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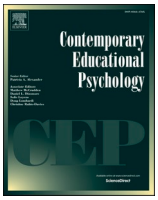

A multi-study examination of intra-individual feedback loops between competence and value beliefs, procrastination, and goal achievement

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ABSTRACT

In the present study, we tested intra-individual feedback loops between competence beliefs, value beliefs, and goal achievement (virtuous circles), and intra-individual feedback loops between goal failure and procrastination (vicious circle). We analyzed data from five independent intensive longitudinal studies with university students ($N = 841$, $k = 23{,}448$ observations). Pre-registered hypotheses were tested across the five studies and aggregated using meta-analytic methods. Results provided support for virtuous circles in self-regulated learning: Students who reported higher competence and value beliefs in one study session reported higher goal achievement, and higher goal achievement predicted higher competence and value beliefs in the subsequent study session. Results provided only partial support for a vicious circle: Procrastination was associated with lower goal achievement but goal achievement did not predict subsequent procrastination. The results have theoretical implications for models of self-regulated learning and methodological implications for the design of experience sampling studies.

1. Introduction

Preparing for an exam typically involves several study sessions, which can be very different. In some study sessions, a student is highly motivated and achieves learning goals with ease. In other study sessions, motivation is low and the same student struggles to get started and reach the learning goal. But does the student's satisfaction with one study session affect the way the student approaches the next study session?

The typical course of a study session and its effect on the subsequent session are both described by models of self-regulated learning. The current study builds on Zimmerman's (2000) model of self-regulated learning. According to this model, self-regulated learning is a dynamic process that consists of three phases. In the first phase, before learning, students analyze the task and set goals. In addition, students' motivation before learning plays an important role (Pintrich, 1999; Schunk & Zimmerman, 2008). Students evaluate their interest in the task (value beliefs) and consider their perceived competence to self-regulate their learning and achieve their goals (competence beliefs). In the second phase, during studying, students' goals and motivation affect the way they study, for example, how much time and effort they invest (Honicke & Broadbent, 2016; Lee et al., 2014). In the third phase, after studying, students compare their goal with the actual outcome. In this phase, students evaluate whether they have achieved their goal and whether they are satisfied with their goal achievement (Schmitz & Wiese, 2006). Because learning processes involve multiple study sessions, this reflective process influences subsequent study sessions in terms of an internal feedback loop (Butler & Winne, 1995; Winne & Hadwin, 1998). That is, learners generate internal feedback about their progress on a task, the effectiveness of their study strategies, or their motivation, which then affects how learners approach the next study session (Butler & Winne,

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1995). For example, motivation (before studying) and procrastination (during studying) predict goal achievement (after studying), which should determine motivation and procrastination in the next study session (see Fig. 1 for an overview). Thus, self-regulated learning is a dynamic process involving intra-individual feedback loops from one study session to the next.

In the current article, we aim to shed light on intra-individual feedback loops in self-regulated learning. We examined the dynamic interplay between competence and value beliefs, procrastination, study time, and goal achievement within and across study sessions. Specifically, we tested (a) whether competence and value beliefs were associated with procrastination and study time, as well as goal achievement within a study session, and (b) whether goal achievement predicted competence beliefs, value beliefs, and procrastination in the subsequent study session. Models of self-regulated learning describe regulatory processes within individuals (e.g., Schmitz & Wiese, 2006; Winne & Hadwin, 1998; Zimmerman, 2000; see Panadero, 2017 for a review of self-regulated learning models). However, intra-individual feedback loops in self-regulated learning have rarely been tested.

We analyzed data from five intensive longitudinal studies of five different research groups to provide robust evidence for intra-individual feedback loops in self-regulated learning (Bäulke et al., 2021; Breitwieser et al., 2021; Liborius et al., 2019; Bellhäuser et al., 2023; Wäschle et al., 2014). The repeated assessments allowed us to test whether competence beliefs, value beliefs, procrastination, and goal achievement reinforced each other over time, which would not be possible with cross-sectional (i.e., between-subject) data. In addition, we used intra-individual analyses to account for within-person changes in self-regulated learning and motivation, which provides a more precise understanding of the functional relations among variables and the temporal dynamics of self-regulated learning (as compared to inter-individual analyses; see Molenaar, 2004). The distinction between the intra- and inter-individual effects is important because relations between variables can differ depending on the level of analysis, as clearly demonstrated in a study by Schmitz and Skinner (1993): At the between-subjects level, more time spent on homework indicated greater overall engagement with school and predicted better homework performance. However, at the within-subjects level, students who spent more time on homework than usual did not show better homework performance, suggesting that students may have had difficulty solving the task. Thus, the relation between variables at the within-subject and between-subject levels of analysis may be very different. In the following, we describe the theoretical background and summarize previous research on intra-individual feedback loops in self-regulated learning.

1.1. *Feedback loops between competence beliefs, value beliefs, and goal achievement*

Motivation refers to internal processes that serve to initiate and maintain goal-directed action (Schunk & DiBenedetto, 2020). In the present study, we focus on two aspects of motivation that play a key role in self-regulated learning models: competence beliefs and intrinsic value beliefs. Competence beliefs include an individual's beliefs about his or her means, processes, and abilities to accomplish a particular task (Schunk & Zimmerman, 2006). In this study, we focus on students' perceived competence to self-regulate their learning in order to achieve their goals. Intrinsic value beliefs refer to an individual's motivation to perform a task for its own sake (e.g., out of interest or enjoyment) (Eccles

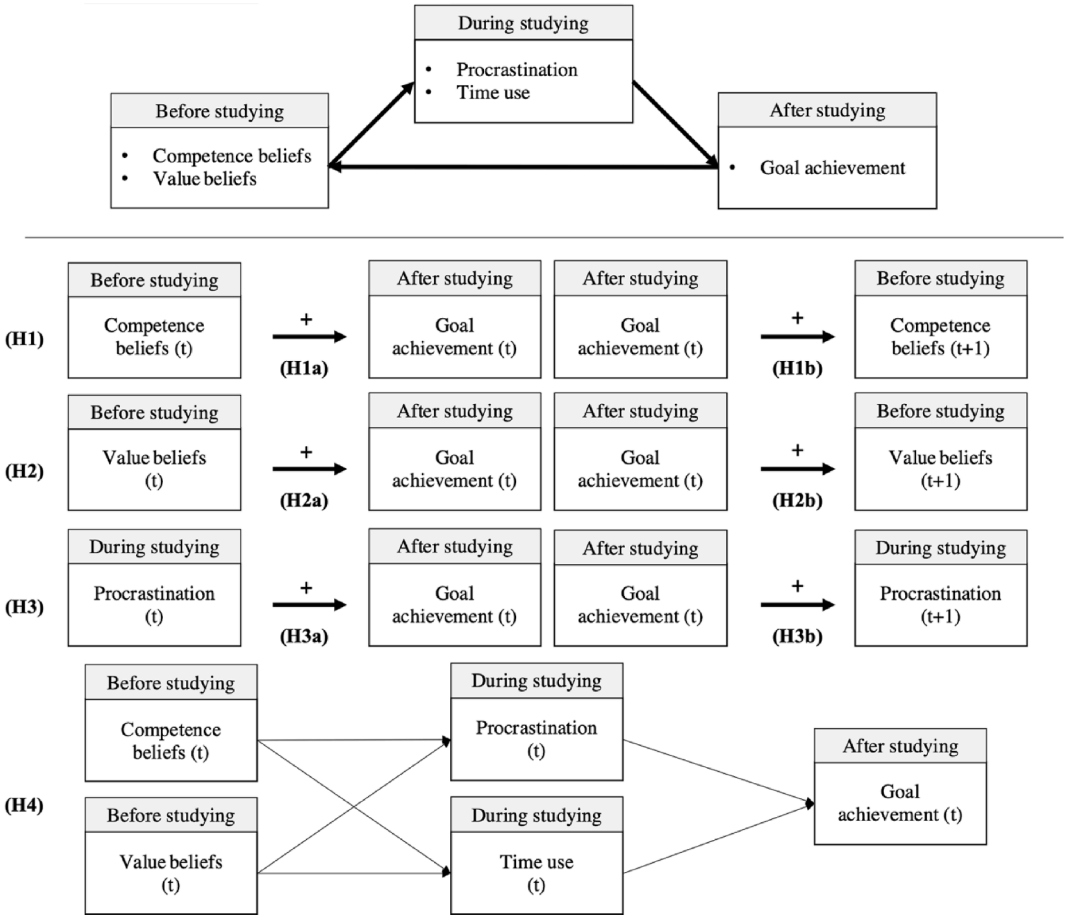

Fig. 1. *Note*. The theoretical model is adapted from Zimmerman (2000) and shows the proposed relation between the focal variables included in the present studies. Below, we provide an overview of the hypotheses tested in this study.

& Wigfield, 2002). In this study, we focus on students' intrinsic value in relation to the current study session. Students with higher competence and value beliefs are more motivated to learn in a self-regulated way (Pintrich, 1999; Schunk & Zimmerman, 2008). Therefore, motivation plays a key role in self-regulated learning models, especially at the beginning of a study session.

Models of self-regulated learning and motivation suggest that competence and value beliefs and goal achievement are mutually reinforcing. On the one hand, models of self-regulated learning assume that competence and value beliefs (prior to studying) promote the use of better learning and self-regulation strategies (during studying), which should enhance goal achievement (self-evaluation after studying) (Pintrich, 1999; Zimmerman, 2000). On the other hand, motivational theories suggest that goal achievement enhances competence and value beliefs. For example, social cognitive theories suggest that mastery experiences are a source of competence beliefs (Bandura, 1997; Usher & Pajares, 2008). That is, learners who achieve their goals become more confident that they can achieve their future goals, which promotes competence beliefs. Furthermore, according to self-determination theory (Deci & Ryan, 2000), goal achievement promotes perceived competence, which increases the intrinsic value of the task. Hence, competence and value beliefs should predict goal achievement and goal achievement should predict competence and value beliefs in terms of a feedback loop.

