# Dynamic Calibration of Self-Efficacy to Cognitive Load: The Longitudinal Mediation Effect of State Anxiety

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Keywords: self-efficacy; state anxiety; cognitive load; mediating effect

*Article*

# Dynamic Calibration of Self-Efficacy to Cognitive Load: The Longitudinal Mediation Effect of State Anxiety

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**Abstract:** The primary aim of this study was to investigate the variations in cognitive load as self-efficacy gradually increases and examine the potential within-mediating effect of state anxiety between self-efficacy and cognitive load. The experiment manipulated the self-efficacy of 49 adult participants through the false feedback paradigm, employing a within-subject experimental design and using facial expression recognition as the experimental task. The data were analyzed using Hierarchical Linear Modeling. The results revealed that self-efficacy negatively predicted state anxiety and cognitive load, while state anxiety positively predicted cognitive load. Moreover, state anxiety played a complete mediating role at multiple levels in this process.

**Keywords:** self-efficacy; state anxiety; cognitive load; mediating effect

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**Educational relevance and implications statement:** The current research predominantly focuses on investigating self-efficacy, state anxiety, and cognitive load from a static, macro perspective. However, limited studies have delved into the potential mediating relationships among these factors during task execution. Our study employs various methodologies to confirm the multi-level mediating role of state anxiety in the immediate influence of self-efficacy on cognitive load. This suggests that establishing effective self-efficacy regulation mechanisms could significantly reduce the cognitive resources occupied by anxiety emotions during learning or work processes, allowing individuals to allocate limited cognitive resources to the tasks themselves, thereby enhancing learning and work efficiency.

## 1. Introduction

Envision a scenario in which one is approaching an examination with full confidence, only to encounter an inability to answer the first question. This not only shakes the initial confidence but also triggers a sense of anxiety, disrupting the previously calm demeanor. Proceeding with the test in this state of unease, even questions of lesser difficulty that one would typically answer correctly would seem insurmountable. Such scenarios occur in daily life, not only in exams but also in contexts such as competitions, games, or any situation where feedback is required. When an individual's self-efficacy changes suddenly, their emotions and resource allocation are likely to change accordingly. In the case of decreased self-efficacy, two potential paths of change exist. One involves individuals choosing to reduce cognitive investment in the task after a decrease in confidence, while the other path entails increasing efforts to tackle the current challenges, thereby consuming more cognitive resources.

From an experiential perspective, during the process of task execution, there may be a dynamic relationships among self-efficacy, state anxiety, and cognitive load. These relationships can significantly affect people's behaviors. However, the mechanisms underlying the relationships

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among the three variables have yet to be clarified. This study aims to explore the dynamic effect of self-efficacy on cognitive load and the role of state anxiety in this process.

## 2. Self-Efficacy and Cognitive Load

Self-efficacy refers to an individual's belief in their ability to mobilize motivational and cognitive resources, and action plans to meet the demands of a given situation (Bandura & Wood, 1989). Cognitive load refers to the total amount of mental activity imposed on an individual's cognitive system during a specific task (Sweller et al., 1998). Due to its subjectivity, implicitness, and variability (Fred et al., 2010), cognitive load can be understood as a subjective experience generated in the learner's mind during the learning process or when solving objective tasks (Paas et al., 2003). Hence, self-efficacy and cognitive load share a common characteristic: they refer to a learner's perception of their ability or the difficulty of a specific task (Feldon et al., 2019), which implies that self-efficacy and cognitive load are closely related.

Consistent with this view, scholars have investigated motivation as a cognitive load coordination mechanism and found that self-efficacy is most likely to affect cognitive load (Christensen Ii, 2005). Further research has also confirmed that self-efficacy has significant effects on subjective measurements of cognitive load, task performance, and physiological measurements (Jin bo & Bai hua, 2009). For example, the findings of a study utilizing self-report ratings of perceived task difficulty to measure cognitive load revealed that participants who perceived themselves as more creative in creative thinking tasks, namely those with higher creative self-efficacy, experienced lower cognitive load (Redifer et al., 2021).

In addition, a study on reading comprehension ability utilized verbal working memory, reading fluency, syntactic skills, and reading comprehension as representative cognitive factors involved in reading comprehension. The results indicated that motivation positively predicts individual reading ability, suggesting that motivation can enhance students' cognitive engagement in reading (Yeung, 2022). Another study revealed a negative correlation between students' English reading self-efficacy and intrinsic cognitive load (Zhang et al., 2023). A study utilizing electroencephalogram to investigate motivation and working memory capacity revealed that high resilience was linked to decreased alpha event-related desynchronization during the encoding and retrieval stages of very challenging tasks. Furthermore, a strong subjective motivation to accomplish the task was linked to a decline in theta event-related synchronization during retention in difficult conditions (Zhozhikashvili et al., 2024). The preceding studies have substantiated that self-efficacy can also influence objective indicators of cognitive load evaluation and physiological measures.

## 3. State Anxiety and Cognitive load

Negative emotions are an important factor that influences cognitive load (Chen & Wu, 2015; Cheng et al., 2020; Li et al., 2010). Anxiety is one of the most prevalent negative emotions experienced by individuals. Speilberger divided anxiety into trait and state anxiety (Speilberger et al., 1983). The former is a personality trait that has a relatively stable tendency toward anxiety with individual differences. The latter refers to a temporary and passive reactive state of individuals in specific situations, characterized by tension, worry, distress, fear, and apprehension (Spielberger, 1966). State anxiety is triggered by situations and can affect an individual's performance in situational tasks; however, the underlying mechanism of this impact has not been clarified (Leal et al., 2017). Anxiety itself can occupy a portion of the cognitive processing resources that should be used for working memory processes (Vytal et al., 2012).

