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The Unique Importance of Motivation and Mindsets for Students' Learning Behavior and Achievement: An Examination at the Level of Between-Student Differences and Within-Student Fluctuations

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Abstract

This study examined the unique and interactive role of students' quality of motivation, as defined in Self-Determination Theory, and their mindsets about intelligence, as conceptualized in Dweck's framework, in predicting a variety of learning outcomes (engagement, learning strategies, persistence, procrastination, and test anxiety) and achievement. Moving beyond past work, their effects were examined both at the level of between-student differences and at the level of semester-to-semester fluctuations within students' own functioning, thereby controlling for students' cognitive ability. The study had a 4-wave longitudinal design, following 3,415 7th grade students across a 2-year period with 6-month intervals (49.8% female; mean age = 12.65 years). Multilevel analyses demonstrated that autonomous motivation and effort beliefs had independent and favorable associations with most outcomes and that controlled motivation and a fixed mindset related more uniquely to maladaptive outcomes, findings that emerged at both levels of analysis. This pattern of associations held after controlling for students' cognitive ability and applied to both students with high and low cognitive ability. The number of interactions between motivation and mindsets was quite limited. It can be concluded that quality of motivation and mindsets about intelligence represent compatible resources for learning that help to explain between-student and within-student differences in learning and achievement.

Key Words: Motivation, Self-Determination Theory, Mindsets about Intelligence, Learning, Achievement, Longitudinal

Educational Impact and Implications Statement

Both students' quality of academic motivation and their beliefs about the role of efforts and intelligence in performance were found to predict students' learning outcomes and achievement. Students reported more favorable outcomes when they perceived the learning material as interesting and personally relevant and when they thought that efforts lead to improved learning. The benefits of such autonomous motivation and effort beliefs emerged both when students scored higher on these motivational resources compared to others (i.e., between-student level) as well as when they scored higher on these resources in a given semester (i.e., within-student level). As such, the findings indicate that both students' quality of motivation and their effort beliefs are useful targets for targets for intervention that should perhaps be combined in educational interventions.

Students differ considerably from each other on a wide range of learning behaviors. Whereas some students are highly engaged for school (Fredricks et al., 2004), persist when facing obstacles (Comings, 2007), and display self-regulated learning (Haggis, 2003), others tend to procrastinate (Cao, 2012) and show signs of test anxiety when being evaluated (Wigfield & Eccles, 1998). Yet, these *between*-student differences tell us only part of the story because students also show variation *within* their own learning behavior across time. Indeed, research highlights that, apart from between-student differences, students may feel engaged, self-confident, and persistent to learn during one particular period, but disaffected, insecure, and inclined to give up at another point in time. For example, engagement (Bakker et al., 2015), learning strategies (Prat-Sala, 2010) and dysfunctional behaviors and emotions (Hong, 1998; Kljajic & Gaudreau, 2016; Roland et al., 2016) have all been shown to fluctuate substantially from time to time within students' own functioning.

Both from a theoretical point of view and from an applied perspective, it is crucial to identify a parsimonious set of critical predictors that can account for both these between- and within-person variations in students' learning. To do so, and to move the literature forward at a conceptual level, herein we rely on two well-established motivational theories, that is, Dweck's social-cognitive framework, which focuses on students' beliefs about intelligence (i.e., their mindsets), and Self-Determination Theory (SDT; Ryan & Deci, 2017), which highlights the importance of high-quality motivation. Although both theories have already received extensive empirical support, they have typically been studied in isolation. This state of affairs is symptomatic for a broader lack of cross-fertilization or even fragmentation of motivational theories in the current literature (Skinner et al., 2022). Because the siloed co-existence of theories represents a threat to conceptual progress in motivation science, many prominent scholars recently argued for more joint examinations of motivational theories (Anderman, 2023; Nagengast & Trautwein, 2023). Through a joint examination of SDT and

Dweck's theory, it can be investigated whether the motivational resources proposed by both theories play a unique and perhaps also interactive role in various learning outcomes.

Methodologically, this 4-wave longitudinal study contributes to the literature by examining the role of students' motivational resources simultaneously at the between-person level (i.e., the level of interindividual differences) and at the within-person level (i.e., the level of intra-individual fluctuations). Only few studies to date formally differentiated between these two levels of analysis. The limited attention given to the level of within-person variations is particularly unfortunate because motivation is an inherently dynamic construct (Schmidt et al., 2007; Schunk, 2023). Studying motivational resources dynamically is essential from an applied perspective because interventions operate precisely at this level, trying to accomplish a positive change in students' functioning. As such, a joint examination of the unique roles of SDT-based motivation and Dweck's mindsets at both the between-person and within-person level can offer important clues for interventions that can even be targeted to the specific educational challenges students are confronted with (Rubenstein et al., 2012). Research disentangling effects of motivation at the between- and within-student level of analysis is also important because the role of motivation can differ depending on the level of analysis. To illustrate, Murayama et al.(2013) showed that, whereas students' intelligence is a strong predictor of students' math achievement at the between-person level, motivation predicted intra-individual progress in achievement across time. The current study aims to extend these findings to a broader range of educational outcomes and addressing the role of both students' quality of motivation and mindsets, thereby providing the most comprehensive joint examination of SDT and Dweck's social-cognitive theory to date.

Mindsets and Quality of Motivation

Dweck's mindsets theory and SDT are two highly influential, contemporary frameworks that highlight different, yet potentially complementary and uniquely important, psychological processes that are essential to students' adaptive learning behaviors and achievement. Dweck's theory on mindsets about intelligence focuses on the type of social-cognitive beliefs students have (Dweck & Master, 2009). These cognitive beliefs shape how students perceive their intelligence and the malleability of their own capabilities. From this point of view, students differ in the extent to which they believe that they are capable of improving their capabilities and performance, with this belief influencing their confidence and their chances to succeed in school. SDT focuses on the quality of students' motivation as an energetic basis for learning, with motivation being considered the 'fuel' needed to enable students to fully commit to school (Ryan & Deci, 2020). Because Dweck's theory and SDT propose distinct but important resources for learning, it is worthwhile to examine whether these resources play unique roles in students' learning process and achievement.

Mindsets

Dwecks' theory distinguishes between a fixed mindset and a growth mindset (Dweck & Leggett, 1988). A fixed mindset is characterized by the belief that intelligence is a stable, fixed trait that cannot grow or be improved through effort or repeated practice. Students with a fixed mindset hold the belief that everyone is endowed with a certain fixed amount of ability and there is little one can do to change that. In contrast, a growth mindset is characterized by the belief that intelligence is malleable and is amenable to change through training and practice. Students with a growth mindset hold the belief that through effort-expenditure everyone is capable to increase his or her intelligence. In addition, beliefs about intelligence have been argued to translate in beliefs about the value and necessity of effort to succeed, that is, students' effort beliefs (Blackwell et al., 2007; Tempelaar et al., 2015). Whereas students with a fixed mindset have weaker effort beliefs, thereby minimizing the value of effort to reach academic goals or perceiving effort as a sign of incompetence, students with a growth mindset endorse strong effort beliefs, perceiving effort as a key factor underlying their development (Miele et al., 2011). In this study, both a fixed mindset about intelligence and effort beliefs were measured.

According to Dweck (2017), these cognitive representations are important factors to understand students' learning behavior. Students who perceive their intelligence as a stable trait and who believe that putting in effort is rather futile are more likely to experience feelings of helplessness when confronted with setbacks. In an attempt to avoid failure, they may, for instance, engage in self-handicapping or procrastination prior to task engagement. During task engagement, they may more easily give up when confronting difficulties as they do not believe they have sufficient ability to do well. The anticipation of failure on an evaluation in school is very threatening as tests are perceived as a direct assessment of their innate ability. As a result, students with a fixed mindset are likely to report more test anxiety and worries about their performance (Cury et al., 2008). In contrast, when students believe that improvement and growth is possible, they are more likely to remain engaged and to persist even in the face of difficulties. Confronted with obstacles and difficulties, students scoring high on effort beliefs may invest extra effort and use more deep-level learning strategies to obtain a deeper understanding of the course materials (Yeager & Dweck, 2012). Because evaluations at school are not just seen as diagnostic for their ability, such students are also assumed to be less prone to test anxiety.

Various studies have demonstrated the beneficial role of students' effort beliefs and the detrimental role of a fixed mindset in learning outcomes, with effort beliefs predicting lower procrastination (Howell & Buro, 2009), higher school engagement (Shih, 2009; De Castella & Byrne, 2015), greater use of deep-level learning strategies (Mangels et al., 2006), more persistence (Mrazek et al., 2018), and less test anxiety (Cury et al., 2008) and with a fixed mindset predicting the opposite pattern of outcomes. Regarding students' achievement, meta-analyses found small but significant negative correlations between a fixed mindset and academic performance (Faria & Costa, 2018; Sisk et al., 2018), whereas students' effort beliefs related positively to students' GPA (Lavrijsen et al., 2022).

The SDT Perspective on Motivation

SDT suggests that the type or quality of motivation of students affects the amount of energy they have available to invest in learning and to cope with academic problems (Ryan & Deci, 2020; Niemiec & Ryan, 2009; Vansteenkiste et al., 2006). To determine students' quality of motivation, SDT distinguishes between autonomous and controlled motivation. When students are driven by autonomous motivation, they experience a sense of volition and their reasons for studying are perceived as self-directed and self-endorsed. When autonomously motivated, students find the learning material to be interesting and enjoyable (intrinsic motivation) or personally valuable and meaningful (identified regulation). In contrast, controlled motivation refers to behavior that is driven by pressure to behave in a certain way. With controlled motivation, students experience their study efforts as stemming from internal forms of pressure such as feelings of guilt, shame or anxiety or the striving for contingent self-approval and pride (introjected regulation) or from externally pressuring forces, such as high environmental demands or expectations, the threat of punishments, or the promise of rewards (external regulation) (Ryan & Connell, 1989).

Autonomous motivation, because of its volitional character, is said to be a source of energy whereas controlled motivation, because of its pressuring and obligatory character, is assumed to deplete students' energy levels (Vansteenkiste et al., 2009). Because of its energizing properties, autonomous motivation can be seen as a resource providing the fuel necessary to display engagement, persistence, and deep-level learning. Controlled motivation can also be a driving force behind students' efforts, resulting at least in short-term behavioral engagement. However, because controlled motivation entails experiences of pressure and tension, students' behavioral engagement would not be accompanied by emotional engagement (e.g., enthusiasm) and may even come with an emotional cost. Although controlled motivation can spur superficial learning, the instrumental focus associated with this type of motivation would hinder deep-level learning. Students with more controlled motivation would more easily give up when confronted with obstacles or may even engage in self-handicapping strategies to protect their self-worth (including procrastination). They would also perceive evaluations as highly threatening, resulting in test anxiety.