A recent review highlighted the theoretical relevance of feedback loops between motivation and achievement and identified several gaps in the literature (Vu et al., 2022). Previous studies that have examined feedback loops between motivation and achievement have often focused on academic self-concept, but have not examined other motivational constructs, such as competence and value beliefs. In addition, previous research examined long-term changes (e.g., over months or years) and did not account for short-term intra-individual variability in competence and value beliefs. For example, competence beliefs have been shown to vary over weeks (Wäschle et al., 2014) but also within a school day (Martin et al., 2015; Malmberg & Martin, 2019). Similarly, students' value beliefs have been shown to vary over a semester (Tanaka & Murayama, 2014), from one school lesson to another (Malmberg et al., 2015; Tsai et al., 2008), and even within a single lesson depending on the current topic (Dietrich et al., 2017). Thus, research on intra-individual feedback loops needs to account for this short-term variability in students' competence and value beliefs.

We identified only a few empirical studies that tested short-term, intra-individual feedback loops between competence and value beliefs and goal achievement. One study found a virtuous circle between competence beliefs and goal achievement (Wäschle et al., 2014): Higher competence beliefs predicted goal achievement and higher goal achievement, in turn, predicted higher competence beliefs the following week. Another study showed that positive feedback about past performance on a math task predicted higher competence beliefs in the subsequent math task (Bernacki et al., 2015). However, these studies did not test intra-individual feedback loops between value beliefs and goal achievement. In addition, Bellhäuser and colleagues (2021) tested the relation between value beliefs and satisfaction with the study session, which can be viewed as a measure of self-evaluated goal achievement. Results showed that higher levels of study satisfaction predicted higher value beliefs the next day. However, this study did not test whether value beliefs also predicted higher satisfaction with the same study session. Taken together, the results of previous studies suggest that competence and value beliefs and goal achievement may be positively reinforcing.

In summary, models of self-regulated learning and motivation suggest that competence beliefs, value beliefs, and goal achievement should be mutually reinforcing in the sense of a virtuous circle: higher competence and value beliefs should facilitate goal achievement (Pintrich, 1999; Zimmerman, 2000; Schmitz & Wiese, 2006), which in turn should promote competence and value beliefs (Bandura, 1997; Ryan & Deci, 2000). However, previous studies have often focused on inter-individual relations, which do not depict intra-individual relations between motivational beliefs and goal achievement (Schmitz & Skinner, 1993; Schmitz 2006), or have tested only one part of the proposed virtuous circles. Thus, we aim to advance research on intra-individual feedback loops by testing two virtuous circles: (1) the virtuous circle between competence beliefs and goal achievement, and (2) the virtuous circle between value beliefs and goal achievement. According to the first virtuous circle hypothesis, we expect that (**H1a**) students who report higher competence beliefs (compared to their average level) will report higher goal achievementin the same study session, and (**H1b**) students who report higher goal achievement in one study session (compared to their average level) will report higher competence beliefs in the subsequent study session. According to the second virtuous circle hypothesis, we expect that (**H2a**) students who report higher levels of value beliefs (compared to their average level) will report higher levels of goal achievement in the same study session, and (**H2b**) students who report higher levels of goal achievement in one study session (compared to their average level) will report higher levels of value beliefs in the subsequent study session.

1.2. Feedback loops between procrastination and goal achievement

Previous research has revealed intra-individual links between procrastination and goal achievement. In the academic context, procrastination is defined as the voluntary postponement of the intended start or completion of a study task despite the expectation of negative consequences (Steel, 2007). One study found that higher levels of procrastination predicted lower goal achievement, as indicated by lower satisfaction with the study session (Liborius et al., 2019). Another study found a vicious circle between procrastination and goal achievement from one week to the next (Wäschle et al., 2014). Students who procrastinated more were more likely to miss their goals, which in turn predicted higher levels of procrastination the following week. Thus, findings from a small number of studies suggest that procrastination increases the risk of goal failure and that repeated experiences of goal failure may promote procrastination.

Why do students procrastinate when they are not satisfied with their goal progress? A motivational perspective on procrastination provides an explanation. For example, according to social cognitive theories (Bandura, 1997), repeated failure may reduce one's subjective sense of control over the situation. Consistent with this notion, it has been shown that students who felt less competent to successfully complete a task were more likely to procrastinate (Klassen et al., 2008; Wolters, 2003). This link between lower competence beliefs and higher levels of procrastination has been consistently found across countries and samples (Hall et al., 2019; Klassen et al., 2010). Applied to the present study, failing to achieve one's learning goal may reduce one's subjective sense of control over the situation, which promotes procrastination and goal failure.

Overall, based on motivational theories of procrastination and previous research, we expect a vicious circle between procrastination and goal failure. We hypothesize that (**H3a**) students who report higher levels of procrastination in a study session (relative to their average level) will report lower levels of goal achievement in the same study session, and (**H3b**) students who report lower levels of goal achievement in a study session (relative to their average level) will report higher levels of procrastination in the subsequent study session.

1.3. Procrastination and study time as mediators between competence and value beliefs and goal achievement

Competence and value beliefs are thought to predict goal achievement indirectly through students' study behaviors. According to models of self-regulated learning, students' competence and value beliefs (prior to studying) affect how much time they spend studying and how

effectively they use their study time (during studying), which in turn should affect goal achievement (after studying) (Zimmerman, 2000, see Fig. 1). Although theoretically postulated, the mediating pathways between motivational beliefs and goal achievement are currently not well understood and have rarely been empirically tested.

Empirical evidence on intra-individual relations between students' competence beliefs, study time, and procrastination is scarce. Some studies have found that higher competence beliefs predicted higher effort investment (Dietrich et al., 2017; Malmberg et al., 2013). Applied to this study, these findings suggest that students who report higher competence beliefs should spend more time studying, as study time can be viewed as a measure of quantitative effort investment (see Boekaerts, 2007). Furthermore, using experience sampling, it has been shown that higher competence beliefs reported prior to studying are associated with better volitional control during studying (Breitwieser & Brod, 2022). That is, students with higher competence beliefs may study more persistently, which supports the finding that higher competence beliefs are associated with lower levels of procrastination (Wäschle et al., 2014). However, none of these studies tested whether procrastination and study time mediated the relation between competence beliefs and goal achievement. Additional evidence comes from studies that tested inter-individual relations. For example, Honicke and Broadbent (2016) conducted a systematic review and found that higher competence beliefs predicted academic achievement through lower levels of procrastination. In addition, Rosário and colleagues (2013) showed that students with higher competence beliefs spent more time studying. However, this study did not test study time as a mediator between motivational beliefs and goal achievement. Furthermore, these inter-individual relations, which focus on overall academic achievement, do not represent the dynamic, intra-individual processes that predict goal achievement in a particular study session. Taken together, the results of previous studies provide a first indication that higher competence beliefs may promote longer study time (as a proximate measure of effort expenditure) and lower levels of procrastination. Conversely, lower competence beliefs may promote a vicious circle of shorter study time and higher levels of procrastination.

Few studies have examined the intra-individual relations among value beliefs, study time, and procrastination. One study found no intra-individual association between value beliefs and time spent on homework (Trautwein & Lüdtke, 2007). However, this study focused on students' self-reported benefits and costs of doing homework and did not assess students' intrinsic value beliefs (as this study does). Another study using daily assessments found that students spent more time studying on days when they reported higher intrinsic value beliefs (Bellhäuser et al., 2021). Similarly, higher intrinsic value beliefs have been shown to be associated with lower levels of procrastination and more time spent studying, whereas higher levels of extrinsic motivation or amotivation were associated with higher levels of procrastination (Lee, 2005; Rosário et al., 2013; Senécal et al., 1995). However, these studies tested inter- and not intra-individual relations and did not examine study time and procrastination as mediators between value beliefs and goal achievement. Taken together, previous findings suggest that when students value a task intrinsically, they may spend more time studying and procrastinate less. However, studies that examine whether study time and procrastination mediate the relation between value beliefs and goal achievement in a given study session are lacking.

In summary, only a few studies have examined intra-individual relations between students' competence and value beliefs, study time, procrastination, and goal achievement. However, the few existing studies have not been replicated and have used different methodological approaches (e.g., regarding the measurement of value beliefs and study time or effort investment). Thus, robust evidence is currently lacking, especially for the theoretically hypothesized mediating pathways linking motivational beliefs to goal achievement (for a similar argument, see Honicke & Broadbent, 2016; Vu et al., 2022). Examining study time and procrastination as mediators between motivational beliefs and goal achievement contributes to a better understanding of self-regulated learning processes and how they drive fluctuations in goal achievement from one study session to the next. This knowledge can be used to develop targeted interventions, which is why studies testing these mediating pathways are needed.

Critically, self-regulated learning models (Zimmerman, 2000) describe processes within individuals that vary over time. However, the relations among motivational beliefs, study time, procrastination, and goal achievement have often been studied using between-subjects, cross-sectional designs. Using cross-sectional designs to study processes that are assumed to unfold over time can lead to significantly biased estimates of effects (Maxwell & Cole, 2007). Therefore, the present study makes an important contribution by examining the intra-individual relations between students' competence and value beliefs, study time, procrastination, and goal achievement in five studies, all of which used longitudinal designs.