Initially, scholars investigated the correlation between cognitive resources and anxiety and found that these resources are limited in quantity. When an individual's level of anxiety is high, this results in a relative insufficiency of working memory resources available for cognitive tasks (Sorg & Whitney, 1992). Subsequently, building upon the foundation of these studies, processing efficiency theory provides a corresponding explanation. The theory of processing efficiency suggests that an individual's cognitive resources are limited (Wilson et al., 2007). When negative emotions such as anxiety occupy an individual's cognitive resources, the resources available for cognitive operations

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will consequently decrease. Therefore, when individuals experience negative emotions such as anxiety, their cognitive functioning is affected, and their engagement in tasks is also affected (Elliman et al., 1997; Eysenck & Calvo, 1992). The theory also distinguishes between task performance and processing efficiency, where task performance refers to the quality of task completion, whereas processing efficiency denotes the ratio between task performance and the resources invested, reflecting the efficiency of the working memory system. Therefore, anxiety does not necessarily impair cognitive performance effectiveness but weakens an individual's processing efficiency, which refers to the relationship between performance outcomes and the processing resources used (Eysenck, 1985).

Numerous studies have corroborated the efficacy of this theory. The literature has shown that state anxiety can impair attentional alertness and orientation in adolescents (Allen et al., 2010). The education literature further validates the above-mentioned theory. A study on online learning indicated that anxiety directly influences students' perceived knowledge improvement, boredom, and cognitive load, thereby negatively impacting their academic performance. Another study on math test anxiety revealed that children with high mathematical anxiety also exhibit higher cognitive load (Shi et al., 2022).

**4. Self-Efficacy and State Anxiety**

Previous studies have revealed that self-efficacy is closely correlated with status anxiety (Vytal et al., 2012). Upon examination, previous studies can be divided into two main strands. (1) Some studies indicate that state anxiety diminishes individuals' sense of self-efficacy (Usher & Pajares, 2008). This can be interpreted as follows: A characteristic of anxiety experience is a distorted self-image, where an individual who has experienced high levels of anxiety may perceive their abilities as inadequate (Beck & Clark, 1997). Holding a pessimistic viewpoint leads individuals to misinterpret their mistakes as incompetence, thereby reducing their self-efficacy. (2) Other studies indicate that self-efficacy often has a greater impact on individuals' emotions, whereby individuals with low self-efficacy are more prone to experiencing negative emotions such as anxiety and worry (Burns et al., 2021; Kavanagh & Bower, 1985). Self-efficacy plays a central role in individual cognitive processes by exerting a strong influence on thoughts, emotions, motivations, and actions (Bandura, 1991). From a static perspective, a study has indicated that students with low self-efficacy tend to exhibit higher levels of state and trait anxiety. Moreover, high levels of general self-efficacy and low levels of trait anxiety predict 27% of the variance in test anxiety. Another study on online learning indicated that academic efficacy can impact students' actual anxiety manifestations (Hong et al., 2023). Both studies demonstrated the significant impact of self-efficacy on state anxiety. From a dynamic standpoint, results from an ecological momentary assessment (EMA) study have shown that higher willpower self-efficacy significantly predicts positive emotions (Veilleux et al., 2020). The research employs a longitudinal design to validate the structure of anxiety predicting factors, revealing that self-efficacy is a crucial factor predicting emotional and performance-related outcomes.

**5. Dynamic Change of Self-Efficacy and State Anxiety in Tasks**

Evidence from theory and empirical studies both support the dynamic changes in self-efficacy and state anxiety during the process of task completion. First, the theory of self-efficacy fluctuation (Mu Xia, 2021) suggests there is a possibility that self-efficacy during task execution may undergo brief and dynamic changes along with the feedback results of that task. Consistent with this hypothesis, the study found that successful experiences convey positive feedback to individuals, thereby enhancing their sense of efficacy, whereas unsuccessful experiences transmit negative feedback, leading to a decrease in self-efficacy. Therefore, feedback serves as a significant method for increasing or decreasing self-efficacy (Bandura, 1977; Tolli & Schmidt, 2008). Previous studies have confirmed the phenomenon of self-efficacy fluctuation (A et al., 2018; Maddux, 1995; Silvia, 2003).

Second, state anxiety seems to exhibit significant variability. For example, feedback information has the potential to alter levels of anxiety. A study found that examination situations can induce state anxiety (Dimitriev et al., 2016). Similar results were found in another study in which participants

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were required to conduct two impromptu speeches, with feedback provided after the first speech. The second speech demonstrated a decrease in anxiety levels and negative assessments compared to the first speech (Chen et al., 2018). McEnoy (2023) also found that the anxiety individuals experience during task execution resembles self-efficacy, as they experience dynamic changes in response to positive or negative feedback. Changes in circumstances can also influence the level of state anxiety. Research has shown that negative events in life can significantly elevate an individual's level of state anxiety (Hui-Ying & Wan, 2017). Literature on establishing a state anxiety tracking model mentions inducing participants' state anxiety by exposing them to images of varying levels of aversion, capturing the dynamic changes in state anxiety levels using dimensional emotion ratings, electrocardiograms, and skin conductance responses (Saviola et al., 2020).