Abundant empirical research has shown that these qualitatively distinct types of motivation are associated with students' learning behavior and achievement (Vansteenkiste, Soenens, & Waterschoot, in press). Most of these studies focused on cross-sectional differences between students or on rank-order changes between students across time. More autonomous forms of motivation were associated with higher engagement (Patrick et al., 1993; Skinner et al., 2009), more deep-level learning strategies (Vansteenkiste et al., 2005), greater persistence (Ratelle et al., 2007; Wijsman et al., 2014), and better achievement (Black & Deci, 2000). In contrast, more controlled forms of motivation (especially introjection) are related positively to behavioral engagement yet negatively to emotional engagement (Van der Kaap-Deeder et al., 2016) and predict the use of superficial learning only (in the absence of deep-level learning) (Grolnick & Ryan, 1987), as well as procrastination (Mouratidis et al., 2018) and test anxiety (Vansteenkiste et al., 2009). Controlled motivation is not necessarily antithetical to autonomous motivation. It can co-occur with autonomous motivation, as is the case for students with a profile of high quantity motivation (Vansteenkiste et al., 2009). Although students who combine autonomous and controlled motivation obtain better learning outcomes than students who score low on both types of motivation (i.e., low quantity of motivation profile), they still fare worse for some outcomes than students with high levels of autonomous motivation only (i.e., students with good quality motivation). Overall then, controlled motivation is a rather mixed blessing for students' learning. Particularly when it is the main motivating force behind students' efforts, it comes with short-term benefits at best and it results in lower quality of learning than autonomous motivation.

The Unique and Complementary Role of Both Frameworks

SDT and Dweck's theory highlight distinct, yet interrelated, resources for learning. It is important to examine the joint and unique effects of the key variables from these two frameworks for both fundamental and applied reasons. From a fundamental point of view, a joint examination of both theories is a first step towards potential greater conceptual integration in the motivational literature (Nagengast & Trautwein, 2023; Skinner et al., 2022). From an applied perspective, such an examination has the potential to inform educational interventions. If SDT-based quality of motivation and Dweck's mindsets would play highly differentiated roles in specific educational outcomes, then perhaps interventions based on these theories should be provided in a targeted fashion. Students would then be offered the intervention targeting the motivational resource (i.e., quality of motivation or mindsets) linked most strongly to the educational challenges they are confronted with. If instead, quality of motivation and mindsets would predict most of the outcomes simultaneously (or even synergistically), then perhaps the available educational interventions would need to be integrated (rather than being offered separately). Universal prevention efforts aimed at enhancing students' academic adjustment and performance would then combine the best of both worlds and include insights from both SDT and Dweck's theory.

The joint role of mindsets and motivation in students' functioning has received only limited prior attention. The few studies available demonstrated significant associations between SDT-based quality of motivation and the mindsets, with autonomous motivation relating primarily to a growth mindset and effort beliefs and with controlled motivation relating positively to a fixed mindset (Boncquet et al., 2020; Lavrijsen et al., 2022; Mouratidis et al., 2017). This pattern of associations is consistent with the broader observation that autonomous functioning typically goes hand in hand with open and flexible social-cognitive modes of functioning and that controlled motivation is associated with more rigid, closed-minded, and defensive modes of cognitive functioning (Hodgins et al., 2006; Hodgins & Knee, 2002; Soenens et al., 2005).

Because SDT-based motivation and Dweck's mindsets are interrelated yet distinct, it is important to consider their unique and interactive roles in student outcomes. Looking at students' achievement, Lavrijsen et al. (2022) found that both autonomous motivation and students' effort beliefs were positively and uniquely related to students' school performance. Controlled motivation was related negatively to achievement while no unique effects of an fixed mindset were found. Using a longitudinal follow-up of students in the transition from 6th to 7th grade, Boncquet et al. (2020) found that autonomous motivation predicted intra-individual increases in both math achievement and well-being, whereas controlled motivation yielded the opposite pattern of relations and an fixed mindset failed to have independent effects beyond motivation.

Even fewer studies have addressed the interactive interplay between both types of resources. Several types of interactions could emerge, including synergistic and compensatory interactions. A synergistic interaction would imply that the simultaneous presence of two adaptive resources (i.e., autonomous motivation and effort beliefs) yields a surplus effect. Two maladaptive predictors (i.e., a fixed mindset and controlled motivation) may create an additional disadvantage not accounted for by the effects of both predictors separately. Yet, also a compensatory effect may emerge, where one of the two available adaptive resources buffers against the detrimental effects associated with the presence of a risk factor. For example, effort beliefs could buffer the negative effects of controlled motivation. The one study to date that examined interaction effects between students' mindsets and motivation (Mouratidis et al., 2017) found that autonomous motivation predicted increases in high school students' study effort and decreases in procrastination, but only for those students who scored low on a fixed mindset. Given the scarcity of studies, additional research is needed.

On the Importance of Examining Motivational Dynamics at the Within-Person Level

There has been an increasing emphasis in educational psychology on the importance of taking into account both inter- and intra-individual differences in learning processes (Curran & Bauer, 2011; Patall et al., 2018). Arguably, processes at the within-person level have the most meaning for the individual itself (Keijsers, 2016): students will more easily notice the progress they made over time than their relative standing compared to others. Also from an applied perspective, the within-person level is key, as this is the level with the highest potential for change during an intervention.

To date, however, studies examining the predictive role of the social-cognitive and motivational resources proposed by Dweck's theory and SDT have mostly focused on the between-person level, with intra-individual variations in student behavior across time receiving far less attention. Moreover, the few available studies that did focus on intraindividual fluctuations in achievement across time yielded rather mixed findings. Some studies (e.g., Blackwell et al., 2007) demonstrated positive longitudinal associations between a growth mindset and achievement but other studies failed to replicate these findings (e.g., Li & Bates, 2020). Further, Murayama et al. (2013) examined changes in students' math achievement from 5th to 10th grade and found that students' intrinsic motivation positively predicted intra-individual progress in math achievement. Similarly, looking at intra-individual week-to-week variations in high school students' functioning over a time span of 5 months, Mouratidis et al. (2017) found that students reported more efforts to study and less procrastination in periods when they were more autonomously motivated. Although a number of studies have begun to examine students' mindsets and motivation at the level of intra-individual fluctuations, there is a need for further research examining more comprehensively the unique and interactive roles of both sets of predictors in a broad set of learning outcomes.

On the Importance of Considering Students' Intelligence

Students' mindsets and motivation are of course not the only potential sources of influence on their learning process and achievement. Cognitive ability plays an undeniably important role, particularly in school achievement. In a meta-analysis, Roth et al. (2015) obtained a correlation of .54 between intelligence and school grades in secondary school. Moreover, intelligence has been associated with various adaptive learning outcomes. In particular, students with higher intelligence tend to report using more deep-level learning strategies (Chamorro-Premuzic & Furnham, 2008), higher engagement (Furnham et al., 2009), higher persistence (Mousavi et al., 2015), and less test anxiety (Moutafi et al., 2006).

Because students' cognitive ability is strongly involved in students' learning and achievement, it is important to examine whether students' mindsets and motivation have incremental predictive value above and beyond students' intelligence. Prior research that considered this issue is limited and yielded somewhat inconsistent results (Kriegbaum et al., 2018). For example, recent studies found that autonomous and controlled motivation showed unique associations with math achievement even when controlling intelligence, but this was not the case for students' fixed mindset (Boncquet et al., 2020). Similarly, Lavrijsen et al. (2022) found that autonomous and effort beliefs played a role in students' achievement above and beyond intelligence, but, again, students' fixed mindset did not. Therefore, the present study also aimed to get more clarity concerning the incremental predictive value of students' motivational beliefs up and above intelligence.

The Present Study

The main aim of this study is to examine whether Dweck's mindsets about intelligence and SDT's motives for studying have unique and interactive associations with students' learning behavior and achievement. In the interest of contributing to cross-fertilization between both theories, the role of students' mindsets and quality of motivation was examined in relation to a rich and broad set of academic outcomes, including school achievement, engagement, learning strategies, persistence, procrastination and test anxiety. By using a 4-wave repeated measures design across a time span of 2 years, this study contributes to the existing literature by looking at the effects of these resources at both the level of between-student differences and within-student (semester-to-semester) fluctuations. This longitudinal approach allows us to provide a more dynamic picture of the importance of students' mindsets and motivation in their learning behavior and achievement. We hypothesized that autonomous motivation and students' effort beliefs would have generally beneficial effects and that a fixed mindset and controlled motivation would have generally negative effects on learning behavior and achievement, with these effects emerging both at the level of between-student differences and at the level of within-student fluctuations across time.

Second, in a more explorative fashion, this study also considered interactions between students' mindsets and motivation. Such interactions could be synergistic in nature (indicating that the combined presence of two resources has positive effects beyond what can be expected on the basis of the main effects) or compensatory in nature (with the presence of one resource buffering against the absence of another resource or the presence of a risk factor).

A third way in which this study aims to contribute to the literature is by taking into account the role of intelligence when predicting students' learning behavior and achievement. By controlling for intelligence at the between-person level, we aimed to test the unique effects of students' mindsets and motivation more conservatively. Considering students' intelligence also allowed us to look exploratively at possible interaction effects of students' intelligence with either students' mindsets or motivation. Do these resources play a role in explaining students' academic functioning regardless of students' level of intelligence? Given that both

Dweck's theory and SDT assume that the proposed resources embody fundamental and robust mechanisms that apply to all students, we hypothesize that the predictive effects of students' mindsets and motivation will not be systematically moderated by students' level of intelligence.

Method

Participants and Procedure

We used longitudinal data collected in the context of the TALENT-study (Tailoring Education and Care to Talents of Youth). The sample consists of 3,415 7^{th} grade students from Flanders (the Dutch speaking part of Belgium) who were followed in the Fall and Spring across a period of 2 school years, resulting in 4 waves of data (M_{age} = 12.38 years, SD = 0.45, 50.2 % boys). At baseline, participants were in 166 classes of 27 schools. In Flanders, Grade 7 is the first year of secondary education. After primary education, all students that successfully completed primary education transfer to the regular stream; a minority of students attend either special needs education or a vocationally preparatory track. In the participating schools, all students within the regular stream were recruited. Hence, between Grades 7 and 8, students were retained in the study when they did not have to repeat a grade and did not change school.