The mediation hypotheses are based on models of self-regulated learning (Schmitz & Wiese, 2006; Zimmerman, 2000, see also Fig. 1) and evidence from previous research. We hypothesize that (**H4a**) higher competence beliefs predict more study time and lower levels of procrastination, which in turn predict higher goal achievement. We further hypothesize that (**H4b**) higher value beliefs will predict more study time and lower levels of procrastination, which in turn will predict higher goal achievement. In other words, mirroring the vicious circle, lower competence beliefs and lower value beliefs should predict less study time and higher levels of procrastination, which predict lower goal achievement. Fig. 1 summarizes our hypotheses.

1.4. The present study

The present study aims to shed light on intra-individual feedback loops in self-regulated learning as hypothesized above. We examine the dynamic interplay between competence and value beliefs, procrastination, study time, and goal achievement within and across study sessions. Our first goal is to test virtuous and vicious circles in self-regulated learning. Specifically, we test (a) whether competence, value beliefs, and procrastination are associated with goal achievement within a study session, and (b) whether goal achievement predicts competence beliefs, value beliefs, and procrastination in the subsequent study session in terms of a feedback loop. Our second goal is to examine whether the link between competence beliefs, value beliefs, and goal achievement is mediated by procrastination and study time. Hence, we test potential mechanisms that could explain the positive link between competence and value beliefs and goal achievement.

Investigating these intra-individual links between motivational beliefs, procrastination, study time, and goal achievement is of theoretical and practical importance. From a theoretical perspective, models of self-regulated learning often describe regulatory processes within individuals (e.g., Schmitz & Wiese, 2006; Winne & Hadwin, 1998; Zimmerman, 2000; see Panadero, 2017 for a review of self-regulated learning models). However, the proposed intra-individual feedback loops and mediating pathways in self-regulated learning have rarely been empirically tested (Vu et al., 2022). Moreover, it is important to specifically test intra-individual relations because variable relations can differ depending on the intra- and inter-individual levels of analysis (see, e.g., Schmitz & Skinner, 1993; Schmitz 2006). From a practical point of view, a better understanding of how intra-individual variations in motivational beliefs and procrastination predict future goal achievement and vice versa can help to design targeted interventions. For example, these interventions can consider the ideal timing, content, and target variables to reduce procrastination and most effectively promote competence beliefs, value beliefs, and goal achievement.

To answer our research questions, we used data from five intensive longitudinal studies (Bäulke et al., 2021; Breitwieser et al., 2021; Liborius et al., 2019; Bellhäuser et al., 2023; Wäschle et al., 2014). We used a conceptual approach to replication. A strength of this approach is

that we can test whether studies with different research designs support the key theoretical assumptions of the process model of self-regulated learning (Zimmerman, 2000), which would speak to the validity of the underlying theory (see Stroebe & Strack, 2014 for an overview of conceptual replication). We therefore tested whether the findings generalized across studies that used different operationalizations of the constructs (e.g., different self-report measures or objective log file data), sample compositions, and study durations. Demonstrating which effects hold across studies (and which do not) is particularly important in light of the replication crisis (Open Science Collaboration, 2015). Using meta-analytic methods in our analyses, we estimated average effect sizes to provide robust evidence for intra-individual feedback loops in self-regulated learning across the five individual studies. In addition, our unique data set allowed us to uncover intra-individual relations within subjects over time, as described in models of self-regulated learning. The results thus complement previous research that has focused primarily on inter-individual relations among competence and value beliefs, procrastination, study time, and goal achievement.

2. Methods

Hypotheses and data analysis procedures were pre-registered prior to the data analysis (https://osf.io/skneq). We reanalyzed data from five studies that focused on different research questions (for details see Bäulke et al., 2021; Breitwieser et al., 2021; Liborius et al., 2019; Bellhäuser et al., 2023; Wäschle et al., 2014). In the following, we provide a brief summary of the design and sample characteristics of the five studies separately.

2.1. Participants and procedure

The five studies tested German university students from different universities and at different academic levels (undergraduate and graduate students). There were no general exclusion criteria for participation in the studies. That is, all students who were approached for the particular study were allowed to enroll. Students gave informed consent before the start of the study. In all studies, students completed the learning diaries online. In the learning diaries, students were asked to report on their self-regulated learning strategies, goal achievement, and competence and value beliefs related to the current study session.

Study 1 included 160 math and economics students who were recruited through advertisements on the university campus and in central math and economics lectures. Of these, 144 started the 28-day study period. Once a day after studying, students reported on their goals, competence beliefs, value beliefs, procrastination, study time, and satisfaction with the study session as a measure of goal achievement. Participants received up to €50 depending on their participation rate (see Bäulke et al., 2021 for details on participants and design).

Study 2 included 554 undergraduate and graduate students from a variety of disciplines at a technical university. Students enrolled in the study by completing an initial pretest survey. Participants were recruited through advertisements on the university campus and in central lectures, and 232 participants started the daily survey period. Of these, 96 students completed at least 80% of the daily learning diaries and were included in the final sample. Participants who dropped out differed from completers in terms of age (completers were older) and the number of credits they wanted to earn in the current semester (completers had lower goals). Students completed learning diaries twice a day, before and after a study session, over the course of 154 days. Before studying, students reported their goals, competence beliefs, and value beliefs. After studying, students reported their study time, procrastination, and goal achievement. Students who completed at least 80% of the learning diaries received €100 for their participation (see Liborius et al., 2019 for details on participants and design).

Study 3 included 359 medical students from across Germany who were preparing for their second medical state examination using a digital learning platform. Participants were recruited through advertisements on the learning platform (https://www.amboss.de), and 338 participants began the study period. Students completed learning diaries twice a day, before and after studying, for 40 days. Before studying, students reported on their goals, competence beliefs, and value beliefs. After studying, students reported on procrastination and goal achievement. Study time and an additional measure of goal achievement were objectively assessed using log files from the learning platform (see Table 1 for details). Participants could earn up to €40 depending on their participation rate (see Breitwieser et al., 2021 for details on participants and design).

Study 4 included 198 forestry and environmental science students. Of these, 150 completed the study. This means that participants who dropped out and therefore completed less than 3 entries were excluded. Students completed the learning diary once a week for 19 weeks (one semester). The learning diary consisted of a reflection section and a planning section. In the reflection section, students were asked to reflect on their preparation for class during the previous week. That is, students reported retrospectively on their competence and value beliefs, study time, procrastination, and goal achievement. In the planning section, students were asked to formulate up to three learning goals for the next week (see Wäschle et al., 2014 for details on participants and design).

Study 5 included 127 university students from various fields of study. Participants were recruited through advertisements on the university campus. Students registered for the study online by completing a pretest survey, and 113 participants began the survey period. Students completed learning diaries twice a day, before and after studying, for 36 days. Before studying, students reported their goals, competence beliefs, and value beliefs. After studying, students reported their study time, procrastination, and satisfaction with the study session as a measure of goal achievement. Students who completed at least 75% of the learning diaries received €50 for their participation (see Bellhäuser et al., 2023 for details on participants and design).

2.2. Measures

Table 1 provides an overview of how competence beliefs, value beliefs, study time, procrastination, and goal achievement were assessed in each of the five studies. When a variable was measured using multiple items, we calculated the mean of all items to create a single measure. Because the five studies were conducted by different research teams, the operationalization of the constructs varied slightly across studies, e.g., in terms of item wording or the number of items used to assess the construct. For example, some studies used multiple items to assess procrastination (Studies 1 and 4), whereas others used a single-item measure (Studies 2, 3, and 5). In Studies 2, 3, and 5, competence and value beliefs were assessed each day before studying and procrastination, goal achievement, and study time were assessed each day after studying. In Study 1, all constructs were assessed once a day after studying, and in Study 4, all constructs were assessed once a week.

Established measures of everyday competence beliefs, value beliefs, and procrastination are not yet available. However, to ensure high content validity, all diary measures were constructed based on established trait measures (e.g., see Ryan & Connell, 1989; Tuckman, 1991; Zimmerman et al., 1992) and the respective definitions of the constructs. In addition, in each study, trait measures of the variables of interest (e.g., general competence and value beliefs and procrastination) were assessed prior to the start of the daily survey period. We correlated these trait measures with the corresponding diary measures of procrastination, competence beliefs, and value beliefs, separately for each study. For example, a trait measure of procrastination assessed once at pretest was correlated with mean procrastination reported across study sessions (i.e., mean procrastination averaged across time points). Although trait measures and aggregate state measures have different predictive utility, they are also often closely related (Augustine & Larsen, 2012). Therefore, correlation analysis between trait and aggregate state measures

Table 1
Measures for competence beliefs, value beliefs, procrastination, time use, and goal achievement.

