



“Have to do” or “willing to do”: Examining the relationship between self-control and academic emotions using experience sampling method

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ABSTRACT

The purpose of this study was to examine the antecedents of academic emotions among university students through real-time and multilevel analyses. We explored the link between state self-control and academic emotions, the influence of self-determination on the relationship between them, and the moderating role of trait self-control. The data was collected over seven consecutive days during which university students (N = 155) completed smartphone questionnaires. Data was organized into hierarchical two-level structures, where situations (Level 1) nested within individuals (Level 2). The results showed that positive emotions were negatively predicted by state self-control while negative emotions were positively predicted by state self-control. Moreover, state self-control under low self-determination was a significant negative predictor of positive emotions, whereas high self-determination had no predictive effect on positive emotions. The relationship between self-determination and negative emotions was further moderated by trait self-control. The limitations of this study and future research directions are also discussed.

1. Introduction

During the last 20 years, it has become increasingly important to understand emotional experiences in educational settings. Further, numerous previous studies have shown that emotional experiences in an academic context influence many psychological variables related to students' academic success, such as self-efficacy, imputation, learning strategy use, and long-term development [1, 2]. Many psychological variables are related to students' academic emotions; among these relevant proximal antecedents of academic emotions is students' self-control, which helps them persevere in their daily learning and life and directly influences their emotional experience. There is, however, little research on the relationship between academic emotions and self-control under different motivations. In line with self-determination theory (SDT), both behavior and the underlying motives have a significant impact on one's emotional experiences [3,4]. The theory holds that self-determined behavior may stimulate positive emotions more readily than

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non-self-determined behavior. Furthermore, the antecedence of emotions students feel in an educational setting includes personality and situational influence (e.g., trait self-control vs. state self-control) as distal antecedents [5,6].

In this study, we utilized the experience sampling method (ESM) to explore the fluctuations in academic emotions among university students across different situations and individuals. The primary objective of this research was to investigate the potential link between students' momentary academic emotions and their state self-control over a seven-day period. To be more precise, we sought to determine whether high or low levels of self-determined motivation in their state self-control predicted the emotional states of students. Furthermore, we investigated whether this association would be affected by students' trait self-control.

1.1. Background

1.1.1. Academic emotions

Academic emotions encompass a range of feelings and experiences that are linked to a student's educational endeavors throughout the learning journey. These emotions are closely associated with achievement-related activities and outcomes, including classroom learning activities and completing homework and examinations [7]. Unfortunately, emotions in educational settings are frequently overlooked, as there is a common misconception that emotions are in conflict with rational thinking [8,9]. Nonetheless, dismissing emotions is not advisable, as they can significantly influence the learning process, either facilitating or hindering it [10–12]. An expanding body of research has demonstrated that academic emotions are related to educational outcomes. Many studies provide evidence of positive correlations between positive academic emotions (e.g., enjoyment and happiness) and achievement as they enhance the use of learning strategies and increase motivation and effort [13–16]. Likewise, research has established a clear link between negative academic emotions and academic performance [14,17,18].

Previous studies used self-reporting to evaluate academic emotions with large samples at the same time point. Their measurements primarily focused on trait-like emotions, which are characterized as enduring and repetitive emotional patterns that individuals typically experience in relation to their academic achievements and outcomes (e.g., trait test anxiety. [19,20]). Notably, these assessments of emotions are largely under the respondents' control. They are vulnerable to response bias, which can lead to deliberate or inadvertent misrepresentations of the respondents' mental perceptions, making it difficult to accurately reflect their day-to-day experiences. Additionally, trait self-reports of emotions are global or "in general" ratings (only evaluated per person), and the inter-individual approaches to conclude about intra-individual (emotional) processes, which results in biases [5]. Alternatively, emotions can also be viewed as transient occurrences within specific situations at defined moments in time (e.g., state test anxiety experienced before an exam). Based on this definition, numerous studies have evaluated momentary academic emotions using real-time assessments that reflect the variability of academic emotions over time in various situations [21–27].

1.1.2. Self-control

The control-value theory [7,11,12] suggests that academic emotions arise when an individual perceives a sense of control or lack of control over activities and outcomes that they personally value. This implies that the evaluations of control and the subjective importance of these activities are the immediate factors influencing these emotions. It is assumed that different types of self-control evaluations in response to the same activities can trigger varying types of academic emotions. However, the conclusions regarding the relationship between self-control and academic emotions have been inconsistent in prior research [28], primarily due to the ambiguity surrounding the concept of self-control (state or trait).

