002), Key Laboratory of Exercise and Physical Fitness (Beijing Sport University), Ministry of Education.

Authors' contributions

C: Conceptualization, Methodology, Investigation, Formal analysis, Writing-original draft.

Y: Writing-review & editing, Supervision, Project administration.

Acknowledgements

We are grateful to the school administrators, teachers and students who actively cooperated with the researchers to collect data.

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Figures

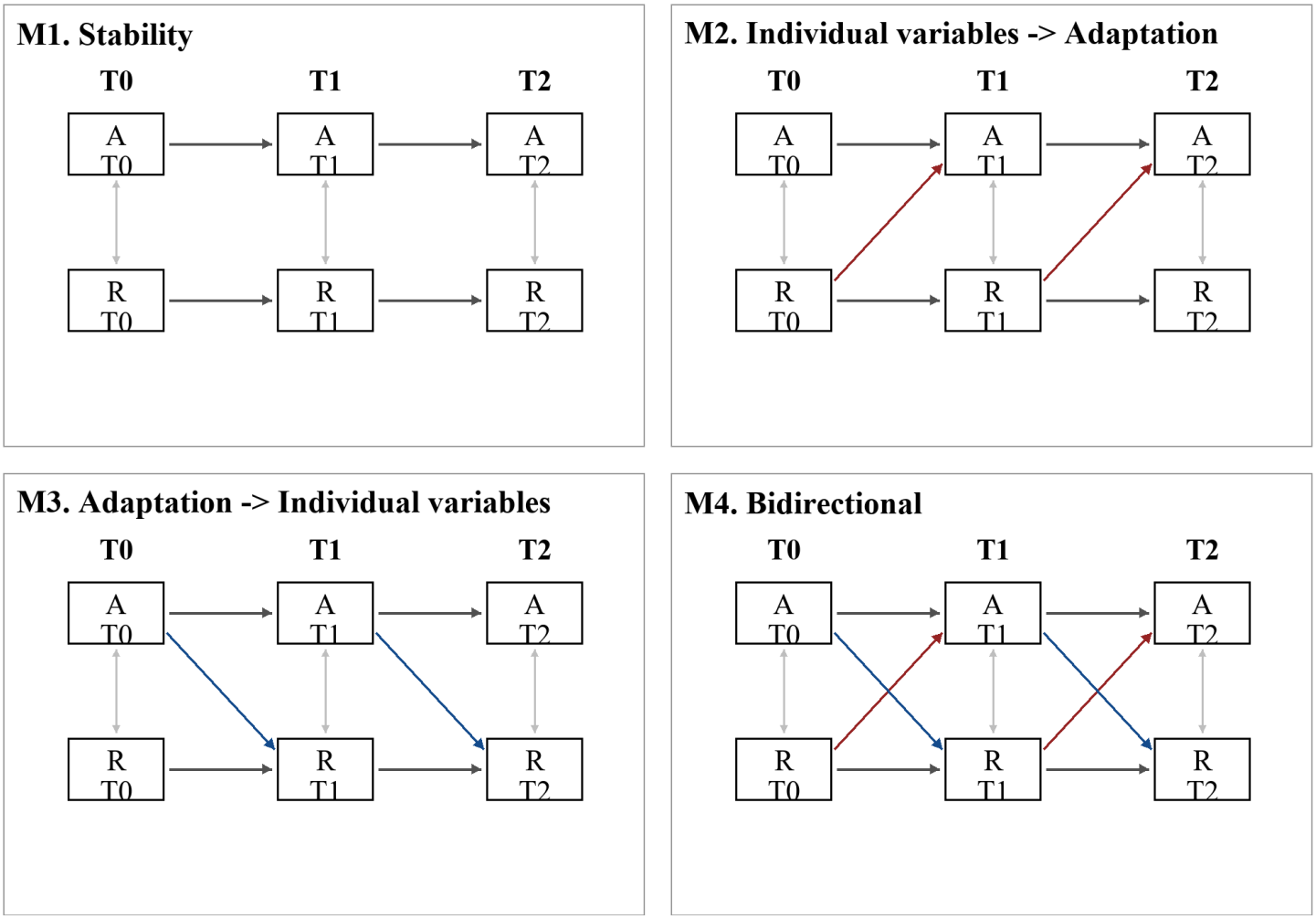


Figure 1

Nested cross-lagged panel models compared in the study. Note. A = CCSAS adaptation; R = individual variables, including positive coping, negative coping, and general self-efficacy. Gray horizontal arrows denote autoregressive paths, vertical double-headed arrows denote within-time correlations, red arrows denote individual-variable-to-adaptation paths, and blue arrows denote adaptation-to-individual-variable paths.