Study	Item Formulation	Reliability
	Competence beliefs	
1	I have managed to overcome my motivation problems when studying. [5-point-scale; This item was only assessed if students reported motivation problems. That is, in this study, the assessment of competence beliefs was conditional on the occurrence of a motivational problem.]	0.45
2	Today, I am sure that I will be able to overcome all study-related challenges. [6-point-scale]	0.88
3	● I think that today I will find it difficult to persist in learning for a long time. [5-point-scale] ● Today, I will be good at preventing my mind from constantly wandering off while learning. [5-point-scale] ● I think I will achieve a satisfactory study load today. [5-point-scale] ● Today, I will be able to motivate myself well. [5-point-scale]	0.94
4	● I perceived last week's study tasks as challenging and I was able to cope with the high demands. [5-point-scale] ● I felt overwhelmed by my study tasks. (reverse coded) [5-point-scale]	0.77
5	Today, I know how to proceed to have a successful study day. [6-point-scale]	0.93
	Value beliefs	
1	Today, I studied because I found the subject very interesting. [5-point-scale]	0.87
2	Today, I am looking forward to my studies and its contents. [6-point-scale]	0.92
3	How interested are you in [Topic 1 / Topic 2 / Topic 3]? [5-point-scale; one separate item for each topic]	0.84
4	Last week's stress ultimately pushed me to complete the tasks. (reverse coded) [5-point-scale]	0.75
5	Today, I am looking forward to my studies and its contents. [6-point-scale]	0.93
	Study time	
1	Assessment of time use for preparing for exams [in hours and minutes]	0.79
2	Assessment of time use for self-study and for attending courses [time use is summed up; in hours and minutes]	0.87
3	Assessment of time spent on learning platform via log files [in hours and minutes]	0.88
4	Assessment of time use for reading, preparing for exams, attending courses, working on homework, working in learning groups [time use is summed up; in hours]	0.81
5	Assessment of time use for self-study and for attending courses [time use is summed up; in hours and minutes]	0.91
	Procrastination	
1	● Today, I did not get into the exam preparation, even though I know how important it is to get started. [5-point-scale] ● Today, I promised myself to get into exam preparation, but then dragged my feet. [5-point-scale]	0.83
2	Today, I have postponed unpleasant tasks. [6-point-scale]	0.85
3	Today, I put off studying for a long time. [5-point-scale]	0.84
4	● Last week, I put off starting tasks until the last minute. [5-point-scale] ● Last week, I tended to overestimate the amount of work I could get done in a given amount of time. [5-point-scale] ● I didn't put off work last week because I knew it absolutely had to be done. (reverse coded) [5-point-scale] ● Last week, I worked on my assignments regularly so I wouldn't fall behind my intended workload. (reverse coded) [5-point-scale]	0.95
5	Today, I have postponed unpleasant tasks. [6-point-scale]	0.71
	Goal achievement	
1	How satisfied are you with your day today? [5-point-scale]	0.75
2	● Today, I am satisfied with my study-related achievements. [6-point-scale] ● I have achieved my study-related goals for today. [6-point-scale]	0.85
3	a. Self-reported goal achievement ● Today, I studied as much as intended. [5-point-scale] ● I am satisfied with today's study day. [5-point-scale]	a. 0.78 b. 0.78
	b Objective goal achievement Goal achievement was further operationalized objectively via logfile data. Students reported how many questions they intended to answer on the learning platform that day. The number of actually answered questions was determined via the logfile data from the learning platform. Goal achievement was a binary variable, indicating if students had answered at least as many questions as intended (1) or less (0).	
4	I have achieved my [first/ second/ third] goal. [5-point-scale; one item for each of the three goals]	0.93
5	Today, I am satisfied with my study-related achievements. [6-point-scale]	0.71

Note. For constructs that were measured with one item, we computed split-half-reliability by correlating the responses on odd and even days for each participant. For constructs that were measured with more than two items, we computed the within-person McDonald's Omega as a measure of reliability.

served to test a form of validity of the respective measures. We found substantial correlations between the diary measures of procrastination, competence beliefs, and value beliefs and the corresponding trait measures in Study 2 (r ranging from 0.38 to 0.48), Study 3 (r ranging from 0.22 to 0.45), Study 4 (r ranging from 0.29 to 0.41), and Study 5 (r ranging from 0.30 to 0.43). In Study 1, only one trait procrastination scale was available. The two diary items correlated significantly with the corresponding trait items assessed at pretest (r between 0.71 and 0.74). Taken together, the significant and substantially high correlations between the aggregated diary measures and the corresponding trait measures support the validity of the diary measures.

2.3. Data analysis

All data analyses were conducted in R, except for the multilevel mediation analysis, which was conducted in MPlus. Significance levels were set at $p < .05$ for all analyses. According to our pre-registered analysis plan, we excluded non-consecutive data points in all studies. That is, a data point t was excluded if the subsequent data point $t + 1$ was missing. For example, a student answered the questionnaire on Monday, did not answer on Tuesday, and answered again on Wednesday. In this case, we do not know whether the student studied on Tuesday, which could affect the relation between goal achievement reported on Monday and competence and value beliefs reported on Wednesday. Based on this criterion, we excluded 273 data points (12%) in Study 1, 1506 data points (22%) in Study 2, 669 data points (8%) in Study 3, 235 data points (15%) in Study 4, and 255 data points (9%) in Study 5. We ensured that inclusion of these data points in the analyses did not change the results, indicating that exclusion of these data points did not introduce systematic bias (see Supplementary Material, Figures S5, S6, & S7).

In addition, study-specific exclusion criteria were applied for certain data points. In Study 2 and Study 5, data points were excluded if students did not study on that day (Study 2: $k = 6{,}296$, Study 5: $k = 1{,}239$). On these days, students did not set a learning goal in the morning questionnaire and also indicated in the evening questionnaire that they did not study that day. In Study 3, data points were excluded if the time between completing the pre- and post-learning questionnaires exceeded 24 h ($k = 771$). In Study 4, five data points were excluded if they occurred during holidays (Christmas and after the end of the semester, $k = 593$). Many students were not studying during these periods, resulting in a high number of missing entries. The final number of data points included in the analyses was $k = 3{,}206$ in Study 1, $k = 6{,}898$ in Study 2, $k = 8{,}819$ in Study 3, $k = 1{,}477$ in Study 4, and $k = 2{,}948$ in Study 5.

To test our hypotheses, we estimated multilevel models (time points clustered within participants). All predictor variables were centered on the person mean to test for intra-individual relations. In all analyses, we accounted for autoregressive effects of the dependent variables by

additionally regressing them on their lagged scores. Fig. 1 provides a graphical summary of the hypotheses. To examine the virtuous and vicious circles in self-regulated learning, we tested a sequence of effects. That is, we first tested intra-individual links between competence beliefs, value beliefs, and procrastination with goal achievement at time *t*. Then, we tested whether goal achievement at time *t* predicted future competence beliefs, value beliefs, and procrastination at time $t + 1$ in terms of a feedback loop. More specifically, to test the virtuous circle between competence beliefs and goal achievement, we regressed goal achievement on competence beliefs at time point *t* (H1a), and we regressed competence beliefs at $t + 1$ on goal achievement at t (H1b). To test the virtuous circle between value beliefs and goal achievement, we regressed goal achievement on value beliefs at time point *t* (H2a), and we regressed value beliefs at $t + 1$ on goal achievement at *t* (H2b). To test the vicious circle between procrastination and goal achievement, we regressed goal achievement on procrastination at time point *t* (H3a), and we regressed procrastination at $t + 1$ on goal achievement at *t* (H3b).

To test whether the link between value and competence beliefs and goal achievement was mediated by procrastination and study time (H4), we estimated a multilevel structural equation model (MSEM, for details see Preacher et al., 2010). MSEM accounts for the nested data structure (time points clustered in participants) and allows for the estimation of within- and between-subject mediation effects. Because we focused on intra-individual relations in this study, we report the within-subject effects in our presentation of results.[1] We estimated direct paths from competence beliefs and value beliefs to procrastination and study time (the mediators), direct paths from procrastination and study time to goal achievement (the dependent variable), and indirect paths from competence beliefs and value beliefs to goal achievement via study time and procrastination (see Fig. 1). All path weights and mediators were estimated in a joint path analysis, which is an advantage of MSEM over conducting multiple single regression analyses. The full analysis script is available on the OSF.

All hypotheses were tested separately in each of the five datasets. In a final step, we synthesized the results using meta-analytic methods. We used the standardized regression coefficients, i.e., beta weights (β), from our multilevel regression analyses as a measure of effect size. We used the "standardize_parameters" function from the effectsize package in R to standardize the regression weights (β) and to estimate the standard errors of the standardized beta weights. The function fits the entire model with a standardized version of the data, which is equivalent to standardizing the variables before fitting the model using z-standardization. The β weights and their respective standard errors were then used to calculate average effect sizes across studies using the metafor package in R. For the MSEM, we also standardized the path weights to obtain beta values by estimating the model using z-scores of all variables. These standardized path weights were then aggregated across studies using meta-analytic methods to obtain an average beta value as a measure of the overall effect size (see the analysis script on OSF for more details).

We chose to use β as a measure of effect size rather than correlation coefficients. Using β allowed us to account for autoregressive effects, making β more conservative but also a more realistic estimate of the true effect size. In addition, we focused on β as an effect size measure (rather than R^2) because our goal was to quantify the average association between competence beliefs, value beliefs, procrastination, and goal achievement. The use of β as an effect size measure has become increasingly popular and has been recommended by several scholars as an effect size measure in meta-analyses (e.g., Borenstein et al. 2009; Rosenthal and DiMatteo 2001). The β weights can be interpreted similarly to correlation coefficients, regardless of the number of covariates in the regression equation (Peterson & Brown, 2005). According to recent guidelines, a correlation coefficient of 0.10 corresponds to a small effect, 0.20 corresponds to a moderate effect, and 0.30 corresponds to a strong effect (Funder and Ozer, 2019).

Note that in Study 3, goal achievement was operationalized in two different ways, using self-reports and objective log files. Therefore, all analyses for this study were conducted separately for the two measures of goal achievement. For the average effect sizes reported below, we focused on self-reported goal achievement to increase comparability with the other studies that also used self-report measures and to avoid including the study twice in the meta-analysis. In the Results section, we briefly summarize the average effect sizes when including objective goal achievement (see Supplementary Materials for detailed results).

3. Results

Results are presented as follows: For each of our hypotheses, we first report the average effect size across studies. We then describe differences in the results across studies.

3.1. Virtuous circle between competence beliefs and goal achievement

First, we tested the virtuous circle between competence beliefs and goal achievement. The results are summarized in Fig. 2.