Building upon previous research, this study defines state self-control as the active management of thoughts, feelings, and behaviors when facing dilemmas that require individuals to choose between valued and momentarily gratifying goals. In this case, state self-control appears to coincide with strong inner conflict, which results in negative emotional experiences. According to the strength model of self-control [29–31], self-control is conceptualized as limited resources, and all forms of self-control quickly consume these common resources. When the current self-control depletes resources, the individual may enter a state of "ego depletion", and subsequent self-control is prone to failure as the remaining available resources reduce. However, few studies focus on "ego depletion" in an academic context with empirical methods. Desires and temptations in everyday life are frequent and vary in intensity, especially in the academic context. Therefore, consequent conflicts and resistance (acts of self-control) are frequent and momentary [32–34]. In this case, students are faced with great inner conflicts and need to consume a lot of resources to control them, thus falling into a state of "ego depletion". Several studies have also shown that state self-control always entails negative outcomes, such as strong inner conflict, low well-being, and negative emotional experiences [35–37]. Specifically, state self-control is applied at every moment in daily life [38]. As described by Weathers and Siemens (2018), state self-control should be referred to as tracking activities that occur over a while and change over time [39,40]. Hence, perceptions associated with the exertion of state self-control may evolve over the course of these activities.

When considering the factors influencing academic emotions, individual differences rooted in a deeper personality structure play an essential role than mere contextual appraisals of academic situations [41]. Trait self-control, as a characteristic, refers to the ability to adjust one's reactions, particularly in order to align them with a set standard that enables an individual to initiate, sustain, or halt and restrain various activities. This includes skills such as formulating and executing plans, resisting temptations, managing impulses, and persevering through challenging tasks [42,43]. The strength model describes trait self-control as the reserves of self-control resources which would influence an individual's behavioral patterns and emotional experience [44–46]. People with high trait self-control possess a greater reserve of self-control resources compared to those with lower trait self-control [31]. A study conducted by Schmeichel and Zell (2007) found that individuals characterized by high trait self-control exhibited superior performance when it came to maintaining their efforts in a self-control task [47]. In the academic context, trait self-control is associated with numerous

favorable academic outcomes, such as higher academic achievement, positive emotions, engagement, creative thinking, and life satisfaction [44,48–51]. However, trait self-control has been discovered to be largely unrelated to state self-control but does show a correlation with engagement in academic activities in the everyday academic setting [28].

1.1.3. Self-determination

According to SDT [3,4], motivation quality determines individuals’ behaviors. Moreover, SDT provides a more nuanced perspective by introducing a motivation spectrum that spans from amotivation (non-autonomous) to intrinsic motivation (fully autonomous) in order to gauge the level of self-determined motivation. Previous studies show that autonomous types of motivation positively predict students’ higher well-being and life satisfaction [52,53], interest or enjoyment in learning [54,55], perceived knowledge transferability [56], more positive emotion [57,58], greater engagement, and lower dropout date [59–61]. As motivation shifts from non-motivation to external to internal motivation, an activity shifts from low to high self-determination [62].

While the strength model offers partial insights into the depletion effect resulting from state self-control, the process model of self-control proposed a general motivational and attentional shift as an explanation for the depletion effect [63]. The impact of state self-control on emotions may, in part, stem from a deficiency in intrinsic motivation. Following an initial exertion of effort in task one, people might be reluctant to undertake another demanding task, even if they have the capability to do so [64]. Many previous studies have also shown that the effect of state self-control on individuals’ performance is influenced by their motivation for state self-control (degree of self-determination). In particular, empirical evidence suggests that individuals who engage in autonomously motivated state self-control (high self-determined) outperform those who feel externally pressured to exert self-control (low self-determined), when it comes to subsequent task performance [65–67]. Similarly, state self-control’s influence on academic emotions depends on underlying motivations. On the one hand, state self-control is considered an imperative, effortful, and self-discordant (i.e., conflict) modus of action [38], highlighting that state self-control occurs under conditions of low self-determination driven by external motivation. Researchers have found that it is associated with intrapsychic conflicts and negative emotional experiences [28,68]. On the other hand, state self-control is regarded as a type of value-based decision-making process, where various options are assigned subjective values [69,70]. As described by Duckworth et al., individuals exercise self-control when opting for an academic goal-congruent response over an academic goal-incongruent one [48]. Thus, state self-control is based on highly self-determined academic motivations [71–73]. Although there is no direct evidence of a relationship between state self-control under high self-determination and academic emotions, it can positively predict students’ academic attainment and academic course grades [74].