The study was approved by the ethical committee of KU Leuven. Prior to the study, we obtained informed consent of all participating students and their parents. Specifically, parents gave passive informed consent for their child's participation in the study through an opt-out procedure. In doing so, several measures were implemented to maximally ensure that parents read the informed consent form. At the start of the school year, schools created an information bundle that was distributed to the parents, containing highly important information (e.g., school regulations). The informed consent forms for the study were included as part of this information bundle. Further, mentoring teachers of participating students were informed about the study and asked repeatedly to remind students to pass the informed consent form to their parents. Schools also communicated actively to the parents about school participation in the study (e.g., through newsletters and the digital school platform). Of the initially contacted 3446 students, 27 parents opted their child out of the study, with 4 additional opt-outs by the student themselves. This resulted in a final sample of 3415 students. Participation was voluntary and students were informed that they were free to withdraw from the study at any time. None of the individual test scores were communicated in any form to the school, parents or students as confidentiality and anonymity were guaranteed. Starting in October/November 2017, students were asked to fill out several paper-and-pencil questionnaires under the guidance of the classroom teacher who was informed about the procedures by the researchers.

In the first school year, 2.7 % and 5.8 % of the sample were missing at Wave 1 and 2, respectively, due to absence at the time of the data collection. In the second school year, 11.0% and 16.2% of the sample were missing at Wave 3 and 4, respectively. Next to absence (e.g., illness), a number of students also changed schools in the transition from 7th to 8th grade, increasing the number of missing students in these respective waves. To determine patterns of missingness in the data, we relied on the normed chi-square test, which can be preferred over Little's missing completely at random test (Little's MCAR-test; Little 1988) because this is too conservative in large samples (Kline, 2005). The normed chi-square test divides the chi-square statistic of the Little's test by its degrees of freedom. Values smaller than 2 indicate a good model fit (Meade et al., 2008). In our data, the normed chi-square test ($\chi2/df$) was equal to 1.14, indicating that the data are missing at random. Therefore, we imputed the missing data using the estimation-maximization algorithm (EM; Schafer & Graham, 2002).

Transparency and Openness

We reported all necessary information about the study, including recruitment of the sample, data exclusions, manipulations, and all the measures in the study, thereby adhering to

Journal Article Reporting Standards (JARS; Kazak, 2018). All data and analysis scripts have been made publicly available at Open Science Framework and can be accessed at https://osf.io/r985q/?view_only=054c100a5217425e891cff5ff0d64c6a. This study's design and its analysis were not pre-registered. Data were analyzed using R, version 4.2.1 (R Core Team, 2022) and the LME4 package, version 1.1.33 (Bates et al., 2015).

Measures

Unless mentioned otherwise, participants responded to the survey items on a 5-point Likert type scale ranging from 1 (*does not apply to me at all*) to 5 (*totally applies to me*). Apart from intelligence, all scales were administered at each of the 4 waves with all items being identical in each of the 4 administrations.

Intelligence

We used the CoVaT-CHC (Magez et al., 2015), a well-validated intelligence test based on the CHC-model of intelligence (Horn & Cattell, 1966) that assesses both fluid and crystallized intelligence (Tierens, 2015). The test was administered in class under the supervision of a researcher with training in intelligence assessment and took students approximately two hours to complete. For each student, an intelligence score was calculated by comparing their test results with a representative norming sample.

Mindsets

We used a short version of the 'Theory of Intelligence Scale' (Dweck et al., 1995) which was translated in Dutch (Glerum, Loyens & Rikers, 2019) to measure students' fixed mindset. The original 3-item questionnaire (e.g. "You have a certain amount of intelligence and you really can't do much to change it.") measures whether students believe that their intelligence is a stable entity that cannot be easily changed. We added one item to this questionnaire to increase scale reliability ("Performing well in school is mostly dependent of the level of ability you were born with.”), resulting in a 4-item scale. Cronbach’s alphas in the four waves ranged from .63 to .74.

We used a Dutch questionnaire (Lavrijsen et al., 2022) to measure students’ effort beliefs which consists of 4 items (“Learning is especially a matter of practicing and training yourself.”). This scale measures students’ beliefs about the value of effort to perform well. We deliberately chose to refer to this scale as a measure of effort beliefs rather than a growth mindset. In Dweck’s theory, the concept of a growth mindset refers to the belief that people can change their intelligence. Conceptualized as such, the notion of a growth mindset is entirely antithetical to the concept of fixed mindset, with the absence of a fixed mindset representing the presence of a growth mindset. Whereas a fixed mindset is perfectly opposite to a growth mindset, it is not entirely antithetical to the concept of effort beliefs, which involves the belief that effort is functional to improve performance and to learn more effectively. The subtle difference here is that effort beliefs (in contrast to a growth mindset) do not reflect the conviction that intelligence itself can be changed. To be conceptually precise and consistent with Dweck’s theory and to use terminology that accurately reflects the measure that we used, we use the term effort beliefs for the measure used in this study. Cronbach’s alphas in the four waves ranged from .68 to .76.

Autonomous and Controlled Motivation

Students reported on their quality of motivation by completing the Dutch translation (Vansteenkiste et al., 2009) of the ‘Academic Self-Regulation Questionnaire’ (SRQ-A; Ryan & Connell, 1989). This scale measures both students’ autonomous and controlled motives to put in effort in school and consists of 16 items with 8 items measuring autonomous motivation (“I am motivated to study because I want to learn new things.”; Cronbach’s alphas in the four waves ranged from .87 to .89) and with 8 items measuring controlled motivation

("I am motivated to study because others would think I'm smart."; Cronbach's alphas in the four waves ranged from .75 to .79).

Procrastination

Participants completed a subscale of the Dutch translation (Lacante & Lens, 2005) of the 'Learning and Study Strategies Inventory' (LASSI; Weinstein & Palmer, 2002). The procrastination subscale consists of 4 items and measures students' tendency to postpone their schoolwork to do other more pleasant activities ("I waste my time instead of studying."). Cronbach's alphas in the four waves ranged from .77 to .82.

(Dis)Engagement

Participants completed a Dutch translation (Engels et al., 2017) of the behavioral subscale of the 'Behavioral and Emotional Engagement Scale' (Skinner et al., 2008) which consists of 10 items. This subscale measures the extent to which students participate or withdraw from classroom activities at a behavioral level. Both behavioral engagement and behavioral disengagement are measured with 5 items (behavioral engagement: "In class, I work as hard as I can"; behavioral disengagement: "When I am in class, I am thinking about other things"). Cronbach's alphas in the four waves ranged from .76 to .80 and from .65 to .77 for engagement and disengagement, respectively.

Learning Strategies

Participants completed two subscales of the Dutch questionnaire 'Children's Perceived use of Self-Regulated Learning Inventory' (CP-SRLI; Vandevelde et al., 2013), which assesses superficial learning and deep-level learning. Both subscales consist of 4 items and measure whether students use more superficial rehearsal strategies ("When studying I read or recall everything again and again until I know it by heart.") and whether they use more elaborative learning strategies to really grasp the study material ("When studying I make a summary."). Cronbach's alphas in the four waves ranged from .68 to .70 and from .60 to .61 for superficial learning and deep-level learning, respectively.

Persistence

We used a subscale of the Dutch questionnaire 'Children's Perceived use of Self-Regulated Learning Inventory' (CP-SRLI; Vandevelde et al., 2013) to assess students' persistence. This scale consists of 6 items ("Even if my schoolwork is difficult or boring, I do my best.") and measures the extent to which students can maintain their focus and effort on the task at hand in class. Cronbach's alphas in the four waves ranged from .82 to .87.

Test Anxiety

We used a subscale of the Dutch translation (Lacante & Lens, 2005) of the 'Learning and Study Strategies Inventory' (LASSI; Weinstein & Palmer, 2002), which consists of 4 items. The subscale test anxiety measures students' tendency to be worried and experience feelings of tension evoked by tests in school ("Even if I am well prepared for a test, I am still worried."). Cronbach's alphas in the four waves ranged from .84 to .86.

Achievement

Two times per school year, once at the end of the first term (December 2017 and 2018) and once at the end of the second term (June 2017 and 2018), participating schools provided the grade point averages of students when they were attending 7^{th} and 8^{th} grade. This grade represents the aggregated score of students' performance on all their school courses (both academic and non-academic). As the meaning of grades might differ between schools, we standardized students' grades within schools to account for such differences.

Plan of Analysis

To examine the unique associations of students' mindsets and motivation with students' outcomes at both the between-person level (reflecting differences between students) and the within-person level (reflecting fluctuations within students), multilevel models were estimated. Associations between a motivational variable and an outcome at the between-person level indicate that, when a participant scores relatively higher (lower) than other participants on a motivational variable across all waves, this participant also has relatively higher (lower) scores on the outcome. Associations between variables at the within-person level indicate that, when a participant displays higher (or lower) scores on a motivational variable in a given semester, relative to this participant's overall score on the variable across the 2-year period, this participant displays correspondingly higher (or lower) scores on the learning outcome within the given semester. In other words, associations at the within-person level reflect correlated fluctuations at the intra-individual level. Moreover, to inspect overall (mean-level) changes in students' learning outcomes and to control for these average changes, time was taken into account as a covariate (Gillet et al., 2012).

To examine whether multilevel modeling is appropriate, we first conducted intercept-only models for all study variables, which allowed us to calculate intraclass correlations ($ICC_{student}$), representing the correlation between measurements (at the different waves) within students. Because students were nested in classes, we also calculated the ICC at the class level (ICC_{class}) representing the correlation between students within classes. The ICCs can be found in Table 1. The ICCs at the student level range from 0.40 to 0.61, indicating that there is substantial variation at both the between-person and within-person level for all study variables. For 11 of the 12 study variables, the ICCs at the class level range from 0.01 to 0.05. Because an ICC smaller than 0.05 can result in convergence problems (Preacher et al., 2010) and 0.10 is considered a cut-off value to perform multilevel models without bias (Preacher et al., 2011), we decided to ignore the class level with respect to these variables. Only for GPA, there was substantial variation at the class level (i.e. $ICC_{class} = 0.26$). So, for all analyses regarding GPA, we took into account the class level. Because we performed multiple hypotheses tests, we relied on the Dunn-Šidák correction to counteract the inflation of type I errors and produce a familywise type I error of 0.05 (Šidák, 1967). Based on the Dunn-Šidák correction formula for 25 different null hypotheses (including both the main and the interaction effects), we will use a significance level of .002 to determine the statistical significance of the examined effects. In total, we constructed one model for each examined outcome variable, resulting in a total of 8 models. In each model, predictors and their interactions, both at the between- and within-person level, were added simultaneously. To disaggregate between- versus within-person level effects, variables at the within-person level were group-mean centered, whereas at the between-person level, predictors were grand-mean centered (Enders & Tofighi, 2007; Raudenbush & Bryk, 2002).