## 6. Aim of the Study

The literature review provides two significant clues for this study. One is that previous research consistently demonstrated that both self-efficacy and state anxiety can have a significant impact on cognitive load, which suggests that self-efficacy may have an influence mechanism on cognitive load, with state anxiety as a mediating factor. The other clue is that individuals' self-efficacy and state anxiety fluctuate when receiving feedback, indicating a dynamic interplay between the two during task performance. Therefore, fluctuations in self-efficacy may lead to changes in state anxiety and cognitive load, indicating the existence of a mechanism where state anxiety mediates the impact of self-efficacy on cognitive load. Previous studies that explored the relationship between emotion and cognitive load mainly employed static scene tasks and single-focus attention paradigms; however, emotions in real life are complex and dynamically changing. Based on this premise, the present study initially verifies self-efficacy as influencing the dynamic calibration mechanism of cognitive load in real-life scenarios through surveys and interviews. Subsequently, the validity of this mechanism is examined using experimental methods. The experiment uses a mixed design, and the experimental task is an expression recognition task. It employs the paradigm of false feedback to manipulate individuals' self-efficacy and explores the impact of dynamic changes in self-efficacy on state anxiety and cognitive load, reflecting the dynamic process of emotional-cognitive changes in task execution. Finally, hierarchical linear modeling is used to verify the experimental results.

## 7. Study 1

In line with the research approach of "extensive collection, preliminary exploration, and subsequent verification," Study 1 utilizes a questionnaire survey and in-depth interviews to investigate the fluctuations in self-efficacy. Participants who meet the criteria and are willing to participate in interviews are selected for in-depth interviews to obtain first-hand information on their perspectives and understanding of the fluctuations in self-efficacy. Furthermore, the obtained textual data are analyzed to explore the psychological connotations and influencing mechanisms of self-efficacy fluctuations.

### *7.1. Method*

#### 7.1.1. Participants

Adopting convenient sampling, we selected 146 students from a university in Guangxi, China to participate in an online questionnaire survey. To ensure the participants' earnest completion of the questionnaire, the course instructor read out the instructions before the class started, and we asked the students to open the questionnaire link simultaneously. From the students who completed the questionnaire, we selected 22 individuals who met the criteria and were willing to further participate in in-depth interviews.

#### 7.1.2. Materials

The online questionnaire had questions on self-efficacy. This survey primarily focused on the phenomenon of fluctuation in individual self-efficacy. After being evaluated by experts in the field

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of self-efficacy, the participants were distributed. The survey investigated the universality of self-efficacy fluctuations, the impact on individual behavioral performance, and the influence on individual emotional states.

The interview guide had 10 questions, which had been reviewed by experts. It mainly focused on the experience of self-efficacy changing in a short period after passing or failing the task. Participants were required to elaborate on the aspects of time, place, characters, and events, then provide detailed explanations of their inner experiences and emotional changes at that moment.

7.1.3. Procedure

First, self-efficacy surveys were distributed to 146 participants. After collecting and analyzing the data, eligible individuals who answered "yes" to all three questions in the questionnaire were invited for interviews within the following week. Ultimately, 22 participants agreed to be interviewed. Upon completion of the interviews, each participant was given a gift.

7.1.4. Result

By examining Figure 1, the results of the survey showed that 93.84% (137 participants) of the participants had experienced fluctuations in self-efficacy($\chi^2$=146.00, $p$<0.001). Among them, 78.83% (108 participants) believed that improving self-efficacy during the task process could increase their positive emotions, whereas decreasing self-efficacy could increase their experience of negative emotions ($\chi^2$=135.00, p<0.001).

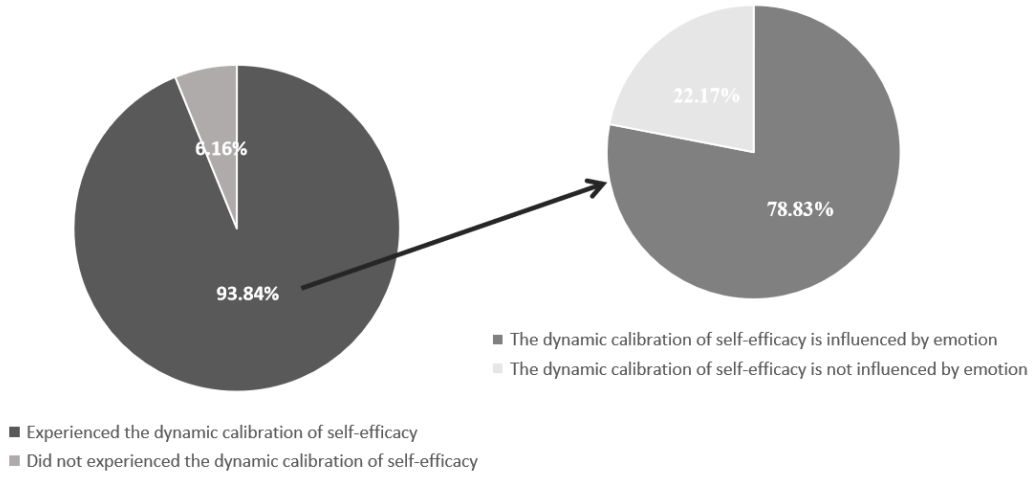


**Figure 1.** Results of self-efficacy dynamic calibration.

The interview results showed that individuals' self-efficacy perceptions can be improved or reduced based on their experiences of success or failure during the task execution process. Success experiences can lead to an increase in perceived self-efficacy, and 59% of the participants expressed positive emotions such as happiness and pride. By contrast, when individuals experience failure, their self-efficacy decreases, and 86% of the participants reported negative emotions such as anxiety, frustration, and sadness.