We found an average effect of $\beta = 0.22$ (CI [0.15; 0.28], $z = 6.90$, $p < .001$) for the link between competence beliefs and goal achievement (see Fig. 2A). Results were similar when objective (rather than self-reported) goal achievement was entered as the dependent variable in Study 3 ($\beta = 0.22$, CI [0.16; 0.29], $z = 6.55$, $p < .001$, see supplementary Fig. S1A). Consistent with hypothesis H1a, students who reported higher competence beliefs (relative to their average competence beliefs) also reported higher goal achievement in this study session. The model's fixed and random effects explained between 24 and 36 percent of the variance in daily goal achievement (Study 1: $R^2 = 0.34$, Study 2: $R^2 = 0.36$, Study 3: $R^2 = 0.33$, Study 4: $R^2 = 0.27$, Study 5: $R^2 = 0.25$). We found an average effect of $\beta = 0.07$ (CI [0.03; 0.11], $z = 3.28$, $p = .001$) for the link between goal achievement and subsequent competence beliefs (see Fig. 2B). Results were similar when objective (rather than self-reported) goal achievement was entered as the dependent variable in Study 3 ($\beta = 0.06$, CI [0.02; 0.11], $z = 2.63$, $p = .009$, see supplementary Fig. S1B). Consistent with hypothesis H1b, students who reported higher goal achievement in one study session (relative to their average goal achievement) subsequently reported higher competence beliefs in the following study session. The model's fixed and random effects explained between 21 and 50 percent of the variance in next day's competence beliefs (Study 1: $R^2 = 0.21$, Study 2: $R^2 = 0.47$, Study 3: $R^2 = 0.50$, Study 4: $R^2 = 0.44$, Study 5: $R^2 = 0.48$).

The virtuous circle between competence beliefs and goal attainment was found in almost all five studies, with the exception of Study 1, where the association between goal achievement and subsequent competence beliefs was not significant. In Study 1, the assessment of competence beliefs was conditional on the presence of a motivational problem (see Table 1). This conditional assessment resulted in a smaller number of data points and may also explain why the reliability of the scale was lower. Therefore, these results should be interpreted with caution.

In summary, the results revealed positive intra-individual links between competence beliefs and goal achievement. Consistent with the first virtuous circle hypothesis, higher competence beliefs predicted goal achievement, and goal achievement predicted higher subsequent competence beliefs, in terms of a feedback loop.

[1] Notably, we also estimated between-subject effects at the inter-individual level of analysis for completeness. In short, the effects at the inter-individual level often did not correspond to the effects at the intra-individual level. Many of the theoretically hypothesized direct and indirect effects were weaker or even absent at the inter-individual level compared to the intra-individual level. These divergent results underscore the importance of distinguishing between effects at the intra- and inter-individual levels of analysis.

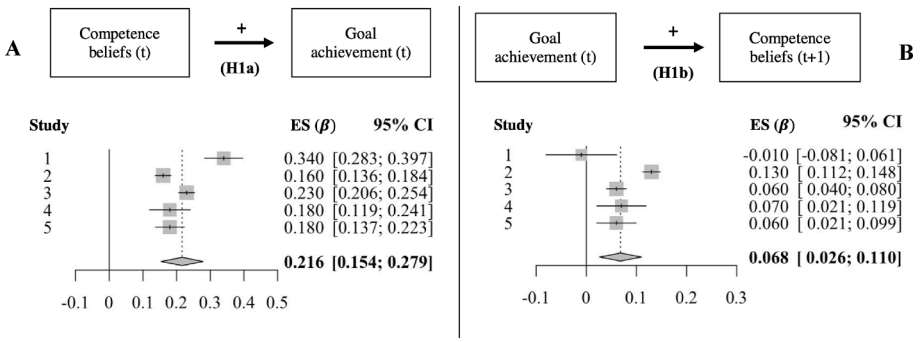

Fig. 2. Virtuous circle between competence beliefs and goal achievement. ES = effect size. (A) Consistent with hypothesis H1a, higher competence beliefs in study session t predict higher goal achievement. (B) Consistent with hypothesis H1b, higher goal achievement in study session t predict higher competence beliefs in the subsequent study session t + 1. Values in bold indicate estimates of the average effect size β across studies.

3.2. Virtuous circle between value beliefs and goal achievement

Next, we tested for intra-individual associations between value beliefs and goal achievement. Results are summarized in Fig. 3. We found an average effect of $\beta = 0.15$ (CI [0.09; 0.22], $z = 4.59$, $p < .001$) for the link between value beliefs and goal achievement (see Fig. 3A). Results were similar when objective (rather than self-reported) goal achievement was entered as the dependent variable in Study 3 ($\beta = 0.14$, CI [0.06; 0.22], $z = 3.32$, $p = .001$, see supplementary Fig. S2A). Consistent with hypothesis H2a, students who reported higher value beliefs (relative to their average value beliefs) reported higher goal achievement in this study session. The model's fixed and random effects explained between 24 and 35 percent of the variance in daily goal achievement (Study 1: $R^2 = 0.28$, Study 2: $R^2 = 0.35$, Study 3: $R^2 = 0.26$, Study 4: $R^2 = 0.25$, Study 5: $R^2 = 0.24$). We found an average effect of $\beta = 0.04$ (CI [0.02; 0.06], $z = 3.01$, $p = .010$) for the link between goal achievement and subsequent value beliefs (see Fig. 3B). Results were similar when objective (rather than self-reported) goal achievement was entered as the dependent variable in Study 3 ($\beta = 0.03$, CI [0.01; 0.06], $z = 2.31$, $p = .021$, see supplementary Fig. S2B). Consistent with hypothesis H2b, students who reported higher goal achievement in one study session (relative to their average goal achievement) subsequently reported higher value beliefs in the following study session. The model's fixed and random effects explained between 24 and 50 percent of the variance in next day's value beliefs (Study 1: $R^2 = 0.43$, Study 2: $R^2 = 0.50$, Study 3: $R^2 = 0.38$, Study 4: $R^2 = 0.45$, Study 5: $R^2 = 0.44$). Taken together, the results revealed positive intra-individual links between value beliefs and goal achievement. Consistent with the second virtuous circle hypothesis, higher value beliefs predicted goal achievement, and goal achievement predicted higher subsequent value beliefs, in terms of a feedback loop.

In all of the five studies, higher value beliefs predicted higher goal achievement. However, in Study 3, this relation was found only for self-reported goal achievement and not for the objective measure of goal achievement (see supplementary Figure S2). Furthermore, in three of the five studies, higher goal achievement predicted higher subsequent value beliefs. That is, the relation between goal achievement and subsequent value beliefs was not consistently found across studies. Nevertheless, the meta-analysis across studies revealed a significant, albeit small, association between goal achievement and subsequent value beliefs.

3.3. Vicious circle between procrastination and goal achievement

Next, we tested intra-individual links between procrastination and goal achievement. The results are summarized in Fig. 4. We found an average effect of $\beta = -0.37$ (CI [-0.45; -0.28], $z = -8.40$, $p < .001$) for the link between procrastination and goal achievement (see Fig. 4A). Results were similar when objective (rather than self-reported) goal achievement was entered as the dependent variable in Study 3 ($\beta = -0.37$, CI [-0.45; -0.30], $z = -9.64$, $p < .001$, see supplementary Fig. S3A). Consistent with hypothesis H3a, students who reported higher levels of procrastination (relative to their average level of procrastination) reported lower goal achievement in this study session. The model's fixed and random effects explained between 29 and 57 percent of the variance in daily goal achievement (Study 1: $R^2 = 0.38$, Study 2: $R^2 = 0.57$, Study 3: $R^2 = 0.36$, Study 4: $R^2 = 0.30$, Study 5: $R^2 = 0.46$). Contrary to hypothesis H3b, the mean effect of $\beta = -0.01$ for the link between goal achievement and subsequent procrastination was not significant (CI [-0.02; 0.01], $z = -0.46$, $p = .646$). Students who reported lower goal achievement in one study session (relative to their average goal achievement) did not report higher procrastination in the next study session (see Fig. 4B). The model's fixed and random effects explained between 20 and 46 percent of the variance in next day's procrastination (Study 1: $R^2 = 0.28$, Study 2: $R^2 = 0.26$, Study 3: $R^2 = 0.28$, Study 4: R^2

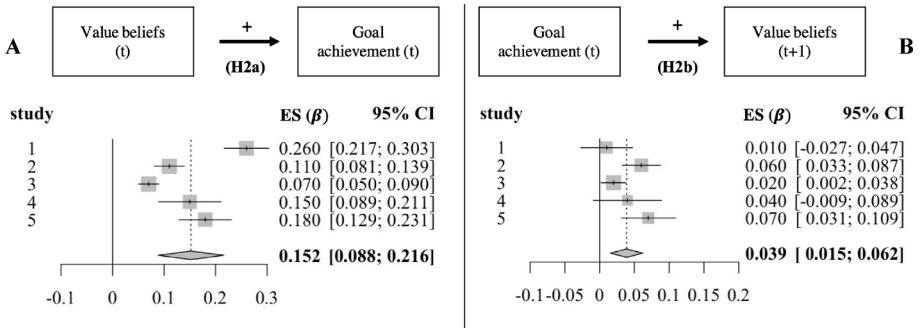

Fig. 3. Virtuous circle between value beliefs and goal achievement. ES = effect size. (A) Consistent with hypothesis H2a, higher value beliefs in study session t predict higher goal achievement. (B) Consistent with hypothesis H2b, higher goal achievement in study session t predict higher value beliefs in the subsequent study session t + 1. Values in bold indicate estimates of the average effect size β across studies.