Results

Descriptive Statistics and Correlations

Prior to the main analyses, a series of Confirmatory Factor Analysis (CFA) was performed to examine whether the measures used in this study were sufficiently distinct. This was done for each measurement wave, resulting in 4 CFAs in total. These models included all study variables. Each model had an RMSEA ≤ .05, and an SRMR ≤ .07, providing evidence for a good model fit (Hu & Bentler, 1998). Moreover, all factors loadings were significant at $p < .001$. When comparing the fit of these models to alternative models where each possible pair of constructs was combined into one common factor, the fit of the models separating each of the study variables was always superior in terms of model fit. As such, these models clearly indicate that the study variables represent distinct constructs. The detailed results of these CFAs (including factor loadings and correlations between the latent variables) can be found in the Supplementary Materials.

Means and standard deviations for all the study variables can be found in Table 2. Correlations between all the study variables at the between- and the within-person level are presented in Table 3. In terms of associations among the hypothesized predictor variables, at the between-person level there was a moderate positive correlation between autonomous motivation and effort beliefs (.46), a weak negative correlation between autonomous motivation and a fixed mindset (-.09) and weak positive correlations between controlled motivation and both a fixed mindset (.14) and effort beliefs (.20). A similar pattern of associations was obtained at the within-person level of analysis, although all associations were less pronounced at that level and small terms of effect size.

Autonomous motivation and effort beliefs showed a similar pattern of correlations with the outcomes, thereby being related positively to behavioral engagement, superficial and deep-level learning, persistence and test anxiety, and negatively to behavioral disengagement and procrastination, both at the between- and the within-person level. Controlled motivation was related positively to behavioral engagement, superficial and deep-level learning, persistence, test anxiety, and procrastination, both at the between- and within-person level. Also, controlled motivation was associated with students' behavioral disengagement, but only at the between-person level. Furthermore, a fixed mindset correlated positively with disengagement, test anxiety and procrastination, and negatively with engagement, superficial learning and persistence, both at the between- and within-person level. Moreover, a fixed mindset related negatively to deep-level learning, but only at the between-person level.

Finally, intelligence was associated negatively with both students' autonomous and controlled motivation and positively with students' effort beliefs. Moreover, intelligence correlated positively with students' achievement and negatively with procrastination, disengagement, superficial learning, deep learning and test anxiety.

Next, to examine whether gender and time were associated with the study variables, we estimated a multilevel model with gender as the between-person predictor, time as a within-person predictor and with all study variables as dependent variables. Because gender and time had significant effects on almost all study variables, we controlled for the effect of gender and time in all further analyses. Specifically, boys were generally less behaviorally engaged (B = -.14, $p < .001$) and more disengaged (B = .16, $p < .001$) than girls. Further, boys reported lower levels of superficial (B = -.25, $p < .001$) and deep-level learning (B = -.32, $p < .001$), were less persistent (B = -.16, $p < .001$) and had less test anxiety (B = -.18, $p < .001$) and reported more procrastination (B = .10, $p < .001$) than girls. Moreover, boys had a lower GPA than girls (B = -.12, $p <.001$). Finally, boys reported less autonomous motivation (B = -.10, $p < .001$), more controlled motivation (B = .09, $p < .001$), higher levels of a fixed mindset (B = .16, $p < .001$) and less effort beliefs (B = -.18, $p < .001$) than girls. With respect to overall trends over time, the results showed that, over time, students displayed decreases in engagement (B = -.34, $p < .001$), superficial learning (B = -.16, $p < .001$), persistence (B = -.25, $p < .001$), test anxiety (B = -.09, $p < .001$), autonomous motivation (B = -.25, $p < .001$), controlled motivation (B = -.05, $p < .001$) and effort beliefs (B = -.09, $p < .001$). Also students' GPA decreased over time (B = -.58, $p < .001$). Students displayed increases in disengagement (B = .31, $p < .001$), deep learning (B = .02, $p = .022$), and procrastination (B = .19, $p < .001$).

Primary Analyses

The main and interaction effects of students' intelligence, motivation and mindsets on students' outcomes can be found in Tables 4A and 4B. The coefficients shown are standardized estimates. Prior to inspecting the main effects of mindsets and types of motivation, we inspected how intelligence related to students' functioning. Intelligence was related positively to achievement and negatively to behavioral disengagement, superficial learning, deep level learning, test anxiety, and procrastination. Intelligence was unrelated to students' behavioural engagement and persistence. Because intelligence was measured only once, all of these associations were situated at the between-person level. Aside from achievement, which was associated strongly with intelligence, the magnitude of the significant effects were mostly similar across all the different outcomes and were small to moderate in terms of effect size.

Unique Effects of Students' Mindsets and Motivation

Next, we inspected the unique effects of students' mindsets and motivation after controlling for students' intelligence. First, autonomous motivation was related uniquely to 7 of the 8 outcomes, both at the between- and within-person level. Specifically, autonomous motivation was related positively to engagement, superficial learning, deep-level learning, persistence, and achievement, and negatively to disengagement and procrastination. Autonomous motivation was unrelated to test anxiety at both levels. At the between-person level, these associations indicate that students with relatively higher scores on autonomous motivation across the 4 waves than other students, display more positive outcomes than others. At the within-person level, these associations indicate that more autonomous motivation during a given semester went together with more positive outcomes.

Second, controlled motivation displayed unique associations with 4 of the 8 outcomes at both the between- and within-person level. Specifically, controlled motivation related positively to behavioral disengagement, superficial learning, test anxiety, and procrastination at both levels. In addition, it was related positively to behavioral engagement and deep-level learning at the within-person level only and negatively to achievement at the between-person level only. Controlled motivation was unrelated to persistence at both levels.

Third, a fixed mindset showed unique associations with 3 of the 8 outcomes at both levels of analysis. Specifically, a fixed mindset was related positively to behavioral disengagement, test anxiety, and procrastination at both levels. In addition, it was associated negatively with persistence at the within-person level only. Students' fixed mindset was unrelated to engagement, superficial learning, to deep-level learning, and to achievement.

Fourth, students' effort beliefs showed unique associations with 6 of the 8 outcomes at both levels. In particular, students' effort beliefs were associated positively with behavioral engagement, superficial learning, deep-level learning, persistence, and achievement and were associated negatively with behavioral disengagement at both the between- and within-person level. In addition, effort beliefs were related positively to test anxiety at the within-person level only and negatively to procrastination at the between-person level only.

Overall, students' autonomous motivation and effort beliefs (i.e., the adaptive resources) revealed systematic associations with all types of outcomes. In contrast, controlled motivation and students' fixed mindset mostly displayed associations with the maladaptive outcome variables only. Controlled motivation and fixed mindset seemed to be of less importance to predict adaptive outcome variables.

Interaction Effects between Mindsets and Motivation

In total, we found only four significant (out of 64 possible) interactions across the between- and within-person level, two of which were related to procrastination as an outcome (Figure 1A-B), one of which was related to behavioral disengagement as an outcome (Figure 2A), and one of which was related to behavioral engagement as an outcome (Figure 2B). First, two interactions for procrastination were identified, one at the between-person and one at the within-person level. At the between-person level, controlled motivation interacted with a fixed mindset (see Figure 1A), with students being particularly less likely to procrastinate when they scored low on a fixed mindset as well as low on controlled motivation. The simultaneous absence of both maladaptive predictors was associated with the lowest level of procrastination. At the within-person level, autonomous motivation interacted with effort beliefs (see Figure 1B) in the prediction of procrastination such that especially the combination of more effort beliefs and more autonomous motivation in a given semester was associated with lower semester-specific procrastination.

Regarding behavioral disengagement, an interaction at the within-person level was found between autonomous motivation and a fixed mindset (see Figure 2A). Autonomous motivation played a buffering role against the disengagement costs associated with a fixed mindset. In other words, if students, in a given semester, are more convinced that their intelligence is fixed, being autonomously motivated helps to reduce the negative consequences in terms of disengagement during such a period.

Finally, regarding behavioral engagement, we found an interaction effect between controlled motivation and a fixed mindset at the between-person level (see Figure 2B). As can be seen in this figure, students reported less overall engagement relatively to other students when they endorsed a relatively high fixed mindset in combination with low controlled motivation. At higher levels of controlled motivation, a fixed mindset was unrelated to behavioral engagement (see Figure 2B).

Examining Interactions with Intelligence

We found only two significant cross-level interactions with intelligence (Figure 3A-B). Both interactions were situated at the within-person level. First, intelligence exacerbated the negative within-person association between autonomous motivation and procrastination (see Figure 3A). When autonomous motivation was elevated during a given semester, it especially came with lower procrastination among highly intelligent students. Second, students' intelligence reduced the positive association between autonomous motivation and achievement (see Figure 3B). The achievement benefits of elevated autonomous motivation during a given semester were less pronounced among intelligent students.

To provide an indication of the effect sizes obtained in this study, we inspected the amount of variance (R-squared) explained by the predictors. In Tables 4A and 4B, we provide the R^2 for each step in the analysis, with the model in Step 1 including only gender and time as predictors, Step 2 additionally including IQ, Step 3 additionally including the motivational predictors, and Step 4 additionally including all interaction terms. As can be seen in the tables, IQ explained a large amount of variance in achievement ($R^2 = 25$) and smaller amounts of variance in the other learning outcomes (with R^2 ranging between .01 and .03). Across both levels of analysis, the main effects of the motivational variables together had R^2 values between .04 (for achievement) and .30 (for engagement), with a mean R^2 value of .18. The total set of interactions had R^2 values between and .001 and .01. Overall then, the main effects of the motivational variables explained the outcomes most substantially, with the interactions explaining only a small part of the variance.