In terms of the frequency of occurrence of fluctuations in self-efficacy, as illustrated in Figure 2, 27% of the participants reported that such events occurred less frequently, 41% reported that such events occurred occasionally in life, and 32% reported that they experienced frequent episodes of self-efficacy fluctuations. When exploring the reasons for changes in individual self-efficacy among the participants, more than half of them believed that self-efficacy often affects subsequent task

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performance and engagement through emotions. This is consistent with previous research findings (Benfer et al., 2018; Namaziandost et al., 2023; Plass & Kalyuga, 2019).

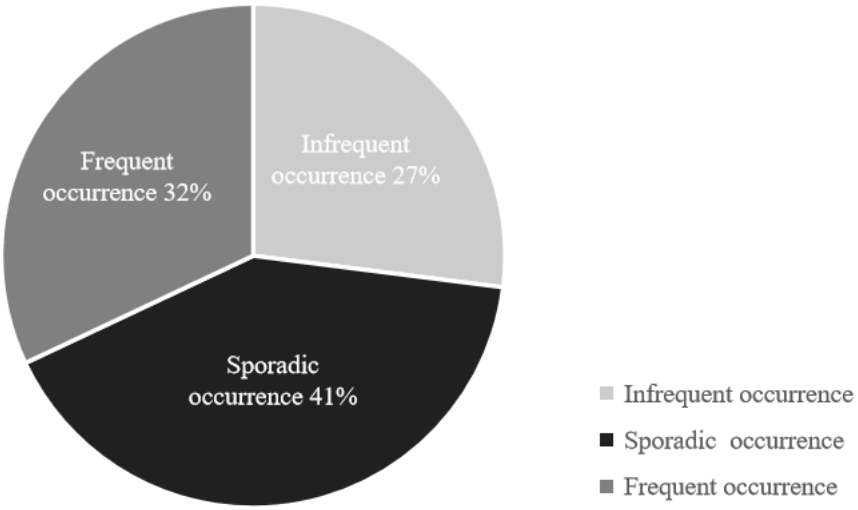


**Figure 2.** Occurrence of the dynamic calibration phenomenon of self-efficacy.

*7.2. Study 2*

7.2.1. Materials

The emotion pictures used in the task were selected from the NimStim database (Tottenham et al., 2009). The evaluation time of the NimStim emotional face database was lengthy and most of the participants in the NimStim evaluation were foreigners. Therefore, to control experimental variables, we first recruited Chinese university students to evaluate the pictures in the emotion database. Using convenience sampling, 40 college students (17 males and 23 females) from Guangxi University for Nationalities were selected as participants. A total of 157 fear, disgust, sadness, and anger emotion pictures with original accuracy below 80% were selected from the NimStim emotional face database.

Finally, 60 pictures were chosen as the materials for the formal experiment. Based on the correct recognition rate of the images by 40 participants, we selected 15 images with the lowest correct rate for each expression as the materials for the formal experiment to adopt the false feedback paradigm. To make the participants believe that the feedback they received was real, we chose tasks with higher difficulty as experiment materials.

7.2.2. Participants

We recruited 96 college students as participants, after screening out invalid data, 86 participants remained (32 male and 54 female students aged between 18 and 24 years). The feedback group consisted of 39 participants, whereas the non-feedback group consisted of 47 participants. The participants had normal or corrected vision and good health conditions. They were given a small gift after completing the experiment. In addition, they were informed that the feedback received during the experiment was not their actual performance.

7.2.3. Materials

A self-constructed self-efficacy questionnaire was used. Bandura recommends using as few items as possible when measuring short-term changes in self-efficacy (Bandura & Pajares, 2006). The questionnaire consisted of one item, namely the level of confidence in completing tasks, on a 9-point

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rating scale. Participants were required to choose a suitable number from 1 to 9 based on their own feelings, with the confidence level increasing sequentially from 1 to 9.

Short State Anxiety Inventory (SSAI): We used the Chinese Brief State Anxiety Scale (Tian et al., 2018), which consists of two factors: anxiety presence and anxiety absence, each with three items. Each item is scored on a scale of 1 (not at all) to 4 (almost always), with the items of anxiety absence being reverse scored. Higher scores indicate higher levels of anxiety. The internal consistency reliability of this scale is 0.82. In this study, only the factor of anxiety presence was used to measure the participants' state anxiety levels.

The revised version of The Cognitive Load Subjective Ratings (Paas, 2003) is a commonly used questionnaire to measure cognitive load. It consists of three items, which evaluate both psychological effort and task difficulty. Two of the items are similar, focusing on the evaluation of task difficulty. To minimize the number of questions in this experiment where participants' cognitive load is measured multiple times, only two questions are used. Both questions adopt a 9-point rating scale. Participants are required to choose a suitable number from 1 to 9 based on their own feelings to answer the two items. The numbers from 1 to 9 represent increasing levels of psychological effort and material difficulty, with 1 indicating minimal effort and "very easy," and 9 indicating maximum effort and "very difficult." The scale demonstrates high reliability, with an internal consistency reliability coefficient of $\alpha$=0.74 (Paas & Merrinboer, 1993). The cognitive load index is the average of the two dimensions.

The Nimstim emotional facial expression database.Sixty negative emotion pictures were selected from the images evaluated in Experiment 1, with a moderate level of difficulty. This includes 15 pictures each of fear, disgust, sadness, and anger(Tottenham et al., 2009).