1.1.4. Experience sampling method (ESM)

In order to gain a deeper insight into the intricate factors that precede academic emotions, this research utilizes the experience sampling method (ESM), a well-established procedure for real-time assessment. ESM allows for the tracking of dynamic shifts in affect, cognitions and behavior, in contrast to conventional questionnaires that can only offer retrospective and episodic “snapshots”. ESM not only enhances ecological validity but also reduces the potential for recall bias. Given the inherent variability in emotional states and behavioral motivation, ESM is widely recognized as the preeminent approach for capturing the fluid nature of subjective experiences [75].

1.2. Objectives of the study

Despite advances in the study of academic emotions in the natural learning context, there remains a dearth of evidence regarding

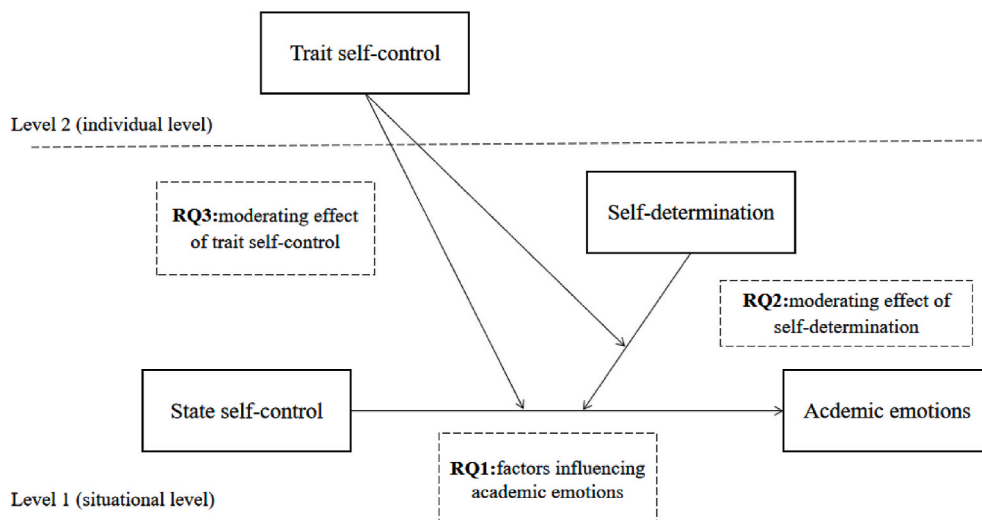


Fig. 1. The proposed research model.

the influence of self-control on academic emotions from the perspective of trait vs. state. Several researchers have indicated that trait and state self-control do not share significant positive associations but are small and negative [76–78]. Additionally, they affect academic emotions differently [28]. To effectively assess these two viewpoints, it is of paramount significance to conceptually differentiate and compare the operationalization of self-control in both aspects.

Moreover, few studies have explored the role of self-determined motivation in self-control and academic emotions. And more and more researchers tend to believe in the process model, regarding the failure of self-control as a motivation state rather than resource consumption. Nevertheless, empirical research confirming this within the academic context is currently lacking. It is imperative to persist in this research direction to unravel the potential impact of self-determined motivation on the connection between self-control and academic emotions.

The present study aims to fill these voids in the literature by surveying students' academic emotional state and behavioral motivation within seven consecutive days using ESM. Specifically, our study proposed the following questions: Research Question [RQ] 1: whether students' state self-control had a negative impact on academic emotions over seven days? RQ2: whether the effects of state self-control driven by different motivations on academic emotions differed? RQ3: whether trait self-control could affect the relationship between state self-control and academic emotions? (Fig. 1).

1.3. Research hypotheses

Our assumptions were as follows. First, we posited that students' state self-control would be accompanied by negative academic emotions over seven days. Second, we expected that the influence of state self-control on academic emotions would vary with self-determination. Specifically, we hypothesized that state self-control under low self-determination would negatively affect academic emotions more than under high self-determination. Third, we further hypothesized that state self-control had a less negative effect on academic emotions for individuals with high trait self-control.

2. Methods

2.1. Participants and procedure

The study included students in the first year of their bachelor's degree at a public university in China. The sample was collected from two classes taking elective courses by volunteer and cluster random sampling. All participants received detailed research information and provided informed consent. They had the option to withdraw if they felt uncomfortable and would be compensated accordingly. The final sample included 157 participants from an initial pool of 204 students invited to participate during class (76.4% women; mean age = 19.34 years; SD = 1.51). Participants from diverse academic backgrounds, primarily psychology majors (72%), joined the study for either course credit or ¥100 (approximately \$14 US). High-compliance participants (answering over 95% of daily signals) received an extra ¥20 (~\$3 US). The study occurred during the final week of the semester.