Discussion

This study provided a joint examination of critical concepts from both Dweck's theory on mindsets and Self-Determination Theory, thereby considering their unique and interactive roles in students' learning behavior and achievement. Both frameworks highlight different resources that, in isolation, were already shown to be important in understanding students' school functioning (e.g., Sisk et al., 2018; Vansteenkiste et al., 2009). We hypothesized that these resources are complementary in nature and can play unique roles in students' learning behavior and achievement. The current study is also among the first to examine these dynamics simultaneously at the level of both between-student and within-student differences. To provide a conservative test of the hypotheses and to examine whether the expected associations apply across the spectrum of students' cognitive ability, we further took into account students' intelligence.

The Unique Role of Mindsets and Motivation

Consistent with previous studies (e.g., Boncquet et al., 2020; Mouratidis et al., 2017), there were significant associations between SDT-based motivations and Dweck's beliefs. Both at the between-person and within-person levels of analysis, autonomous motivation was related positively to effort beliefs and negatively to a fixed mindset. This pattern of associations confirms SDT-based predictions that autonomy typically goes together with a more open, flexible, and pro-active mindset (Hodgins & Knee, 2002). In contrast, controlled motivation was related positively to both a fixed mindset and effort beliefs. In SDT, controlled motivation is considered a mixed blessing, potentially motivating people into action (a tendency reflected in the positive association with effort beliefs) but also creating risk for inner tension and ego-concerns (a risk shared between controlled motivation and a fixed mindset). The size of these associations was small (.20 or less), with one exception: the correlation between autonomous motivation and effort beliefs at the between-person level was moderate in terms of effect size (.46) and suggests that these constructs shared about 20% of their variance at that level. Even with this moderate association, it is still possible that a minority of students displays only one of the two positive resources (autonomous motivation or effort beliefs) but not the other. Overall, the motivational resources forwarded by SDT and Dweck are interrelated, yet clearly distinct. As such, it remains useful to examine the unique and interactive roles of both resources (Nagengast & Trautwein, 2023). However, particularly when considering interactions between autonomous motivation and effort beliefs at the between-person level, it should be kept in mind that it is more common for these resources to co-occur than to operate in isolation from one another.

Considered across all outcomes, both students' motivational quality and students' beliefs about intelligence and effort contributed uniquely to students' learning behavior and achievement, as we had hypothesized. In particular, autonomous motivation contributed positively to behavioral engagement, persistence, deep and superficial learning, and achievement, and negatively to behavioral disengagement and procrastination. Similarly, effort beliefs related positively to behavioral engagement, persistence, deep and superficial learning, and achievement, and negatively to behavioral disengagement, procrastination (at the between-person level) and test anxiety (at the within-person level). One seemingly surprising finding was that autonomous motivation and effort beliefs were associated positively not only with deep-level learning, but also with superficial learning, which is typically considered a maladaptive learning strategy (Diseth, 2003; Salamonson et al., 2013). However, it has been argued that in some situations, also superficial learning strategies can be advantageous (Hattie & Donoghue, 2016), for example when course materials are to be learned by heart (Lublin, 2003). Hence, being able to flexibly switch between deep and superficial learning may improve academic achievement (Beattie et al., 1997; Frasineanu, 2013) and the combination of these strategies may be adaptive.

The unique importance of both autonomous motivation and effort beliefs suggests that both predictors do not cancel out each other's benefits. More specifically, both the degree to which students find the learning material interesting and meaningful and the degree to which they believe that effort is essential to make progress matter for their learning.

A different pattern was obtained for controlled motivation and a fixed mindset, which were related positively to several undesired learning outcomes and, in a few cases, negatively to desired outcomes. A fixed mindset was related positively to procrastination and disengagement and negatively to persistence (at the within-person level). Similarly, controlled motivation was related positively to procrastination, disengagement, superficial learning and negatively to engagement (at the within-person level) and achievement (at the between-person level). It should be noted that controlled motivation was also related positively to deep-level learning, albeit only at the within-person level. This finding is consistent with SDT's portrayal of controlled motivation as a mixed blessing. It can spur students into action and it is more beneficial for learning than a total lack of motivation (i.e., amotivation), but the effects are limited and typically short-lived (Vansteenkiste et al., 2005). The finding that controlled motivation was related to engagement and deep-level learning at the within-person level, but not at the between-person level, indeed indicates that more controlled motivation in a given semester can go together with more in engagement and deep-level learning. However, at the between-person level, which reflects relatively more enduring differences between students, controlled motivation was not related to engagement or deep-level learning, indicating that controlled motivation does not foster engagement or deep-level learning in the longer haul. Overall, the number of maladaptive outcomes associated with controlled motivation outweighed the number of adaptive outcomes. Previous research did show that controlled motivation can be somewhat more adaptive when it is combined with autonomous motivation, although even the combination of high autonomous and high controlled motivation is less beneficial for learning than the combination of high autonomous motivation and low controlled motivation (Vansteenkiste et al., 2009).

Three summarizing reflections may help to further synthesize the large set of findings. First, most significant associations were observed both at the between- and the within-person level. That is, predictors that accounted for between-student variation in learning behavior played a similar role at the within-person level. For example, students who were more autonomously motivated than others procrastinated less than others, and students procrastinated less in a given semester when they had more semester-specific autonomous motivation (relative to their levels of autonomous motivation across the 2-year period). This is important, as previous studies have examined the role of mindsets and motivational quality mostly at the between-person level (e.g., motivational quality, Black & Deci, 2000; mindsets, Faria & Costa, 2018). The cross-level importance of the same set of motivational predictors is both conceptually interesting and promising from an applied perspective as it suggests that motivational interventions can target at the within-person level the very processes that matter also at the level of between-person differences.

Second, whereas the two adaptive motivational resources (i.e., autonomous motivation and effort beliefs) related both to adaptive outcomes (positively) and maladaptive outcomes (negatively), controlled motivation and a fixed mindset related primarily to the maladaptive outcomes (positively). This observation aligns with the idea that controlled motivation and a fixed mindset are motivational risk factors that come with certain pitfalls. In particular, both risk factors independently predicted procrastination, disengagement and test anxiety, at both levels of analysis. Apparently, when students feel pressured to learn or hold the belief that their intelligence is fixed, they tend to postpone getting immersed in their studies (i.e., procrastination) and they more easily get distracted when they eventually come to study (i.e., disengagement). Presumably, due to their poorer preparation, they are more anxious when their knowledge is getting evaluated (i.e., test anxiety).

Third, it should be noted that the effects of mindsets and motivation emerged after controlling for the role of intelligence. In line with previous studies, intelligence was a strong predictor of achievement (Roth et al., 2015). It also related positively to negatively to behavioral disengagement, procrastination and test anxiety (Mousavi et al., 2015; Moutafi et al., 2006). In contrast with previous research among university students (Chamorro-Premuzic & Furnham, 2008), more intelligent students reported to make less use of deep-level learning methods, possibly because of the lower level of schoolwork difficulty in the early years of secondary school (Dresel & Haugwitz, 2005). Importantly, given that intelligence is a powerful predictor of students' learning (Roth et al., 2015), including intelligence as a covariate at the between-person level ruled out the possibility that associations between the motivational predictors and the learning outcomes would be spurious in nature (i.e., caused by associations of intelligence with each of the study variables). This is important from an applied perspective, as it indicates that students with lower levels of intelligence may perform better than expected when they are highly autonomously motivated or strongly believe that achievement depends on their efforts.

Interplay between Mindsets and Motivational Quality

Interestingly, mindsets and motivational quality not only mattered independently from each other, but their combinations produced a couple of additional effects on various outcomes. The interactions obtained should be interpreted with some caution as only 4 out of 64 possible interactions emerged. Also, because of the significant associations between the SDT-based types of motivation and Dweck's beliefs, certain combinations of variables borrowed from both frameworks are relatively less common.

Three of the four significant interactions applied to undesirable outcomes, that is, to procrastination (i.e., two significant interactions) and to behavioural disengagement (i.e., one significant interaction), whereas one interaction applied to behavioural engagement. The interaction pattern for procrastination suggests that especially the combined presence of two motivational resources or the simultaneous absence of two risk factors came with the lowest level of procrastination. Specifically, at the between-person level, the simultaneous absence of fixed mindsets and controlled motivation related to the lowest levels of procrastination. At the within-person level, the combination of high autonomous motivation and effort beliefs related to the lowest levels of procrastination. In other words, more effort beliefs in a given semester are particularly protective against procrastination if students simultaneously display elevated levels of autonomous motivation: autonomous motivation may provide the energy needed for students high on effort beliefs to put these beliefs in practice (Mouratidis et al., 2017). When, in contrast, effort beliefs were combined with low autonomous motivation, students displayed more procrastination. This combination is probably characteristic of students who feel able to invest the right amount of efforts to succeed, but who do not see the value of doing so. The ultimate goal of their efforts is unclear and experienced as lacking personal relevance. Because of this perceived lack of value and meaningfulness, they may postpone their efforts, resulting in procrastination.

With respect to behavioral disengagement, the findings indicate that autonomous motivation played a rather protective role by buffering the undesirable effect of a fixed mindset. Specifically, a higher presence of autonomous motivation in a given semester buffered the risk for disengagement if a fixed mindset was more elevated as well. Autonomous motivation thus increases students' resilience when they lack effort beliefs (Wijsman et al., 2018). Only one rather unexpected interaction effect was identified. Students displayed low levels of behavioral engagement when they scored high on a fixed mindset and low on controlled motivation. Rather than reinforcing the undermining effect of a fixed mindset, high controlled motivation buffered the risk for low engagement among students with a high fixed mindset. Although unexpected at first, controlled motivation may provide at least some energy to stay engaged in class, just because students feel pressured to do so. However, this moderating effect of controlled motivation was limited because students did not actually benefit from a fixed mindset at high levels of controlled motivation. The association between a fixed mindset and engagement was no longer significant after the interaction between a fixed mindset and controlled motivation was considered. Moreover, although controlled motivation may to some extent safeguard behavioral engagement among students with a fixed mindset, it did not offset the negative repercussions of a fixed mindset for students' test anxiety and procrastination. Finally, this moderating effect of controlled motivation should be considered in light of the overall negative effects of controlled motivation in the learning outcomes.