Procedure

The study employed a 3 (repeated measures: first time, second time, third time) × 2(conditions: feedback group, non-feedback group) mixed experimental design. The feedback conditions were considered between-subjects factors, while the repeated measures were regarded as within-subjects factors. A facial expression recognition task was utilized as the experimental content, manipulating participants' self-efficacy through a false feedback paradigm. The experiment consisted of 4 task blocks, each task block comprising 15 trials. The first block served as practice, followed by the cyclical execution of the subsequent three task blocks, as illustrated in Figure 1. Within this cycle, each block commenced with a false feedback(correct recognition numbers) that incrementally increased. The first false feedback based on the practice task, randomly presenting correct recognition numbers ranging from 1 to 3. With the second block displaying correct recognition numbers ranging from 6 to 8, and the third block presenting numbers from 11 to 13. After participants received false feedback, their self-efficacy and state anxiety levels were promptly assessed. Following this, participants engaged in the facial expression recognition task, where they were required to identify fear, disgust, sadness, and anger in 15 facial expression images. Cognitive load was evaluated immediately after the completion of the facial expression recognition task, marking the conclusion of a full block. A more elucidating experimental procedure is presented in Figure 3.

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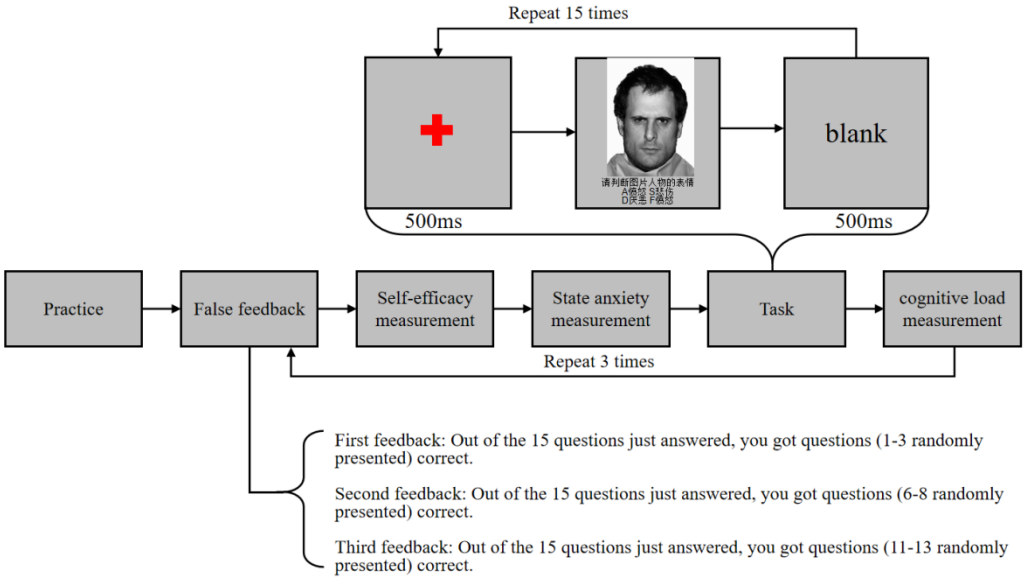


**Figure 3.** The formal experiment process.

Data Analysis

The data were subjected to descriptive analysis using IBM SPSS 26 to understand the performance of the main variables in the experiment, followed by mixed-design ANOVA to verify the effectiveness of manipulating self-efficacy perception in the false feedback paradigm. Repeated measures represent a within-subject factor, while grouping delineates a between-subject factor. Subsequently, HLM 6.08 was employed to conduct multilevel linear analysis on the data from the feedback group, confirmed that the impact of self-efficacy on cognitive load is mediated through multi-level mechanisms of state anxiety.

## Result

*Self-Efficacy Manipulation Test*

Descriptive statistical analysis was conducted on the data of 86 participants using SPSS 26.0. The mean trends of self-efficacy, state anxiety, and cognitive load across three measurements by participants are illustrated in Table 1.

**Table 1.** Descriptive statistics (Mean, SD).

| | First measurement | | Second measurement | | Third measurement | |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Feedback group(n=39) | | | | | | |
| Self-efficacy | 4.74 | 2.19 | 5.79 | 2.05 | 6.67 | 1.75 |
| State anxiety | 5.72 | 2.08 | 4.69 | 1.76 | 3.87 | 1.28 |
| Cognitive load | 6.82 | 1.12 | 6.26 | 1.23 | 5.76 | 1.35 |
| Non-feedback group(n=47) | | | | | | |
| Self-efficacy | 5.45 | 1.84 | 5.34 | 1.76 | 5.51 | 1.91 |
| State anxiety | 5.40 | 2.03 | 5.36 | 2.12 | 4.87 | 2.04 |
| Cognitive load | 6.35 | 1.35 | 6.30 | 1.32 | 6.28 | 1.47 |

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After the participants received three different intensities of false feedback, their self-efficacy, state anxiety, and cognitive load were measured in a timely manner. The effectiveness of self-efficacy manipulation was verified using repeated-measures analysis of variance.The study also confirmed that significant variations exist in state anxiety and cognitive load following changes in self-efficacy under different conditions. For p-values that did not meet the assumption of sphericity, Greenhouse-Gessisser correction was applied. Bonferroni correction was used for multiple comparisons.