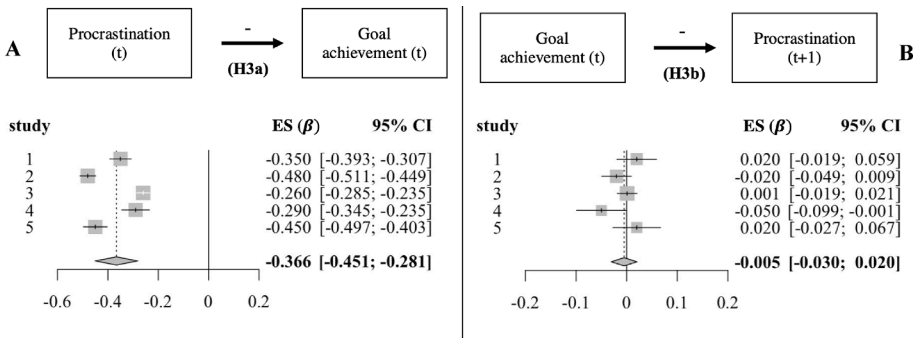

Fig. 4. Vicious circle between procrastination and goal achievement. ES = effect size. (A) Consistent with hypothesis H3a, higher levels of procrastination in study session t predict lower goal achievement. (B) In contrast with hypothesis H3b, lower goal achievement in study session t does not predict higher levels of procrastination in the subsequent study session t + 1. Values in bold indicate estimates of the average effect size β across studies.

= 0.46, Study 5: R^2 = 0.20). The link between goal achievement and subsequent procrastination was also not significant when objective (rather than self-reported) goal achievement was entered as the dependent variable in Study 3 (β = -0.01, CI [-0.03; 0.02], z = -0.47, p =.642, see supplementary Fig. S3B). Together, results are only partially in line with the vicious circle hypothesis. Procrastination was linked to lower goal achievement in the same study session, but lower goal achievement did not predict subsequent procrastination, in terms of a feedback loop.

In all five studies, higher procrastination was associated with lower goal achievement. However, contrary to our hypothesis, the relation between goal achievement and subsequent procrastination was not significant. Therefore, we conducted a follow-up analysis to explore the reasons for the divergent results. We found that the relation between goal achievement and subsequent procrastination (i.e., the slope parameters) varied considerably for individual students (see Fig. 5). While some students tended to report more procrastination after goal failure, others tended to reduce their procrastination after goal failure. Students in Study 3 performed a very similar study task each day (i.e., answering old exam questions to prepare for the exam), which may explain the lower variance in the slopes for the relation between goal achievement and procrastination. Taken together, these differences in the direction of regulation after goal failure within and across studies may explain the nonsignificant overall relation between goal achievement and subsequent procrastination.

3.4. *Procrastination and study time as mediators between competence and value beliefs and goal achievement*

According to our fourth hypothesis, we tested whether the relation between competence and value beliefs and goal achievement was mediated by procrastination and study time. We used multilevel structural equation modeling to estimate all direct and indirect (i.e., mediation) paths together in a joint model. The results are summarized in Fig. 6. Because of our focus on intra-individual relations and for clarity, we report only the within-person (and not between-person) effects. The path weights shown in Fig. 6 are the aggregated betas obtained from the meta-analysis across studies. Since our hypothesis is specifically related to the expected indirect paths, we have also included forest plots showing the betas for the indirect path for each study separately. In addition, for ease of reading, Fig. 6 shows the average path weights separately for the four proposed mediations. Note, however, that the paths were estimated together in a joint model. The results of the mediation analysis when including objective goal achievement (instead of self-reported goal achievement) in study 3 are reported in supplementary Figure S4. Despite some small differences in the absolute beta weights, the results were similar.

The results showed that competence and value beliefs partially predicted goal achievement through procrastination. That is, higher competence and value beliefs predicted lower levels of procrastination, which in turn predicted higher levels of goal achievement. This mediation was found in all but one study. In Study 3, the indirect path from value beliefs through procrastination to goal achievement was not

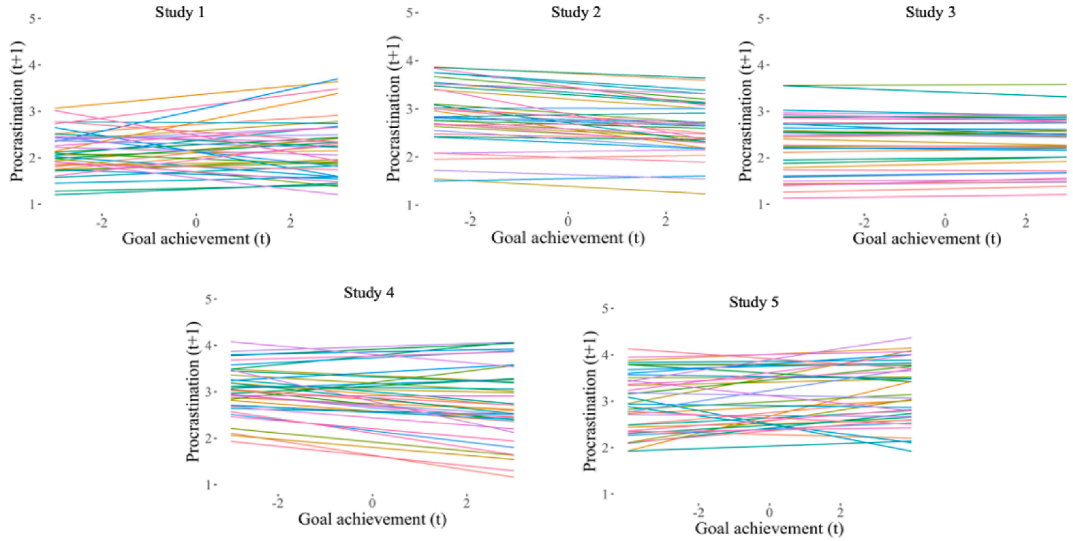

Fig. 5. Relation between goal achievement and subsequent procrastination. The figure shows a random sample of 40 individual slopes for each study.

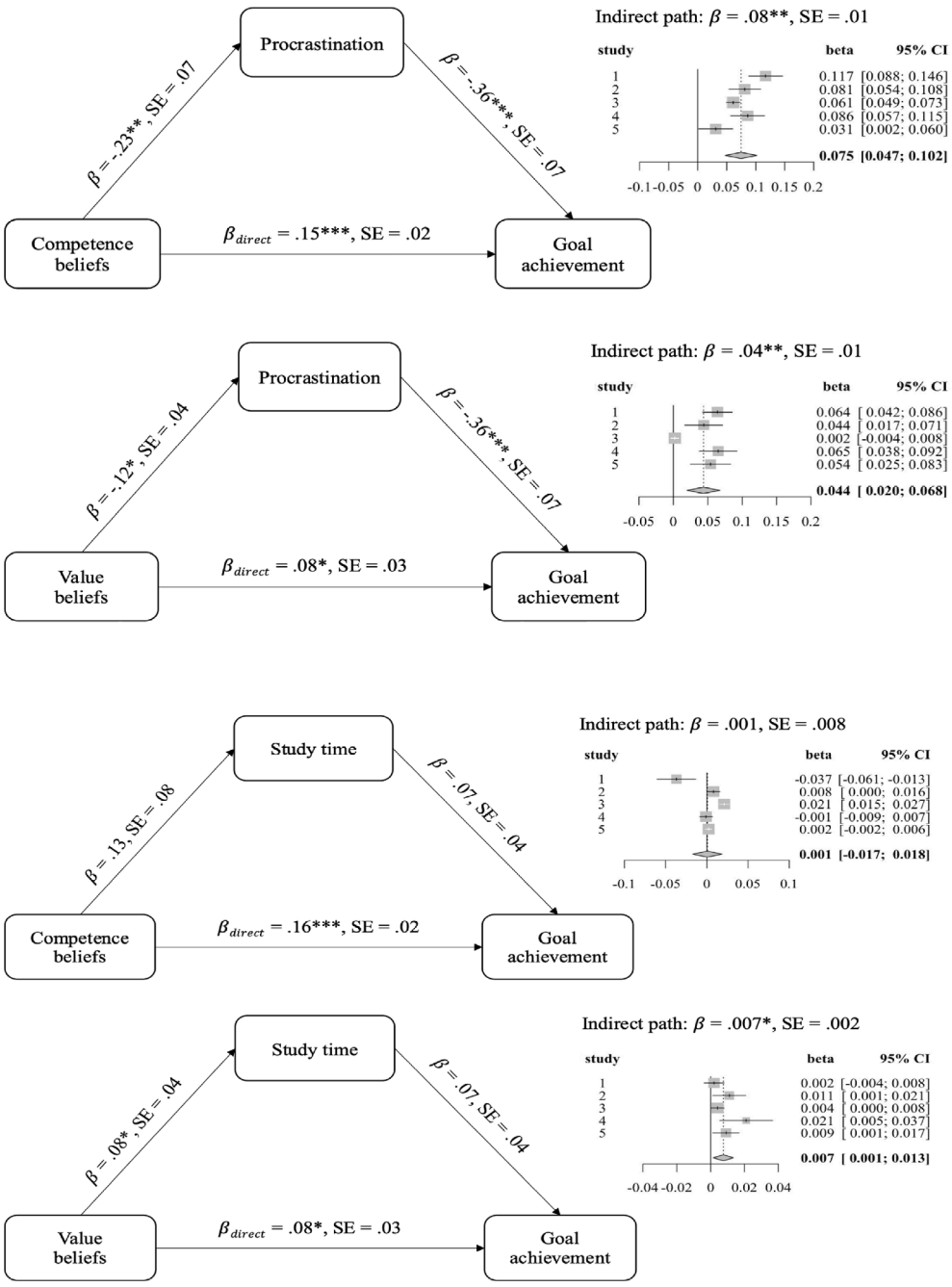

Fig. 6. Multilevel structural equation model linking motivational beliefs to goal achievement via procrastination and study time. The figure shows the aggregated standardized path weights (β) for the within-person direct and indirect effects. That is, the path weights for the direct and indirect paths were first estimated for each study and then aggregated across studies using meta-analytic methods. As we focus on intra-individual relations, only the within-person effects are shown and not the between-person effects. In addition, the forest plots show the betas for the focal indirect path for each study separately. The average path weights are presented separately for the four proposed mediations. Note, however, that the paths were estimated together in a joint model. *p <.05, **p <.01, ***p <.001.

significant. Taken together, our results suggest that students with high competence and value beliefs procrastinate less, which promotes goal achievement. In addition, results indicated that study time did not mediate the relation between competence and value beliefs and goal achievement. We found that students who reported higher value beliefs (compared to their personal average) reported more study time. However, study time was not related to goal achievement, which is a necessary condition for mediation to occur. Therefore, the significant indirect path from value beliefs to goal achievement via study time cannot be interpreted. Taken together, the results of the mediation analysis are partially consistent with hypothesis 4. The positive relation between competence and value beliefs and goal achievement was partially mediated by procrastination, but not by study time.