In the current study, we also examined interactions between students' level of intelligence and their motivational beliefs. Overall, only 2 out of 32 possible interactions were significant, suggesting that most benefits of motivation applied to all students, regardless of cognitive ability. Whereas in general, effects of motivation were thus independent of intelligence, the following interactions were observed. First, the achievement benefits of autonomous motivation were somewhat reduced among students with higher intelligence, indicating that there is somewhat less room for autonomous motivation to play a role in achievement when intelligence is high. At the same time, the findings suggest that especially less intelligent students benefit from being autonomously motivated. Second, the negative contribution of autonomous motivation in the prediction of procrastination at the within-person level was smaller for students with lower intelligence. Possibly, even when autonomously motivated, students with lower intelligence are still tempted to procrastinate because they feel deeply insecure about their competence (Haghbin et al., 2012).

Practical Implications

Our findings have several practical implications. First, the results showed that students' mindsets and motivation not only differ between students, but also fluctuate within students over time. These within-person (semester-to-semester) fluctuations indicate that students' mindsets and motivation are prone to change and can be targeted in interventions or through parents' and teachers' practices.

Second, both students' mindsets and their quality of motivation were found to provide unique benefits for students' learning in school. Considered across all outcomes, especially the two positive resources identified in SDT and Dweck's theory (i.e. autonomous motivation and effort beliefs) were consistently associated with students' functioning. This finding meshes with intervention-based research showing that it is more beneficial to boost the positive rather than to refute the negative (Yeager et al., 2016). Most importantly, the finding that autonomous motivation and effort beliefs were uniquely related to favourable educational outcomes 'across the board' suggests that educational interventions could perhaps be strengthened by combining insights from both theories. The significant associations between these motivational resources and the fact that they sometimes interacted in the prediction of learning outcomes further underscore the intricate interplay between students' mindsets and quality of motivation and the need to target both resources simultaneously. Currently, most educational interventions focus either on autonomous motivation (for instance through sense-of-purpose or self-affirmation interventions; Yeager et al., 2014 or through interventions enhancing autonomy-supportive contexts at school or at home; Yu & Reeve, 2011) or on effort beliefs (through mindset interventions; Blackwell et al., 2007). The impact of universal motivational prevention efforts can perhaps be maximized by adopting a more comprehensive approach in which both resources are targeted. As such, future research would do well to examine the effectiveness of an intervention program combining insights from SDT and Dweck's theory. Notably, such a more comprehensive approach in universal prevention programs does not preclude a more tailored approach in the context of individual counselling, where students may present specific difficulties with one of these resources and may need in-depth guidance to enhance either autonomous motivation or effort beliefs (Rubenstein et al., 2012; Snyder & Linnenbrink-Garcia, 2013).

Limitations

Although the present study has a number of strengths (e.g., the longitudinal design, large sample size, and objective assessment of achievement), we acknowledge several limitations. First, there was a certain degree of attrition in the second year of data collection, in particular due to students changing schools. Future studies would do well to accomplish higher retention rate by tracking students that changed schools. A second limitation is that our surveys were separated by 6-month intervals. Future research could aim to replicate our findings on a more short-term basis with momentary assessments. For example, studies with weekly intervals or with a daily diary design would allow to examine whether the associations between the motivational frameworks and students' adjustment hold also on a short-term basis (see e.g., Patall et al., 2018; Vandenkerckove et al., 2019). This is important because adolescence is a developmental period characterized by quickly evolving changes on a short-term basis. Third, we solely relied on students' self-report to capture students' motivation and their learning process, resulting in possible bias due to shared method variance. The associations between autonomous motivation and engagement were particularly high. These two variables are proximally related from a substantive point of view and shared method variance most likely further inflated their associations in the current data. Although we looked at students' GPA to also obtain a more objective assessment of achievement, future research would do well to include multi-informant assessments of students' learning behaviour, for example through teacher- or parent-reports. Fourth, the reliabilities of several measures were rather low in at least one wave, suggesting that improvements to the scales would be beneficial. Finally, in the current study we focused on examining the unique role of students' intelligence and effort beliefs and students' motives for learning, and possible interactions between them. However, these constructs may also directly influence one another. Possibly, the effects of one motivational construct are partially mediated by the other motivational construct. For example, a fixed mindset may result in more controlled motivation, because students feel internally pressured to perform well, which may in turn, result in more maladaptive functioning.

Conclusion

Empirical work within the tradition of Dweck's mindsets about intelligence and SDT's motives for studying has burgeoned during the last two decades. Yet, most of the work in these two traditions has been done in isolation, with few studies examining their joint role in learning. Findings from the current longitudinal study, including a broad variety of outcomes, examining research questions at both the between- and within-student level of analysis, and controlling for students' intelligence, indicate that students' effort beliefs and autonomous motivation represent complementary motivational resources displaying unique associations with students' learning outcomes. As such, the results emphasize the need to adopt a comprehensive approach to interventions focused on improving students' learning, thereby attending simultaneously to students' mind (i.e., their cognitive beliefs about intelligence) and soul (i.e., their interest, passion, and motivation for learning).

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Table 1

Estimated random intercept variances and residual error variances, and ICC's for the class and student level.

	u_{00j}	r_{0ij}	e_{tij}	$ICC_{student}$	ICC_{class}
Predictors					
Autonomous motivation	0.027	0.339	0.224	0.575	0.046
Controlled motivation	0.007	0.278	0.224	0.546	0.014
Effort Beliefs	0.022	0.180	0.247	0.400	0.050
Fixed mindset	0.011	0.296	0.341	0.457	0.017
Learning outcomes					
Behavioral engagement	0.014	0.239	0.208	0.518	0.030
Behavioral disengagement	0.019	0.254	0.237	0.498	0.037
Superficial learning	0.022	0.257	0.250	0.486	0.042
Deep-level learning	0.019	0.297	0.246	0.528	0.034
Persistence	0.019	0.296	0.206	0.568	0.038
Test anxiety	0.025	0.629	0.404	0.594	0.024
Procrastination	0.025	0.490	0.332	0.579	0.029
Achievement	0.255	0.604	0.140	0.605	0.255

Note. u_{00j} = variance situated at the class level (level 3); r_{0ij} = variance situated at the student level (level 2); e_{tij} = variance situated at the measurement level (level 1)

Table 2

Means and Standard Deviations for Each of the Study Variables at all Measurement Waves

	Wave 1		Wave 2		Wave 3		Wave 4	
	M	SD	M	SD	M	SD	M	SD
Intelligence	102.8	14.09	-	-	-	-	-	-
Autonomous motivation	3.24	0.74	3.03	0.79	2.96	0.76	2.91	0.75
Controlled motivation	2.99	0.72	2.93	0.74	2.97	0.71	2.91	0.69
Fixed mindset	2.81	0.80	2.82	0.85	2.90	0.79	2.82	0.79
Effort Beliefs	3.99	0.65	3.92	0.70	3.93	0.66	3.86	0.66
Behavioral engagement	3.94	0.62	3.79	0.67	3.71	0.67	3.52	0.68
Behavioral disengagement	2.02	0.64	2.13	0.70	2.25	0.71	2.43	0.73
Superficial learning	3.66	0.73	3.56	0.75	3.55	0.71	3.43	0.70
Deep learning	3.08	0.75	3.11	0.78	3.10	0.74	3.11	0.73
Persistence	3.76	0.68	3.66	0.73	3.59	0.72	3.45	0.72
Test anxiety	3.00	1.01	2.85	1.07	2.92	1.02	2.81	1.00
Procrastination	2.45	0.86	2.61	0.95	2.66	0.92	2.76	0.91
Achievement	74.98	9.32	72.09	10.31	72.67	8.93	72.00	9.63

Note. There is only one mean and one standard deviation presented for intelligence, as this was only measured once.

Table 3

Correlations among Study Variables at the Between (below the diagonal) and Within Person-Level (above the diagonal).

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Intelligence	-	-	-	-	-	-	-	-	-	-	-	-	-
2. Autonomous motivation	-0.08***	-	.26***	-.03*	.20***	.35***	-.24***	.20***	.16***	.30***	.04***	-.18***	.25***
3. Controlled motivation	-0.06**	.23***	-	.05***	.11***	.12***	.01	.10***	.09***	.09***	.12***	.04***	.06***
4. Fixed mindset	0.02	-.09***	.14***	-	.04*	-.03*	.08***	-.02*	.01	-.05***	.08***	.08***	-0.02*
5. Effort Beliefs	0.06***	.46***	.20***	-.16***	-	.18***	-.12***	.18***	.11***	.20***	.05***	-.05***	.12***
6. Behavioral engagement	-0.002	.64***	.19***	-.13***	.47***	-	-.43***	.28***	.14***	.39***	.03*	-.25***	.32***
7. Behavioral disengagement	-0.14***	-.49***	.08***	.25***	-.40***	-.73***	-	-.19***	-.07***	-.34***	.06***	.33***	-.33***
8. Superficial learning	-0.08***	.55***	.21***	-.09***	.53***	.60***	-.49***	-	.26***	.40***	.04**	-.16***	.17***
9. Deep learning	-0.18***	.49***	.15***	-.07***	.34***	.44***	-.28***	.57***	-	.23***	.03*	-.07***	-.01
10. Persistence	.002	.62***	.13***	-.13***	.52***	.73***	-.68***	.71***	.43***	-	-.01	-.34***	.26***
11. Test anxiety	-.24***	.07**	.31***	.12***	.11***	.05*	.26***	.13***	.22***	-.06**	-	.26***	.01
12. Procrastination	-0.06**	-.42***	.11***	.22***	-.25***	-.57***	.77***	-.46***	-.24***	-.73***	.36***	-	-.24***
13. Achievement	0.51***	.16***	-.08***	-.05**	0.23***	.26***	-.44***	.21***	.02	.29***	-.28***	-.35***	-

Note. ****p* < .001, ***p* < .01, **p* < .05; Means and standard deviations are averaged over the four weeks.