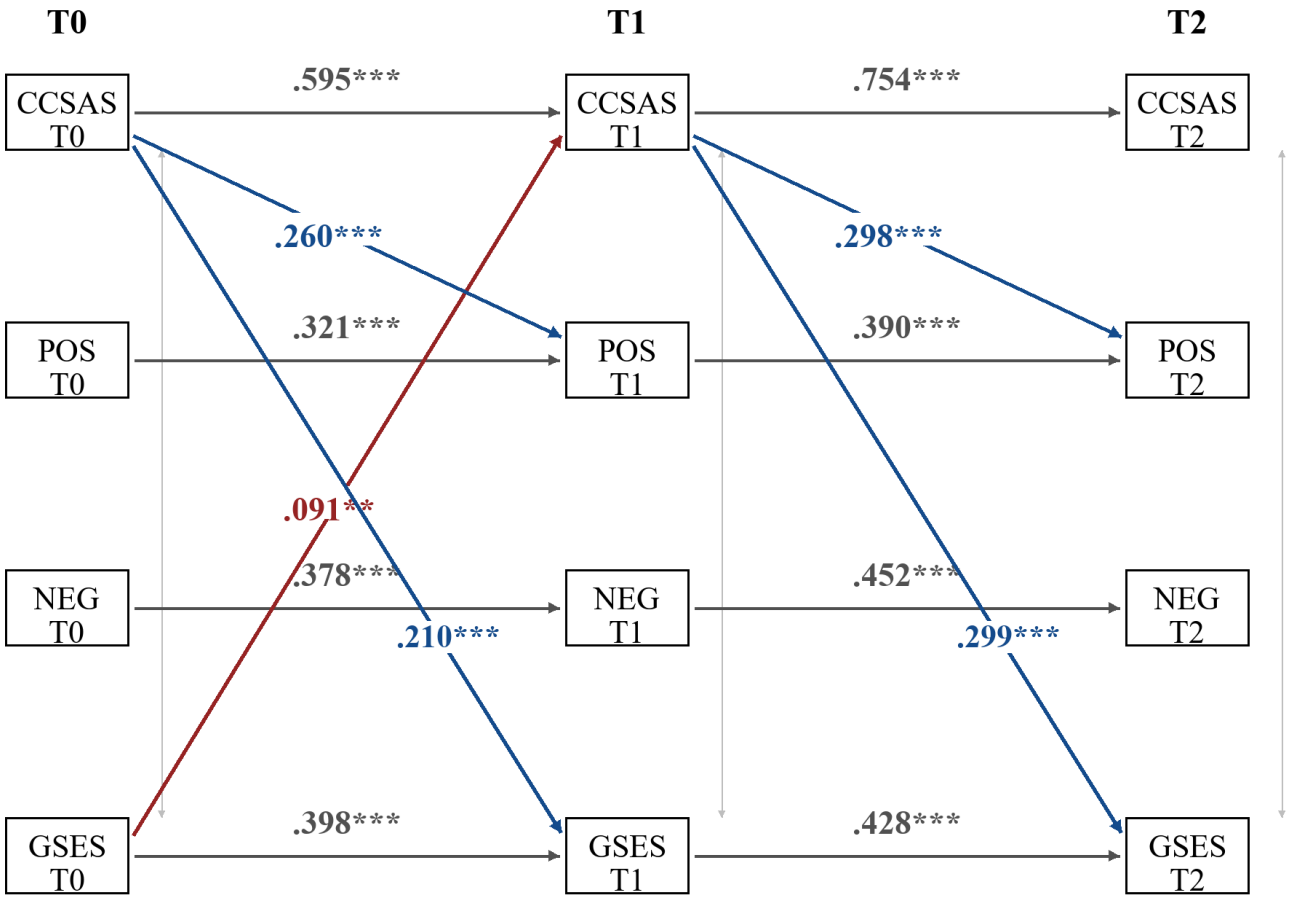


Figure 2

Final bidirectional cross-lagged panel model. Note. Standardized coefficients are shown. Only significant focal cross-lagged paths involving CCSAS are displayed; all autoregressive paths were estimated and shown in gray. Non-significant focal cross-lagged paths were omitted for clarity. POS = positive coping; NEG = negative coping; GSES = general self-efficacy. The model adjusted for sex, age, and residence. **p < .01; ***p < .001.

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