Firstly, a repeated measures analysis of variance was conducted with self-efficacy as the dependent variable, using a 3 (measurement time: 1, 2, 3) × 2 (group: Non-feedback group, Feedback group) design. The results revealed a significant main effect of measurement time, $F(2, 168) = 22.821$, $p<0.001$, $\eta_{2p}^2=0.214$.Additionally, a significant interaction effect between measurement time and group was observed, $F(2, 168) = 20.367$, $p<0.001$, $\eta_{2p}^2=0.195$. Further simple effects analysis indicated a significant simple effect of measurement time under the feedback condition, $F(2, 83) = 25.755$, $p<0.001$, $\eta_{2p}^2=0.383$. The self-efficacy perception as measured three times by the feedback group exhibited a significant gradually increase, rising from 4.74 in the first measurement to 6.67. Furthermore, all associated p-values were below 0.001. While no significant simple effect of measurement time was found under the non-feedback condition, $F(2, 83) = 0.693$, $p=0.503$, $\eta_{2p}^2=0.016$. It suggests that by using the false feedback paradigm and creating different feedback conditions for the participants, their self-efficacy can be effectively manipulated.

Previously, to examine whether changes in self-efficacy affect state anxiety and cognitive load, a repeated measures analysis of variance was conducted for both variables, with three measurement times (1, 2, 3) and two groups ( Feedback group，Non-feedback group).

Conducting a repeated measures analysis of variance with state anxiety as the dependent variable across three measurement time (1, 2, 3) and two groups ( Feedback group, Non-feedback group,) revealed a significant main effect of measurement time $F(2, 168) = 25.183$, $p<0.001$, $\eta_{2p}^2=0.231$. The interaction effect between measurement time and group is statistically significant, $F(2, 168) = 8.294$, $p<0.001$, $\eta_{2p}^2=0.090$. Further simple effect analysis revealed that under feedback conditions, the simple effect of measurement time on state anxiety was significant, $F(2, 83) = 24.829$, $p<0.001$, $\eta_{2p}^2=0.374$. The state anxiety perception as measured three times by the feedback group exhibited a significant gradually decrease, reducing from 5.72 in the first measurement to 3.87. Furthermore, all associated p-values were below 0.001. Whereas under non-feedback conditions, the simple effect of measurement time on state anxiety was not significant, $F(2, 83) = 2.994$, $p=0.056$, $\eta_{2p}^2=0.067$.This indicates that there are significant differences in state anxiety within the feedback group that correspond to changes in self-efficacy.

Cognitive load was taken as the dependent variable in a repeated measures analysis with 3 (measurement time: 1, 2, 3) × 2 (group: Feedback group, Non-feedback group) design. The main effect of measurement time on cognitive load was found to be significant, $F(2, 168) = 11.603$, $p<0.001$, $\eta_{2p}^2=0.121$.There was a significant interaction effect between measurement time and group, $F(2, 168) = 8.748$, $p<.001$, $\eta_{2p}^2=0.094$.Further simple effects analysis revealed that under feedback conditions, there was a significant simple effect of measurement time on cognitive load, $F(2, 83) = 13.627$, $p<0.001$, $\eta_{2p}^2=0.247$. The three measurements of cognitive load by the feedback group demonstrates significant gradually decrease, reducing from 6.82 in the first measurement to 5.76. Furthermore, all associated p-values were below 0.01. Conversely, under non-feedback conditions, the simple effect of measurement time on cognitive load was not significant, $F(2, 83) = 0.081$, $p=0.922$, $\eta_{2p}^2=0.002$. It suggests that cognitive load within the feedback group varies significantly with changes in self-efficacy.

Based on this, we can preliminarily confirm that within this study, false feedback can successfully manipulate participants' self-efficacy, namely, individuals' self-efficacy in the task increases with the accuracy of false feedback. Furthermore, following changes in self-efficacy, individuals' state anxiety and cognitive load in the task also undergo alterations.

*Multilevel Mediation Effects of State Anxiety*

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The experimental group consisted of 48 valid participants. Since this study used a multilevel linear model to test the mediation effects, and the data at level 2 were contextual variables, it was necessary to test the within-group consistency of the data. Firstly, in order to ensure the within-group consistency of the data, it was stipulated that $r_{wg}$ must exceed 0.70. Within this study, the average $r_{wg}$ of the three variables included were 0.71, 0.84, and 0.88, respectively, all meeting the criterion of being greater than 0.70, indicating a high level of within-group consistency. The ICC(1) for the three variables were 0.59, 0.54, and 0.51, all greater than 0.06. The ICC(2) was 0.76, meeting the criterion of being greater than 0.70, indicating a high level of between-group heterogeneity and allowing for multilevel mediation analysis.

In this study, self-efficacy and state anxiety are centralized at the individual level. Based on the variables of self-efficacy, state anxiety, and cognitive load in this study, a 1-1-1 lower-level mediation model was constructed for analysis, as shown in Figure 4.