Data collection utilized the Teacher Mate System (TMS) within WeChat, an interactive educational platform. TMS (accessible at <https://portal.teachermate.com.cn>) not only offers various teaching functions like class attendance, homework assignments, resource sharing, and asynchronous discussions but also enables the collection of students' responses at specific time points and provides deadline reminders, facilitating the implementation of ESM programs. At the outset, participants were instructed to access our pre-established online classroom via their WeChat accounts and underwent a 1-h user training session, which covered the use of TMS and how to respond to signals.

During the seven days of data collection, we contacted participants via mobile phone six times a day to prompt them to complete the questionnaire. The sampling schedule was fixed, with participants selecting their initial sampling time between 7 a.m. and 10 a.m., typically at 9 a.m. [79]. This schedule involved each participant receiving six random signals at 2-h intervals from 9 a.m. to 9 p.m. Daily sampling included a morning questionnaire at 9 a.m., followed by four daytime questionnaires at 11 a.m., 3 p.m., 5 p.m., and 7 p.m., and an evening questionnaire at 9 p.m. No questionnaires were administered during the 1 p.m. lunch break. TMS sent an SMS reminder to the participant's mobile phone, along with a questionnaire link. Participants were instructed to complete the questionnaire promptly; otherwise, an additional reminder signal would be sent within 15 min.

The assessment procedure yielded a maximum of 42 completed state questionnaires for each participant (over seven days, with six signals per day), resulting in a total of 6594 questionnaires (42 questionnaires per person from 157 participants). Two students' answer rates were too low, so they were excluded. A total of 5665 fully or partially completed questionnaires were collected (85.9%). On average, each participant completed 36.1 questionnaires (23–42). Data points where participants did not report their current activity or could not be coded (e.g., examination or sleep) were excluded. A total of 4316 valid questionnaires were obtained. Before the seven-day diary period, participants answered a pre-test questionnaire that assessed their trait self-control and background information.

2.2. Measures

2.2.1. Self-determination

First, participants' daily activities were categorized into five groups: leisure, study, job, daily routines, and others. Participants reported their current location and the activities they were involved in based on these categories. Based on this, dummy variables were created (1 = study-related, 0 = other). Out of the 4316 valid questionnaires, 2726 (approximately 63.2%) contained data related to academic activities. Subsequent analyses focused exclusively on these academic situations. In line with prior studies on momentary

motivation [28,80], participants assessed the degree to which their current activities were driven by three autonomous reasons: "out of pleasure," "out of interest" (intrinsic motivation), and "because it is important to me" (identified motivation). Additionally, they evaluated three controlled reasons: "because someone else wants me to," "because the situation requires me to" (extrinsic regulation), and "because I would feel guilty or anxious if I did not do it" (introjected regulation). Ratings for all these reasons ranged from 1 (*not at all*) to 7 (*very much*) on a seven-point Likert scale. A composite self-determination score was computed for each activity, incorporating the following weights: $(2 \times \text{intrinsic} + 1 \times \text{identified}) - (1 \times \text{introjected} + 2 \times \text{external})$. This scoring method emphasized the continuum of self-determination. Scores spanned from -18 (non-self-determination) to 18 (self-determination).

2.2.2. Self-control

The evaluation of self-control encompassed two aspects: trait self-control at level 2 before the ESM procedure, and state self-control at level 1, during the ESM procedure. Trait self-control was assessed using the Brief Self-Control Scale [28], which is an adapted version of the original scale developed by Tangney [42]. This shortened scale consisted of 13 items, such as "I am good at resisting temptation" and "I am lazy." Participants rated these items on a five-point Likert scale, ranging from "does not apply at all" to "applies completely." The Cronbach's α for the present sample was 0.83.

State self-control refers to whether participants feel they are exercising self-control at a given moment. We assessed state self-control using three items adapted from Kuhl and Fuhrmann [38]. To streamline the questionnaires and minimize participant burden [28], we employed a real-time assessment of their engagement in everyday activities. Participants were asked to report how they felt during specific activities, rating items such as "While I am doing it, I need to pull myself together a lot" and "I find it easy to stick to it" on a six-point scale, ranging from 1 (not at all) to 6 (very much). Level-specific Cronbach's α for state self-control was 0.79 at the situational level and 0.69 at the individual level.