4. Discussion

The present study tested intra-individual feedback loops between competence beliefs, value beliefs, procrastination, and goal achievement. We also examined procrastination and study time as mediators between competence and value beliefs and goal achievement. We synthesized results from five independent diary studies to provide average effect sizes. Results revealed virtuous circles between competence beliefs, value beliefs, and goal achievement. Students who reported higher competence and value beliefs in a study session reported higher goal achievement, and higher goal achievement predicted higher competence and value beliefs in the subsequent study session. In addition, results indicated that higher levels of procrastination were associated with lower levels of goal achievement. The relation between goal achievement and subsequent procrastination was more complex, however. In addition, the positive relation between competence and value

beliefs and goal achievement was partially mediated by procrastination, but not by study time.

The present study conceptually replicated and extended previous findings on intra-individual feedback loops in self-regulated learning. Self-regulated learning models suggest that competence and value beliefs, procrastination, and goal achievement reinforce each other through feedback loops from one study session to the next (Schmitz & Wiese, 2006; Zimmerman, 2000), but prior research has rarely tested this assumption. The present study is unique in that it synthesizes findings from five independent studies with an intensive longitudinal design. This allowed us to obtain robust estimates of the proposed intra-individual feedback loops in self-regulated learning. In addition, the repeated assessment allowed us to account for intra-individual dynamics that would not be possible with one-time, between-subject measures. Thus, our results extend previous research by focusing on intra-individual (rather than inter-individual) relations among competence and value beliefs, procrastination, study time, and goal achievement. The present findings have theoretical implications for models of self-regulated learning and methodological implications for the design of experience sampling studies.

4.1. Virtuous circles between competence beliefs, value beliefs, and goal achievement

Our findings suggest that competence and value beliefs are maintained through repeated goal achievement. We found two virtuous circles: A virtuous circle between competence beliefs and goal achievement, and a virtuous circle between value beliefs and goal achievement. That is, students who reported higher competence and value beliefs before learning reported higher goal achievement after learning. The finding that competence and value beliefs can vary from one study session to the next is not new (Malmberg et al., 2015; Martin et al., 2015). In this study, however, we provide evidence from multiple studies that these variations in motivational beliefs reliably predict whether students achieve their learning goal in a given study session. Furthermore, our findings suggest that differences in goal achievement may explain why competence and value beliefs vary across study sessions. Higher goal achievement after learning predicted higher competence and value beliefs in the next study session. The results are consistent with models of self-regulated learning that posit a positive relation between competence and value beliefs and subsequent goal achievement (Pintrich, 1999; Zimmerman, 2000). The results are also consistent with theories of motivation. Repeated goal achievement strengthens learners' beliefs in their own abilities to achieve their goals, which in turn strengthens competence beliefs (Bandura, 1997) and intrinsic value beliefs (Deci & Ryan, 2000). Despite the theoretical relevance, research that considers short-term feedback loops between competence and value beliefs and performance has been largely lacking (Vu et al., 2022). Thus, the current study extends previous research by providing robust evidence that competence and value beliefs and goal achievement positively reinforce each other. The findings thus contribute to a better understanding of the dynamic interplay between motivation and goal achievement in self-regulated learning.

Notably, the association between goal achievement and subsequent value beliefs was not consistently found across studies. One explanation for the inconsistent findings concerns the assessment of value beliefs. The two studies that did not find a significant association between goal achievement and subsequent value beliefs (Study 1 and Study 4) differed from the other studies in how they assessed value beliefs. In Study 1, daily value beliefs were assessed retrospectively after the study session was completed. Thus, experiences during the study session may have influenced students' value beliefs and masked the effect of the previous day's goal achievement on value beliefs. In Study 4, value beliefs were assessed once a week, resulting in a larger time gap between study sessions. Again, experiences during the week other than prior goal achievement may have influenced students' value beliefs.

Another explanation for the weak association between goal achievement and subsequent value beliefs relates to the context specificity of value beliefs. For example, Bong (2001) showed that value beliefs in one domain (e.g., mathematics) are only modestly correlated with value beliefs in another domain (e.g., language). In Studies 1, 2, and 5, the assessment of value beliefs was not tied to a specific course. That is, students may have studied for different courses across study sessions, which could explain why goal achievement in one domain (e.g., statistics course) did not increase value beliefs in another domain (e.g., finance course). Furthermore, even within a single course, value beliefs may differ for specific topics (Dietrich et al., 2017). For example, in Study 3, all students were preparing for a medical exam. However, value beliefs for one topic (e.g., learning about how the heart works) may be higher than for another topic (e.g., learning about how the brain works). This domain specificity may also apply to the relation between goal achievement and future competence beliefs. Although goal achievement consistently predicted future competence beliefs, the strength of this link may also depend on whether competence beliefs are assessed within or across domains. In summary, future studies should examine whether and to what extent goal achievement predicts future value and competence beliefs within and across domains.

Results from the mediation analyses provide insight into potential mechanisms linking competence and value beliefs to goal achievement. The relation between competence and value beliefs and goal achievement was partially mediated by self-reported procrastination in the same study session. That is, students who reported higher competence and value beliefs in a given study session procrastinated less while studying, which predicted higher goal achievement. Our findings extend those of previous studies that have suggested a relation between competence beliefs, value beliefs, and procrastination (e.g., Lee, 2005; Wäschle et al., 2014). In particular, higher competence beliefs may help students to study more persistently and to use better volitional strategies while studying (Breitwieser & Brod, 2022). Taken together, students procrastinate less on days when they are highly motivated, which predicts higher goal achievement.

Study time did not mediate the link between competence and value beliefs and goal achievement, however. In line with previous findings, we found a positive relation between value beliefs and time spent studying (e.g., Bellhäuser et al., 2021). That is, students who reported higher value beliefs in a particular study session tended to study longer. However, study time was not related to goal achievement. This finding is consistent with previous research suggesting that more time spent completing an assignment may indicate that students are struggling with the material (Flunger et al., 2015) or may even indicate a learning disability (Geary et al., 1991). This finding is also consistent with previous studies that have tested inter-individual associations between study time and academic performance (e.g., Plant et al., 2005; Theobald et al., 2018). Results from these studies suggest that it is not the absolute amount of time spent studying that predicts academic performance. It is more important that students use strategies to make effective use of their study time, such as planning and implementing effective cognitive and metacognitive strategies (e.g., organizing and elaborating or self-testing one's understanding, see Nückles et al., 2020 for a review). Thus, students who are highly motivated study longer, but studying longer does not necessarily promote goal achievement.

4.2. Vicious circle between procrastination and goal achievement

Our results provide only partial support for a vicious circle between procrastination and goal achievement. Students who procrastinated more in one study session reported lower goal achievement, which is consistent with previous findings (Liborius et al., 2019; Wäschle et al., 2014). However, lower goal achievement was not associated with a higher level of procrastination in the subsequent study session. Thus, procrastination was associated with goal failure, but goal failure did not increase future procrastination.

One possible explanation for the lack of a direct link between goal failure and future procrastination is that students differed in how they dealt with goal failure. We found considerable variance in the relation between goal failure and subsequent procrastination. That is, some students tended to procrastinate more after goal failure, while others tended to procrastinate less after goal failure. These opposite tendencies may explain the overall null effect. From a theoretical perspective, both tendencies – higher and lower procrastination after goal failure – are plausible. *Higher* procrastination after goal failure can be explained by social-cognitive theories (Bandura, 1997): Repeated failure should reduce the subjective sense of control over the situation, which in turn promotes procrastination. That is, after goal failure, students feel less competent to master their goals and may begin to avoid the task altogether (Klassen et al., 2008; Wolters, 2003). *Lower* procrastination after goal failure can be explained by the cybernetic model of self-regulation (Carver & Scheier, 1990). According to the cybernetic model, learners set internal standards or goals. Learners then strive to reduce the discrepancy between their goal and their current level of performance. If students fall short of their goal, they should invest more effort to make up for the previous failure. Applied to this study, after a goal failure, students should procrastinate less to reduce the discrepancy between their goal and their current level of performance. Taken together, in some cases, repeated goal failure may perpetuate procrastination, but in other cases, goal failure may lead to higher goal-directed effort, thereby reducing procrastination.

Future studies could examine moderators of the link between goal failure and procrastination. For example, students' emotional reactions to failure may play a role. Students have been shown to report higher levels of procrastination following days in which they experienced higher levels of negative affect (Pollack & Herres, 2020). In addition, students who have a general tendency to procrastinate, such as less conscientious students (Steel, 2007), may be more likely to report increased procrastination following failure. Future studies should examine which factors contribute to increased or decreased levels of procrastination after failure.