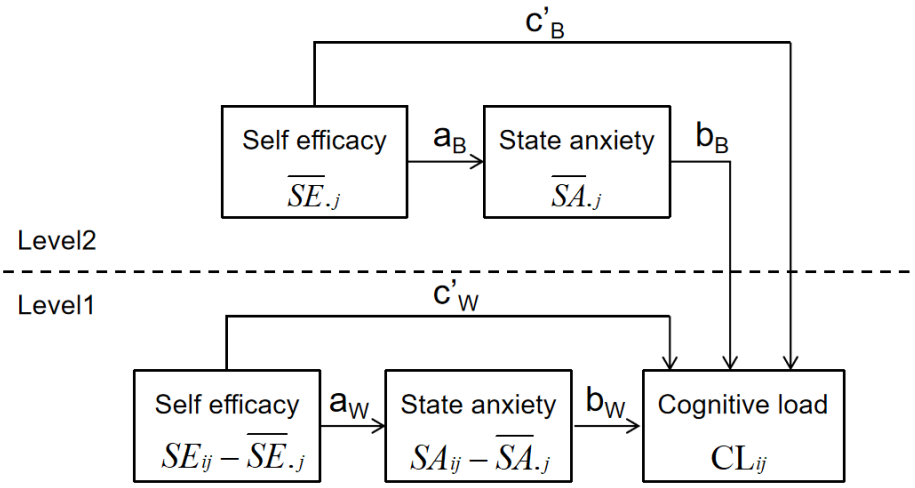


**Figure 4.** The Multilevel Mediational Model of State Anxiety.

The method of sequential testing of regression coefficients(Baron & Kenny, 1986)was employed to conduct a multilevel analysis on the mediating effect of state anxiety between self-efficacy and cognitive load.

Step 1, establish a null model. Among them, ICC = $u_0$ /( $u_0$ + r) =.5174, and the within-group correlation coefficients are all greater than 0.060. The nested structure of the data cannot be ignored, and a multilevel mediation analysis is needed.

Step 2, test the direct effect of the independent variable on the dependent variable c. The results show that self-efficacy can negatively predict cognitive load ( $\gamma_{10}^{c}$=-0.22 , $p$<.001), indicating a significant effect c.

Step 3, test the effect of independent variable on the mediating variable a. The results show that self-efficacy can negatively predict state anxiety ($\gamma_{10}^{a}$ = -.53, $p$ < .001), indicating a significant effect of a.

Step 4, the effects of both the independent variable and the mediating variable on the dependent variable, c' and b, were examined. The results indicate that self-efficacy and state anxiety simultaneously have a non-significant effect on cognitive load, c' ($\gamma_{10}^{c'}$=-.13, p=.078), but the effect of b ($\gamma_{20}^{b}$=.21, p<.05) is significant.Based on previous research, when regression coefficients a, b, and c are all significant and the t-test for the estimated value of regression coefficient c' does not reach significance level, it indicates that this mediating effect is a complete mediating effect. The size of the

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mediating effect is measured by ab($r_{a1\,10} \times r_{b1\,20}$), and the mediating effect is 0.25. Based on the above results, a sobel test was conducted for the mediating effect. The results showed that the mediating role of state anxiety was significant ($t = 2.25$, $p < 0.05$).

Detailed data can be found in Table 2.

**Table 2.** A multi-level mediation model of self-efficacy, state anxiety, and cognitive load.

| Model | Parameter estimation | | | | |
|---|---|---|---|---|---|
| | $\gamma 00$ | $\gamma 10$ | $\gamma 20$ | $\tau 00$ | $\sigma^2$ |
| The null model | 6.27*** | | | 3.58*** | 0.82 |
| Level 1：$CL_{ij} = \beta_{0j} + r_{ij}$ | | | | | |
| Level 2：$\beta_{0j} = \gamma_{00} + u_{0j}$ | | | | | |
| Self efficacy-Cognitive load | 7.53*** | -0.21*** | | 3.63*** | 0.70 |
| Level 1：$CL1ij = \beta_{0j} + \beta_{1j}*(SE_{ij}) + r_{ij}$ | | | | | |
| Level 2：$\beta_{0j} = \gamma_{00} + u_{0j}$ | | | | | |
| $\beta_{1j} = \gamma_{10}$ | | | | | |
| Self efficacy-State anxiety | 7.82*** | -0.53*** | | 1.69*** | 1.07 |
| Level 1：$SA_{ij} = \beta_{0j} + \beta_{1j}*(SE_{ij}) + r_{ij}$ | | | | | |
| Level 2：$\beta_{0j} = \gamma_{00} + u_{0j}$ | | | | | |
| $\beta_{1j} = \gamma_{10}$ | | | | | |
| Self efficacy、State anxiety-Cognitive load | 7.63*** | -0.13 | 0.21* | 3.74*** | 0.66 |
| Level 1：$CL_{ij} = \beta 0j + \beta 1j*(SE_{ij}) + \beta_{2j}*(SA_{ij}) + r_{ij}$ | | | | | |
| Level 2:$\beta_{0j} = \gamma_{00} + \gamma_{01}*(SE_j) + \gamma 02*(SA_j) + u_{0j}$ | | | | | |
| $\beta_{1j} = \gamma_{10}$ | | | | | |
| $\beta_{2j} = \gamma_{20}$ | | | | | |

## Discussion

The purpose of this study is to explore the multiple mediating mechanism of self-efficacy and cognitive load. Study 1 investigates the possible causal relationships and mediating trends among variables using survey and interview methods.Upon validation of the evidence presented herein,study 2 validated the impact of failure experiences on perceived efficacy, state anxiety, and cognitive load through experimental research. Hierarchical Linear Modeling (HLM) was utilized to separate the effects of individuals and measurement time on each variable. Furthermore, the mediating effects were further verified, addressing the shortcomings of the simple mediating effects that easily overlook the organizational level (individual) independent variables, thus enhancing the explanatory power of the mediating effects(Wen, 2009).

The study1 utilized survey and interview methods to gather empirical evidence. The survey questionnaires investigated the dynamic calibration of self-efficacy phenomena and their sustained impact on emotions and subsequent tasks. The preliminary results suggest that self-efficacy influences the dynamic calibration of cognitive load through the generation of emotions. In-depth interviews with individuals participating in the survey revealed that an increase in self-efficacy is associated with a decrease in cognitive load.(Jiang, 2023). Self-efficacy may have an impact on cognitive load through the mediation of anxiety, which aligns with previous research findings(Ansari & Derakshan, 2011; Szczygieł, 2021).