Table 4A

Effects of Mindsets, Motivation and Intelligence on Students' Procrastination, (Dis)Engagement and Persistence (Standardized Coefficients)

	Procrastination		Engagement		Disengagement		Persistence	
	Between-Person	Within-Person	Between-Person	Within-Person	Between-Person	Within-Person	Between-Person	Within-Person
Fixed effects								
Predictors								
IQ	-.06 (.01)*		.03 (.01)		-.12 (.01)*		.02 (.01)	
AM	-.33 (.01)*	-.09 (.01)*	.40 (.01)*	.16 (.01)*	-.33 (.01)*	-.11 (.01)*	.39 (.01)*	.14 (.01)*
CM	.15 (.01)*	.05 (.01)*	.03 (.01)	.02 (.01)*	.14 (.01)*	.05 (.01)*	-.02 (.01)	.01 (.01)
FM	.11 (.01)*	.05 (.01)*	-.03 (.01)	-.01 (.01)	.11 (.01)*	.05 (.01)*	-.03 (.01)	-.03 (.01)*
EB	-.06 (.01)*	-.01 (.01)	.14 (.01)*	.07 (.01)*	-.14 (.01)*	-.05 (.01)*	.21 (.01)*	.09 (.01)*
Time		.09 (.01)*		-.17 (.01)*		.18 (.01)*		-.11 (.01)*
Interaction effects								
AM*FM	-.002 (.01)	-.001 (.01)	-.01 (.01)	.01 (.01)	-.01 (.01)	-.02 (.01)*	-.002 (.01)	.000 (.01)
AM*EB	-.03 (.01)	-.04 (.01)*	-.02 (.01)	-.001 (.01)	.03 (.01)	-.01 (.01)	-.01 (.01)	-.003 (.01)
CM* FM	-.05 (.01)*	.01 (.01)	.04 (.01)*	.01 (.01)	-.01 (.01)	-.001 (.01)	.03 (.01)	.002 (.01)
CM*EB	-.02 (.01)	-.01 (.01)	.01 (.01)	.01 (.01)	-.04 (.01)	-.02 (.01)	-.004 (.01)	.02 (.01)
IQ*AM	-.03 (.01)	-.02 (.01)*	-.001 (.01)	.001 (.01)	.001 (.01)	-.01 (.01)	-.03 (.01)	.01 (.01)
IQ*CM	-.01 (.01)	.01 (.01)	-.001 (.01)	-.01 (.01)	-.03 (.01)	.01 (.01)	.004 (.01)	-.01 (.01)
IQ*FM	-.03 (.01)	-.01 (.01)	-.01 (.01)	.01 (.01)	-.02 (.01)	-.001 (.01)	.01 (.01)	.002 (.01)
IQ*EB	-.01 (.01)	.01 (.01)	.004 (.01)	.004 (.01)	.002 (.01)	.01 (.01)	.003 (.01)	-.01 (.01)
R^2 step 1	0.02 [0.02-0.03]		0.06 [0.05-0.06]		0.06 [0.05-0.07]		0.04 [0.03-0.04]	
R^2 step 2	0.02 [0.02-0.19]		0.06 [0.05-0.06]		0.07 [0.06-0.08]		0.04 [0.03-0.05]	
R^2 step 3	0.18 [0.17-0.19]		0.34 [0.32-0.35]		0.26 [0.25-0.28]		0.34 [0.31-0.35]	
R^2 step 4	0.19 [0.18-0.20]		0.35 [0.32-0.35]		0.27 [0.26-0.28]		0.34 [0.32-0.35]	
Random effects								
u_0	.39 (.62)		.15 (.38)		.18 (.42)		.18 (.42)	
e_0		.30 (.55)		.16 (.40)		.19 (.44)		.17 (.41)

Note. *p < .002, AM= Autonomous motivation, CM = Controlled motivation, FM = Fixed mindset, EB = Effort beliefs, IQ = Intelligence

Table 4B

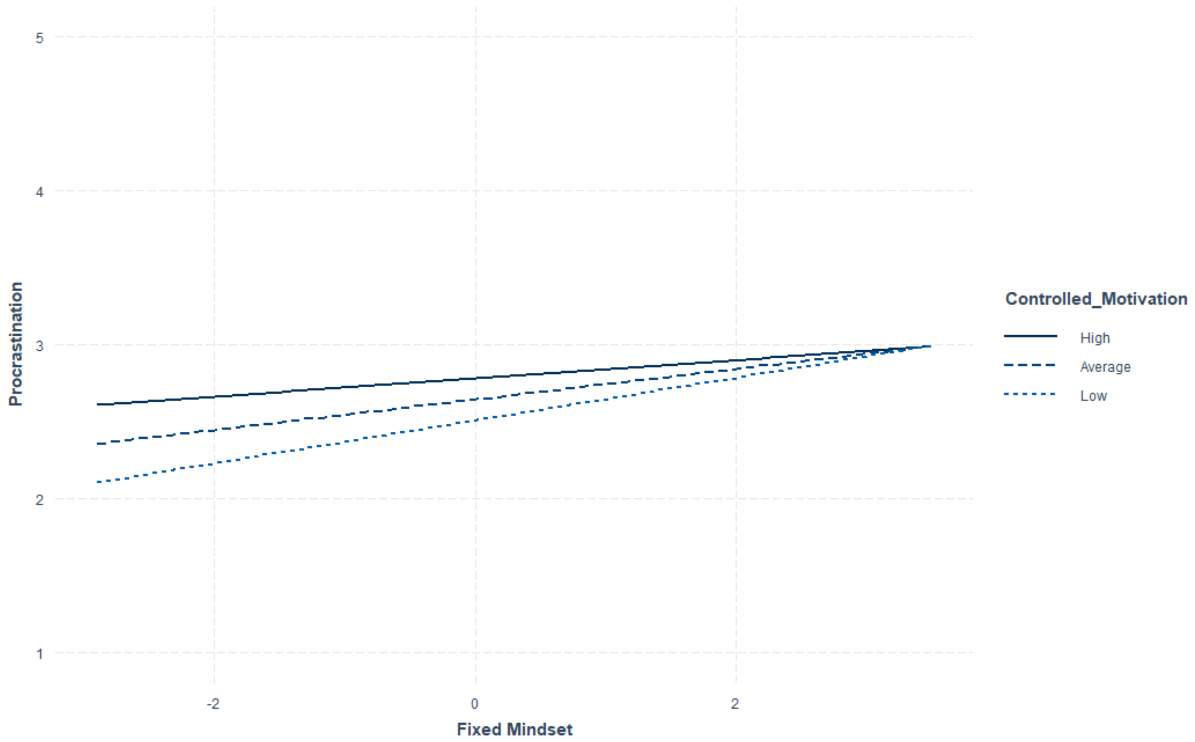
Effects of Mindsets, Motivation and Intelligence on Students' Learning Strategies, Test Anxiety and Achievement (Standardized Coefficients)

	Superficial Learning		Deep Learning		Test Anxiety		Achievement	
	Between-Person	Within-Person	Between-Person	Within-Person	Between-Person	Within-Person	Between-Person	Within-Person
Fixed effects								
Predictors								
IQ	-.04 (.01)*		-.09 (.01)*		-.15 (.01)*		.50 (.01)*	
AM	.27 (.01)*	.09 (.01)*	.29 (.01)*	.10 (.01)*	-.04 (.01)	-.01 (.01)	.13 (.01)*	.04 (.003)*
CM	.05 (.01)*	.03 (.01)*	.04 (.01)	.03 (.01)*	.24 (.01)*	.07 (.01)*	-.08 (.01)*	.000 (.003)
FM	.001 (.01)	-.02 (.01)	.01 (.01)	.004 (.01)	.09 (.01)*	.05 (.01)*	.01 (.01)	-.01 (.003)
EB	.23 (.01)*	.09 (.01)*	.09 (.01)*	.05 (.01)*	.05 (.01)	.02 (.01)*	.12 (.02)*	.02 (.003)*
Time		-.07 (.01)*		.05 (.01)*		-.05 (.01)*		-.21 (.003)*
Interaction effects								
AM*FM	.004 (.01)	.02 (.01)	-.01 (.01)	-.001 (.01)	-.02 (.01)	.01 (.01)	-.02 (.01)	.000 (.01)
AM*EB	-.02 (.01)	.000 (.01)	.01 (.01)	-.01 (.01)	-.03 (.01)	-.01 (.01)	-.004 (.01)	.003 (.02)
CM* FM	.02 (.01)	.01 (.01)	.02 (.01)	.02 (.01)	.01 (.01)	.001(.01)	-.02 (.01)	-.01 (.01)
CM*EB	-.01 (.01)	.01 (.01)	-.02 (.01)	-.004 (.01)	-.03 (.01)	-.01 (.01)	.01 (.01)	.01 (.02)
IQ*AM	-.02 (.01)	.01 (.01)	.01 (.01)	.01 (.01)	-.01 (.01)	-.01 (.01)	.02 (.01)	-.01 (.01)*
IQ*CM	.01 (.01)	-.003 (.01)	-.02 (.01)	-.003 (.01)	.01 (.01)	.01 (.01)	-.002 (.01)	.01 (.01)
IQ*FM	.01 (.01)	.01 (.01)	-.01 (.01)	.001 (.01)	-.04 (.01)	-.02 (.01)	.01 (.01)	.000 (.01)
IQ*EB	-.01 (.01)	-.01 (.01)	.003 (.01)	-.002 (.01)	-.01 (.01)	-.01 (.01)	-.04 (.01)	-.001 (.01)
R^2 step 1	0.04 [0.03-0.05]		0.06 [0.05-0.07]		0.02 [0.01-0.03]		0.06 [0.05-0.06]	
R^2 step 2	0.04 [0.03-0.05]		0.07 [0.06-0.08]		0.05 [0.04-0.06]		0.31 [0.29-0.33]	
R^2 step 3	0.26 [0.24-0.27]		0.21 [0.19-0.23]		0.13 [0.12-0.14]		0.35 [0.34-0.37]	
R^2 step 4	0.27 [0.25-0.28]		0.21 [0.19-0.23]		0.13 [0.13-0.15]		0.35 [0.34-0.38]	
Random effects								
r_0							.07 (.27)	
u_0	.16 (.40)		.21 (.46)		.53 (.73)		.48 (.70)	
e_0		.23 (.48)		.23 (.48)		.39 (.62)		.09 (.31)

Note. *p < .002, AM= Autonomous motivation, CM = Controlled motivation, FM = Fixed mindset, EB = Effort beliefs, IQ = Intelligence