2.2.3. Academic emotions

In accordance with Ketonen et al. [81], participants evaluated all activities for eight emotions in the ESM questionnaire, utilizing an adapted version of the Positive and Negative Affect Schedule (PANAS). They were prompted to report the intensity of emotions they experienced at that specific moment. This assessment covered four items pertaining to positive academic emotions (interested, enthusiastic, determined, and active) and four items related to negative (anxious, nervous, irritable, and stressed). Participants provided ratings on a seven-point Likert scale, ranging from 1 (not at all) to 7 (very much). The Cronbach's α for negative emotions were 0.93 at the situational level and 0.96 at the individual level. For positive emotions the Cronbach's α were 0.89 at the situational level and 0.95 at the individual level.

2.3. Statistical analysis

The ESM data had a hierarchical structure with two levels: Level 1, representing situations ($N_{\text{Level1}} = 2726$), nested within Level 2, which represented individuals ($N_{\text{Level2}} = 155$). We adopted a multilevel modeling approach because it can effectively handle the nested data structure inherent in ESM. Since participants underwent multiple assessments each day for seven days, situational assessments were nested within individuals. To account for this nested structure, we partitioned the variance of the criterion variable into components at both Level 1 and Level 2. First, we conducted descriptive statistics for all variables using an unconditional multilevel model and explored the correlations between variables at each level. Second, we developed two multilevel models for positive and negative emotions. To streamline the model and prevent issues of non-identification, we treated positive and negative emotions as manifest factors. We assessed the impact of state self-control and self-determination on academic emotions at the situational level. Individual-level analyses determined the relationships between the variables across individuals. In improving model interpretation, variables were analyzed for variation around the grand mean at the individual level, identifying between-individual differences. In contrast, variables were analyzed for variation around each individual's mean (i.e., group mean) at the situational level, identifying within-individual functioning [82].

As per the framework proposed by Heck et al. [83], our model development progressed through five consecutive steps. In steps 1–3, we initially established a "null model" (Step 1), then incorporated predictors at both the situational level (Step 2) and the individual level (Step 3), treating all effects as fixed. In Step 4, we allowed the fixed effects at the situational level to exhibit random variations across participants. This involved examining random-effects at the level-1 parameters. In Step 5, we modeled the observed variability between individuals in situational-level effects by considering individual-level factors. This process involved constructing what are known as cross-level interactions [83–85]. During the model development process, assessments based on information criteria and deviance testing consistently indicated that each progressive step, culminating in the inclusion of cross-level interaction terms (Step 5), yielded a superior model fit. Consequently, we selected the cross-level interaction model (Step 5) as the final model, which is detailed in the subsequent section. For ease of presentation, only the final model results are provided. The process of model building and its fitting are presented in the **Appendix**. In all models, we employed a maximum likelihood (ML) estimator, and any missing data were imputed using the full-information maximum likelihood (FIML) procedure within M plus 8.4.

3. Result

3.1. Descriptive and Preliminary statistics

Table 1 presents the mean and standard deviation of the study variables. The results in Table 1 show that high state self-control (M

= 3.92, SD = 0.95) and low self-determination ($M = -1.19$, $SD = 5.78$) were reported in the academic context. The students stated that they experienced more positive ($M = 3.95$, $SD = 1.98$) than negative emotions ($M = 3.60$, $SD = 2.71$). Correlations between study variables were significant, except for gender and age. Table 1 displays the intraclass correlations (ICCs) for state assessment. The ICC quantifies the proportion of total variance attributable to differences between individuals, while the remaining percentage of variance within the total is associated with situational fluctuations alone (excluding cross-person variations). The findings in Table 1 reveal that the majority of the variance in academic emotions was observed at the individual level. Specifically, approximately 54% and 59% of the total variability in positive (ICC = 0.54) and negative emotions (ICC = 0.59), respectively, were accounted for by individual differences. Moreover, less than 50% of the variation was explained by this situation. Individual differences accounted for approximately 41% and 48% of the total variability in state self-control (ICC = 0.41) and self-determination (ICC = 0.49), respectively, indicating that the largest portion of the variance was located at the situational level.

3.2. State self-control and academic emotions

As expected, state self-control negatively affected academic emotions (Table 2). Specifically, state self-control negatively predicted positive emotions ($\beta = -0.346$, $p < 0.01$) and positively predicted negative emotions ($\beta = 0.462$, $p < 0.001$), thus supporting Hypothesis 1. However, trait self-control and self-determination positively predicted positive emotions ($\beta_{TSC} = 0.468$, $\beta_{SED} = 0.073$, $ps < 0.01$) and negatively predicted negative emotions ($\beta_{TSC} = -0.373$, $\beta_{SED} = -0.057$, $ps < 0.01$).