4.3. Implications for models of self-regulated learning and assessment

Our findings largely support assumptions from process models of self-regulated learning (Schmitz & Wiese, 2006; Zimmerman, 2000). Process models of self-regulated learning assume that students' competence and value beliefs prior to studying affect their study behavior during studying (e.g., study time or procrastination), which in turn affects their learning outcomes after studying (e.g., goal achievement). That is, process models describe intra-individual relations within a given study session. Thus, to test model assumptions, data analyses should focus on intra-individual relations rather than inter-individual differences between students. Inter-individual relations between competence and value beliefs, procrastination, and goal achievement are well documented (e.g., Steel, 2007). However, the results of the current study provide robust evidence for intra-individual relations linking competence and value beliefs, procrastination, and goal achievement within a study session.

The distinction between intra- and inter-individual levels of analysis is important because correlations may differ at the intra- and inter-individual levels. For example, Schmitz and Skinner (1993) found a positive relation between time spent on homework (as a measure of effort investment) and homework performance at the inter-individual level, but not at the intra-individual level. At the intra-individual level, students who spent more time on homework were *not* more likely to do their homework correctly. Higher time spent on homework may indicate higher task difficulty, as students spent more time studying than they usually do. This may explain why more time spent does not lead to better performance at the intra-individual level. Similarly, in the current study, students who spent more time studying on a given day were not more likely to achieve their goal. Therefore, future studies should continue to differentiate between intra- and inter-individual relations.

Our findings support the idea that study sessions are linked by internal feedback loops and provide avenues for further research. Models of self-regulated learning assume feedback loops from one study session to the next, but do not make precise predictions about how and under what circumstances students adapt their study behavior. For example, students are thought to adjust their goals and plans based on internal feedback from the previous study session (Butler & Winne, 1995; Winne & Hadwin, 1998). However, it is still unclear how exactly students revise their goals and plans. A recent study showed that students mostly lowered their goals after a goal failure (Theobald et al., 2021). However, goal revision also depended on students' emotional response to failure. High negative emotions attenuated downward goal revision after failure. Thus, future studies should continue to examine how students adjust their goals and strategies from one study session to the next. This would allow researchers to refine predictions about how students self-regulate their learning.

4.4. Limitations and future directions

The results of the current study revealed several future directions worth mentioning. First, following a conceptual replication approach, the target sample, study duration, and learning diary design varied across studies. For example, some studies recruited heterogeneous samples of students from different majors (e.g., Studies 2 and 5), while others tested more homogeneous samples (e.g., only medical students in Study 3). The duration of the studies ranged from 28 days (Study 1) to 154 days (Study 2). In some studies, students reported their self-regulation and motivation twice a day (Studies 2, 3, and 5), once a day (Study 1), or once a week (Study 4). Despite these differences in study design, most of the hypothesized relations were found across studies. In other words, the hypothesized relations do not seem to depend on a particular operationalization or study design, which supports the generalizability of our findings. Nevertheless, these differences in study design may explain differences in absolute effect sizes between studies. However, the aim of this study was to test intra-individual feedback loops in self-regulated learning across five original studies using the same data analysis procedures. Thus, the number of studies was too small to conduct moderator analyses. A comprehensive meta-analysis including a larger number of primary studies should be conducted to test potential methodological moderator effects.

Second, to date, there are no validated questionnaires for assessing momentary self-regulated learning. For example, although all of the studies included in this article assessed the same theoretical constructs, the operationalization of the variables differed across studies. As a first step, research groups could share their questionnaire items to facilitate the sharing of previously tested questionnaires. For example, the Experience Sampling Method Repository (https://www.esmitemrepository.com) collects items that have been used in previous experience sampling studies. In the long term, research efforts should focus on developing reliable and valid questionnaires that assess momentary changes in self-regulated learning.

Third, in addition to developing self-report questionnaires, future research should use additional, more objective measures of self-regulated learning. The studies included in this article mostly relied on self-reports, which can be biased, for example, due to social desirability (Veenman, 2011). However, there are several points in favor of using self-reports in this study. First, our repeated assessment, which took place in students' typical learning environment, reduced the risk of memory bias and increased ecological validity (Panadero et al., 2016). Second, self-reports provide important insights into how students perceive their self-regulated learning, which may influence their study decisions. In addition, self-report questionnaires may also be useful for assessing and differentiating between different aspects of motivation (Fulmer & Frijters, 2009), such as competence and value beliefs. Finally,

self-reported self-regulated learning strategies and motivation predict individual differences in students' academic performance, as documented in Study 2, Study 3, and Study 4 (see Breitwieser et al., 2021; Liborius et al., 2019; Wäschle et al., 2014). These findings support the predictive validity of self-report measures. Nevertheless, future studies should use additional measures besides self-reports, such as log file measures. Log file measures have been used to assess various aspects of students' self-regulated learning, such as distributed practice, planning strategies, or self-monitoring (e.g., Theobald et al., 2018). In this article, one study included log file measures of daily goal achievement (Study 3). Results for self-reported and objective goal achievement were often similar, indicating the validity of self-report measures. However, we also found some discrepancies. For example, higher value beliefs predicted higher self-reported but not objective goal achievement. Thus, self-reports and log files may assess different aspects of goal achievement. Therefore, future studies should use both self-reports and log files to get a complete picture of students' goal achievement and self-regulated learning.

Finally, we encourage more direct and conceptual replications of previous findings. In our study, we used a conceptual replication approach to test key theoretical assumptions of the process model of self-regulated learning. A strength of this conceptual replication approach is that it allows for testing whether hypothesized theoretical assumptions generalize across different research designs, which supports confidence in the validity of the underlying theory (Stroebe & Strack, 2014). Future studies should also test whether study findings are replicable. This can be done by testing whether using the same methods and study design leads to the same results. To this end, standardized guidelines for experience sampling studies in self-regulated learning research would be helpful. For example, what is the optimal length of the survey period? How many times per day should students report on their current self-regulation? Future experience sampling studies should also consider the risk of selection bias when recruiting their samples. For example, the regular completion of a learning diary already requires a certain level of self-regulation. Therefore, findings from experience sampling studies may not always apply to student samples with lower self-regulatory competencies. As we focused exclusively on university students, future studies should test whether the findings apply to other populations, such as schoolchildren. In addition, research teams often differ in the way they analyze their data, which can lead to different results and conclusions (Schweinsberg et al., 2021). Guidelines for data analysis could contribute to a more standardized approach. To increase transparency, researchers could make data and data analysis scripts publicly available. In summary, transparent research methods and guidelines for study design and data analysis would facilitate future replication studies.

4.5. *Practical implications and conclusions*

Findings from the present study underscore that enhancing students' competence and value beliefs can initiate a virtuous circle. Students who are motivated to learn are more likely to achieve their goals, and goal achievement, in turn, promotes competence and value beliefs. To enhance students' competence and value beliefs, teachers could create learning environments that support students' needs for autonomy, competence, and relatedness (Deci & Ryan, 2000). For example, it has been shown that students' motivation to complete homework was positively related to teachers' perceived support of students' needs (Katz et al., 2009): Students were more motivated when teachers allowed students to choose homework assignments (autonomy), provided optimally challenging assignments (competence), and promoted peer acceptance (relatedness). Teachers could also provide training programs to support self-regulated learning, which has been shown to increase competence beliefs (Theobald, 2021). For example, a teacher-led self-regulated learning training program improved middle school students' strategy use, competence, and value beliefs (Núñez et al., 2013). In this program, teachers provided weekly mentoring sessions over the course of an entire school year. During the mentoring sessions, teachers helped students acquire, monitor, and reflect on their self-regulated learning strategies. In addition, teachers provided students with feedback on their use of the strategies and promoted transfer of the strategies to different contexts (e.g., classroom situations or completing homework). As this example shows, self-regulated learning training programs can help students use better learning strategies and achieve their goals, which ultimately improves students' competence and value beliefs. Taken together, these findings provide guidance on the factors that interventions should target to most effectively promote student motivation and goal achievement.

Our findings highlight that self-regulated learning is a dynamic and highly variable process. Competence and value beliefs, procrastination, and goal achievement varied from one study session to the next. These dynamics call for adaptive, individualized interventions that account for situation-specific changes in self-regulated learning. Thus, the present findings may help to design targeted interventions that take into account, for example, the ideal time to intervene. For example, motivational interventions could be provided prior to studying to increase students' intrinsic value to engage with the learning content (see, e.g., Nückles et al., 2020). In addition, daily metacognitive prompts provided before, during, or after studying could help students achieve their goals (see, e.g., Breitwieser et al., 2021; Theobald & Bellhäuser, 2022). Thus, future intervention research should consider the intra-individual dynamics of self-regulation in order to provide students with adaptive guidance that meets their individual needs.

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Open Science Statement

Research questions and data analysis procedures were pre-registered prior to the data analysis via the Open Science Framework: https://doi.org/10.17605/OSF.IO/SKNEQ. The original data and data analysis scripts are available via the Open Science Framework: https://osf.io/wg9km/. Note that data from study 1 cannot be shared due to data privacy restrictions.

Author contributions

Study 1 was designed and conducted by L.B, M.DA., and M.DR. Study 2 was designed and conducted by P.L. and H.B. Study 3 was designed and conducted by J.B. and G.B. Study 4 was designed and conducted by M.N. Study 5 was designed and conducted by M.T. and H.B. L.B. (study 1), P.L. and B.M. (study 2), J.B. (study 3), and M.T. (study 4 and 5) performed the data analyses. M.T. synthesized the findings. M.T. drafted the paper. All co-authors provided critical revisions. All authors approved the final version of the paper for submission.

Declaration of Competing Interest

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

Data availability

Data and data analysis scripts are available via the open science framework: https://osf.io/wg9km/

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cedpsych.2023.102208.

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