Feedback is a crucial method for individuals to receive experience of success and failure, and to change their self-efficacy(Bandura, 1977; Tolli & Schmidt, 2008). Negative feedback is related to reduced self-efficacy, whereas positive feedback and social support are related to increased self-efficacy(Dimotakis et al., 2017), even if the efficacy of feedback information is manipulated by the experimenter (rather than reflecting the actual performance of the participants). Study 2 employed false feedback to provide subjects with varying experiences of success and failure, effectively manipulating individual self-efficacy, thus establishing a manipulation paradigm for future research on self-efficacy.

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In addition, study 2 takes a micro-dynamic perspective and uses a multilevel linear model to investigate the dynamic changes of self-efficacy and cognitive load in the task process. In previous research on the relationship between self-efficacy and cognitive load, one main perspective has been identified. It suggests that self-efficacy negatively predicts cognitive load(Wei et al., 2022). In measurement time dimension, self-efficacy can negatively predict cognitive load during task execution, and at the individual level, individual differences are small, indicating that this phenomenon is relatively common. The outcome substantiates the initial viewpoint mentioned above. At the same time, it is consistent with the Predictive and Reactive Control Systems (PRCS) theory, providing preliminary validation that individuals' attention resource allocation is dynamically changing when dealing with tasks.This study not only found that such changes can help individuals to effectively complete current tasks with fewer resources but also that resource allocation is calibrated based on changes in self-efficacy as a clue to adjust the attention resource investment required to perform tasks (i.e., cognitive load)(Tops et al., 2015).

In line with social cognitive theory, the research findings indicate that self-efficacy can influence an individual's emotional state, thereby affecting their resource allocation, thus reaffirming the core role of self-efficacy mechanisms in personal cognitive processes. The anxiety emotions generated by individuals during task execution are similar to self-efficacy feelings and undergo dynamic changes in response to positive or negative feedback(McEvoy et al., 2023). Self-efficacy can negatively predict state anxiety, meaning the higher the self-efficacy, the lower the anxiety individuals feel in the current situation, and conversely, they experience higher anxiety. Self-efficacy theory provides an explanation for this phenomenon, suggesting that anxiety stems from a sense of inefficacy in dealing with potential threats behaviorally and cognitively(Bandura, 1988). In this study, individuals experience a decrease in self-efficacy due to failure, leading to the onset of anxiety.

State anxiety fully mediates the impact of self-efficacy on cognitive load. According to the processing efficiency theory, individuals' cognitive resources are limited. Negative emotions such as anxiety occupy these cognitive resources, resulting in a reduction in available resources for cognitive operations and an increase in cognitive load. This suggests that emotions play an important role in the mechanism of self-efficacy and cognitive load. Previous studies have mostly focused on exploring the static mediation relationship between self-efficacy, state anxiety and cognitive load(Chung & Kim, 2022; Feldon et al., 2018).

Overall, a significant characteristic of this study, in comparison with existing research, is the more comprehensive and thorough investigation of the relationships between self-efficacy, state anxiety, and cognitive load from a dynamic perspective. This study combines multiple research methods to explore the impact of self-efficacy on cognitive load from different perspectives, enhancing the credibility of the research results. It serves as a positive supplement to existing studies in the field of self-efficacy, with implications for understanding how self-efficacy affects an individual's cognitive load. The findings are of significant importance for elucidating the role of self-efficacy in cognitive load and have implications for further developing relevant intervention methods. However, there are some limitations to this study. Firstly, the participants in the research were all university students, and research has not yet been conducted on high school students. By studying high school students, not only can the universality of the impact mechanism of self-efficacy and cognitive load be verified, but it can also provide guiding suggestions for students to improve learning efficiency. Secondly, this study only verified the impact of individual state anxiety and cognitive load when self-efficacy is increase, and has not yet started from the direction of reducing self-efficacy, and further improvement of experimental design is still needed. Finally, existing studies have shown that with an increase in self-efficacy, the degree of individual engagement and persistence in tasks will also increase(Hutchinson et al., 2008). It suggests that self-efficacy may positively predict cognitive load in certain circumstances. So, during task execution, how does the overall impact mechanism of self-efficacy on cognitive load operate? In the future, we will incorporate neurophysiological indicators such as eye track and electroencephalography in our research to obtain more objective evidence, thereby enhancing the self-efficacy theory.

**Conclusion**

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Study1 has provided robust empirical evidence for research. The investigation into the fluctuation of self-efficacy feelings can elucidate this as a commonly encountered phenomenon in life, while also hinting at the potential mechanisms between self-efficacy and cognitive load. Moreover, the results from the interview method reveal a potential mediating variable within the self-efficacy-cognitive load mechanism, namely state anxiety.

Following this research direction, we conducted study 2 which employing experimental methodology to provide empirical evidence in support of the conclusions drawn in study 1. First of all, feedback is an important way to manipulate self-efficacy. The present investigation found that negative feedback can reduce self-efficacy. Therefore, the false feedback paradigm has been verified as an effective paradigm for manipulating self-efficacy. Moreover, self-efficacy can negatively predict state anxiety and cognitive load. Higher levels of state anxiety can lead to higher levels of cognitive load. During tasks, state anxiety plays a fully mediating role between self-efficacy and cognitive load.

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