3.3. Moderating role of self-determination and trait self-control

To explore the impact of state self-control on academic emotions under different self-determination conditions, we used an interaction item between self-determination and state self-control (Step 4 in the Appendix). The results reveal several significant interaction effects. It is safe to conclude that a one-unit rise in SED is linked to a 0.012 increase in the “SSC→PE” slope ($\beta = 0.012$, $p < 0.01$). Furthermore, to visually illustrate the impacts of self-determination, distinct regression lines were graphed for various SED values (Fig. 2). Fig. 2 shows that low self-determination was associated with significant negative effects of state self-control on positive emotions ($\beta = -0.424$, $p < 0.01$). Nevertheless, under high self-determination, the effect of state self-control on positive emotions was insignificant ($\beta = -0.281$, $p = 0.363$). However, for negative emotions, the interaction effect of state self-control and self-determination was insignificant ($\beta = -0.001$, $p = 0.485$).

The results showed a statistically significant interaction effect regarding the moderating effect of trait self-control. It can be concluded that a one-unit increase in TSC was associated with a 0.031 decrease in the “SED→NE” slope ($\beta = -0.031$, $p < 0.05$). Moreover, as shown in Fig. 3, trait self-control moderated the size of self-determination on negative emotions. Further, high trait self-control was associated with significant negative effects of self-determination on negative emotions ($\beta = -0.074$, $p = 0.05$). However, under low trait self-control, the effect of self-determination on negative emotions was insignificant ($\beta = -0.041$, $p = 0.286$).

4. Discussion

4.1. State self-control and academic emotions

Our findings indicate that state self-control negatively influences academic emotions in a real-world academic context. We found that state self-control was associated with more negative and less positive emotions. The more state self-control students exhibited in continuous academic activities, the higher their exhibited negative academic emotions and the lower their positive ones, which is consistent with the results of a previous study [28]. When students engaged in self-control within an academic context, they were essentially involved in a self-monitoring process, guided by specific standards related to the desired or appropriate level of the targeted behavior. These standards could originate from internal sources (i.e., set by the individuals themselves) or external sources (i.e., determined by individuals other than the ones performing the activity) [86]. In other words, state self-control is often initiated when desired, and current states are detected. Moreover, monitoring plays an important role in self-control [87]. Mental monitoring of

Table 1
Descriptive statistics of and correlations among variables.

Item	Mean	SD	ICC	1	2	3	4	5	6
Level 1									
1. SSC	3.92	0.95	0.41						
2. SED	-1.19	5.78	0.48	-0.51**					
3. PE	3.95	1.98	0.54	-0.52**	0.47**				
4. NE	3.60	2.71	0.59	0.51**	-0.44**	-0.26**			
Level 2									
5. Sex	1.75	0.43		0.05	-0.13	0.01	0.12		
6. Age	19.39	1.51		-0.03	-0.08	-0.08	0.07	0.07	
7. TSC	2.86	0.56		-0.31**	0.16*	0.31**	-0.17*	0.02	0.15

Note. SSC, state self-control; SED, self-determination; PE, positive academic emotions; NE, negative academic emotions; TSC, trait self-control. Level 1 correlations are presented above the diagonal, and Level 2 correlations are presented below the diagonal. *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$.

Table 2
Multilevel analysis of self-control (state and trait) and self-determination as predictors of academic emotions (only final model).

	Final Model (PE)		Final Model (NE)	
	β	SE	β	SE
Fix				
Intercept	4.006***	0.075	3.502***	0.096
TSC	0.468***	0.134	-0.373*	0.195
SSC	-0.346***	0.033	0.462***	0.039
SED	0.073***	0.006	-0.057***	0.007
SED*SSC	0.012**	0.004	-0.001	0.005
TSC*SSC	0.042	0.057	-0.106	0.066
TSC*SED	0.020	0.011	-0.031*	0.012
TSC*SED*SSC	0.010	0.009	-0.001	0.012
Random				
Level 1				
Residual	0.618***	0.042	0.763***	0.053
Level 2				
Intercept	0.776***	0.086	1.225***	0.141
Slope _{SSC}	0.052**	0.016	0.083**	0.029
Slope _{SED}	0.003***	0.001	0.003***	0.001
Slope _{SSC*SED}	0.001	0.001	0.001	0.002

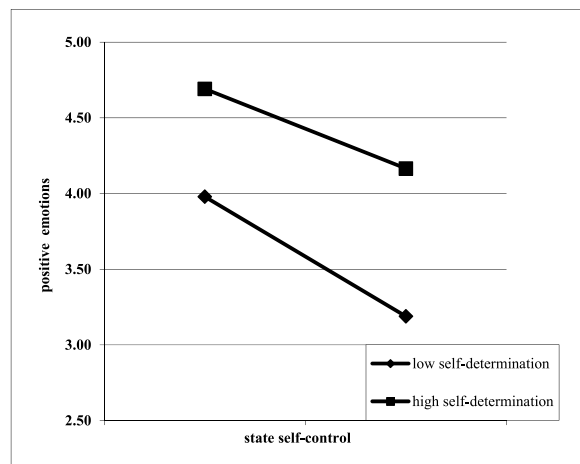


Fig. 2. Moderating effects of self-determination on “SSC→PE”.

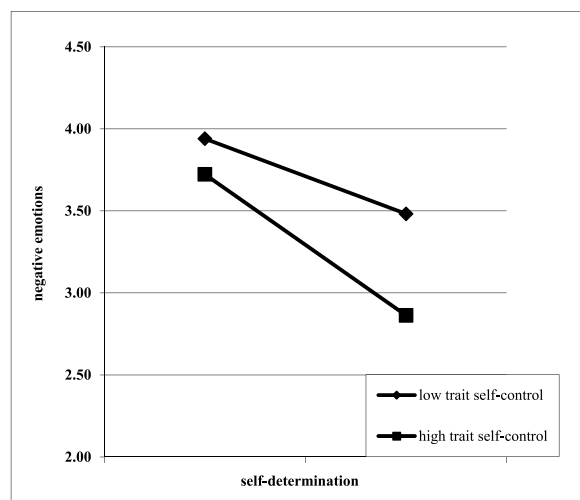


Fig. 3. Moderating effects of trait self-control on “SED→NE”.

current behavior is often considered laborious and draining internal resources, increasing students' negative emotional experiences [39]. Additionally, the detrimental effect of state self-control stems from alienation caused by the chronic application of self-control [88]. Frequent instances of state self-control can be viewed as a recurring and protective mechanism resulting from the persistent disregard of emotionally pertinent facets of the self, including needs and preferences. This research provides additional evidence supporting the adverse impact of state self-control on academic emotions.

4.2. State self-control and self-determination

As discussed above, it is crucial to delve into the connection between state self-control and academic emotions. Our findings indicated a significant interaction between self-determination and state self-control. State self-control under low self-determination significantly negatively predicted positive emotions, while the effect of state self-control under high self-determination on positive emotions was insignificant.

Overall, state self-control decreased positive emotions, but self-determination played a similar role as a moderator. In alignment with the control-value theory proposed by Pekrun [9], academic emotions are triggered when individuals perceive themselves as being in control or out of control regarding subjectively significant activities. This suggests that assessments of control and value play a pivotal role in shaping these emotions [89,90]. When students exercise state self-control under low self-determination, they often encounter challenging and cumbersome goal pursuit. This pursuit can be easily disrupted by competing motives from alternative action tendencies, resulting in decreased persistence and heightened negative emotions [91]. This may make them feel out of control of their current activities and perceive them as having low value. This "have to do" behavior pattern that integrates the uncontrollability of success or failure with the negative intrinsic value of the action will stimulate and exacerbate the negative emotional experience [92], just as Grund and Carstens describe state self-control as a *self-controlled* mode of action [28]. In contrast, when students exercise state self-control under high self-determination, they expect smoother pursuit of goals. This effectively realizes the goal functionally and allows students to be relatively relaxed and happy during participation [93]. Duckworth described self-control as necessarily self-initiated; in this process, students attribute their self-control to the controllability of expected success or failure; that is, they know that their current activities are consistent with their goals [48]. Therefore, they consider their current activities to have higher intrinsic value. This "willing to do" behavior pattern should stimulate and promote a positive emotional experience. Similarly, state self-control can be understood as a *self-controlled* mode of action.

Based on SDT, we integrated these two forms of self-control from the motivation perspective. The theory proposes that owing to the limitation of attention, individuals can only activate one of two (or more) minds regarding activities to pursue, think, or feel in a given situation. The key to how people respond is to interpret these activated perceptions. Therefore, state self-control under low self-determination can be considered driven by external motivation that students perceive as something they do not want to do and is bad for them. In contrast, state self-control under high self-determination can be considered driven by intrinsic motivation that students believe is consistent with their goals and can help improve them. For example, in preparing for exams, some students study hard to master knowledge, whereas others study hard to avoid failing, which affects their academic emotions differently.

4.3. Moderating role of trait self-control

Although no cross-level interaction was found between trait and state self-control, this study found significant cross-level interactions between trait self-control and self-determination. As the trait self-control levels decreased, the negative effects of self-determination gradually weakened. On the one hand, the effect of self-determination motivation on the academic emotions of individuals with high trait self-control was significant. Individuals with high trait self-control were willing to interpret their current activities as autonomous rather than controlled. As Fujita proposed, the dual-motivation conceptualization of self-control defines trait self-control as the general process by which people advance abstract, distal over concrete, proximal motives in judgment, decisions, and behavior [70]. Self-control promotes abstract and distal motivations rather than the specific and proximal ones of competition. Therefore, if individuals with high trait self-control think their current behavior is of low self-determination, they will experience greater conflict with their autonomous self-interpretation, resulting in a more negative emotional experience. On the other hand, even if an individual has to study under low self-determination, they can foresee potential failures and negative effects of current activities, thus prospectively limiting the possibilities and opportunities for future addiction to temptation [94–97]. This psychological expectation exacerbates negative effects on academic emotions.

4.4. Implications and limitations

In summary, this study provides several noteworthy theoretical contributions. First, it substantiates the connection between self-control and academic emotions, shedding light on the trait vs. state perspective within the Chinese context while reconciling prior conflicting findings. Second, our empirical results provide evidence for the moderating role of self-determination motivation on the relationship between state self-control and academic emotions. This study supplements the resource model of self-control by emphasizing that the impact of state self-control on academic emotions hinges on the motivation behind self-control behaviour – specifically, how students interpret and perceive their current actions – rather than the mere availability of resources. In the future, further research could delve into the motivation behind self-control to conduct a series of investigations into the antecedents of academic emotions. Furthermore, a noteworthy practical implication of this study underscores the importance of implementing effective interventions aimed at cultivating adaptive emotions among students and enhancing their persistence in challenging tasks through the

alteration of their learning motivation. Teachers can improve their teaching strategies to encourage students to learn more out of intrinsic motivation, and to ensure that students experience the joy of learning while focusing on learning.

This study had several limitations that warrant consideration in future research. First, the sample comprised primarily women, which may have affected the ecological validity of the results. The sampling time range of our ESM was relatively small. For instance, we only investigated the real-time status of students during the tensest week of reviewing for final exams. This may have limited the possible conclusions regarding students' academic emotions and self-control, as there may be different patterns in their daily academic context. Moreover, students' academic emotions may be affected by working days, such as positive weekends and negative back-to-work/school effects [98]. Further, the possible reciprocal and autoregressive effects of emotions may exist because of the cross-sectional design.

Second, in evaluating variables, the modified version of the PANAS used in this study assessed the activating dimensions of academic emotions, such as interest activity, anxiety, and nervousness, while neglecting other academic emotions, such as deactivation, boredom, and relaxation, which should also be considered. In addition, ESM essentially relies on the self-report of participants, which has potential limitations and biases, such as social desirability bias or recall bias. Future research could use various physiological indicators and cognitive neural methods to explore the differences between the two forms of self-control and their effects to verify and supplement the results of self-reporting data.

In conclusion, the statistical analysis in this study is based on two levels: the situational level is nested at the individual level without considering the variation in academic emotions at the day level. Although some studies consider the variation between days at an additional level, this results in a small within-day sample size that is difficult to explain. Simultaneously, no other study clearly distinguished the source of variance of academic emotions; therefore, we only reported the significance of situation- and individual-level variation for ease of analysis and interpretation.

5. Conclusion

This study uses a multilevel analysis method to examine the link between students' state self-control and academic emotions from a motivational perspective and the moderating role of trait self-control. The study has several main findings. First, through the ESM procedure, we found that students' state of self-control in their real academic context was always accompanied by negative academic emotions. We further explored the role of self-determination in the relationship between state self-control and academic emotion. State self-control under low self-determination significantly and negatively predicted positive emotions, whereas the effect of state self-control under high self-determination on positive emotions was insignificant. In conclusion, trait self-control moderated the relationship between self-determination and academic emotion. These findings support the creation of instructional strategies and worthwhile interventions that support students' development of adaptive emotions and enhance students' perseverance in challenging tasks by altering students' self-control motivation.

Ethical approval

The procedures for human participants involved in this study were consistent with the ethical standards of Central China Normal University and the 1975 Helsinki Declaration. The approval number is CCNU-IRB-202201013b.

Informed consent

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

Data availability statement

Data will be made available on request.

Supplementary content related to this article has been published online at [URL].

CRediT authorship contribution statement

Zhong-Jian Liu: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Jun Hu:** Conceptualization, Investigation, Writing – original draft. **Yuan Tian:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Project administration, Supervision. **Yu-Ting Xi:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Software.

Declaration of competing interest

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

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2023.e20598>.

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