Figure 1A

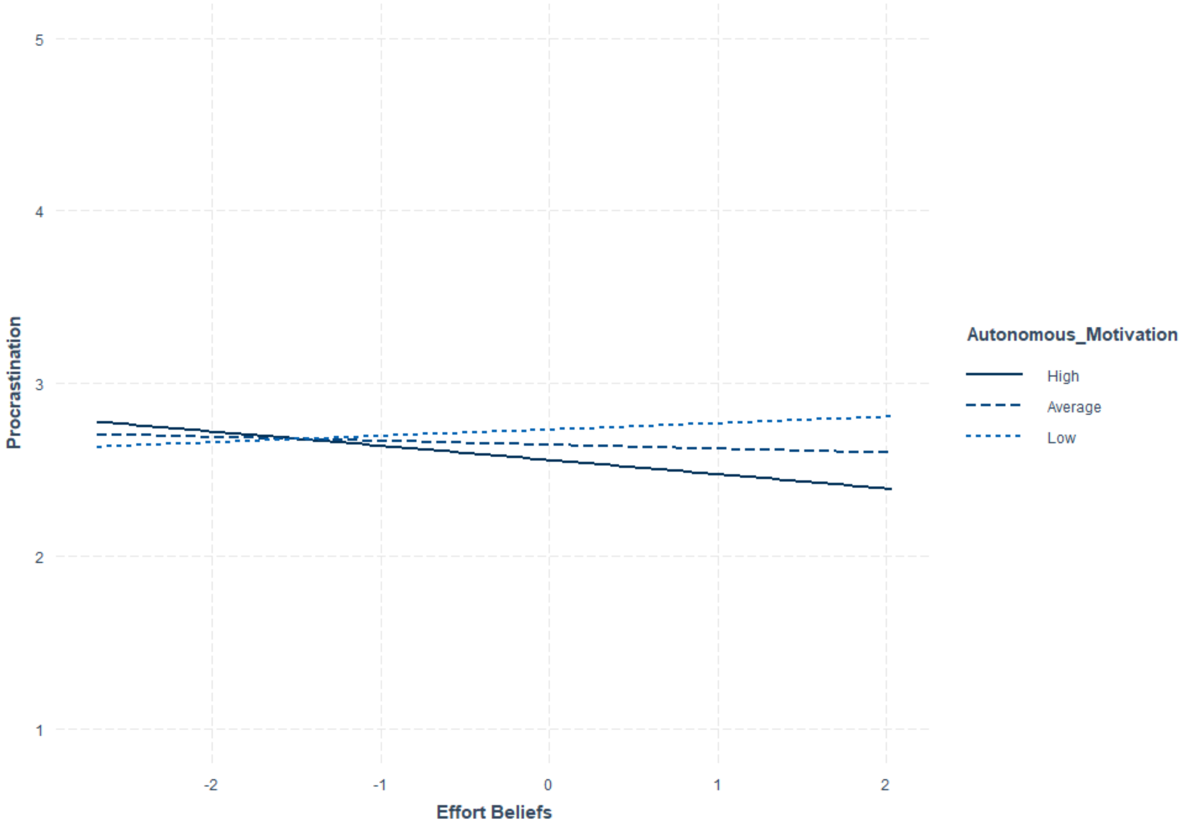
Interaction between Controlled Motivation and a Fixed Mindset on Procrastination at the Between-Person Level.



Note. Slope of fixed mindset at low levels of controlled motivation: B = 0.14*, at moderate levels of controlled motivation: B = 0.10*, at high levels of controlled motivation: B = 0.06*. * $p < .05$.

Figure 1B

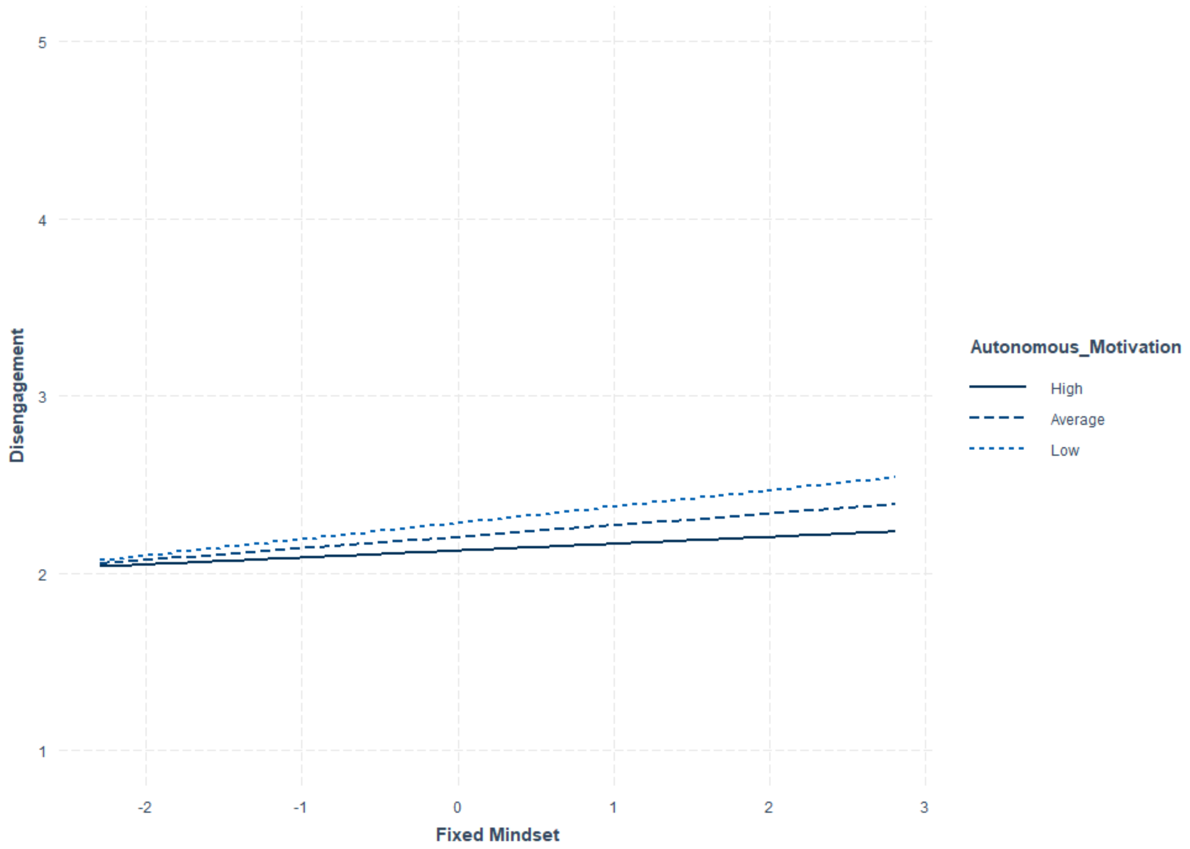
Interaction between Autonomous Motivation and Effort Beliefs on Procrastination at the Within-Person level.



Note. Slope of effort beliefs at low levels of autonomous motivation: B = 0.04, at moderate levels of autonomous motivation: B = -0.02, at high levels of autonomous motivation: B = -0.08*. * p < .05.

Figure 2A

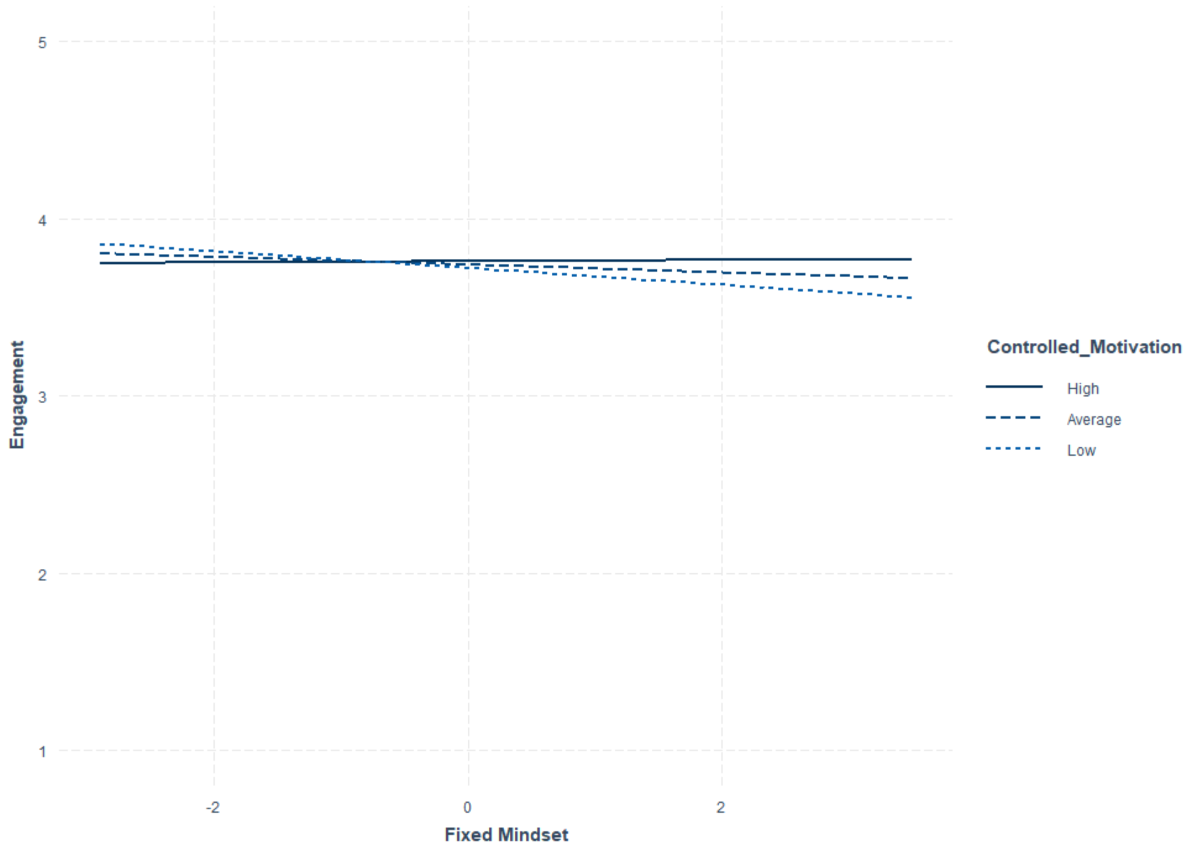
Interaction between Autonomous Motivation and Fixed Mindset on Behavioral Disengagement at the Within-Person level.



Note. Slope of fixed mindset at low levels of autonomous motivation: B = 0.09*, at moderate levels of autonomous motivation: B = 0.07*, at high levels of autonomous motivation: B = 0.04*. * $p < .05$.

Figure 2B

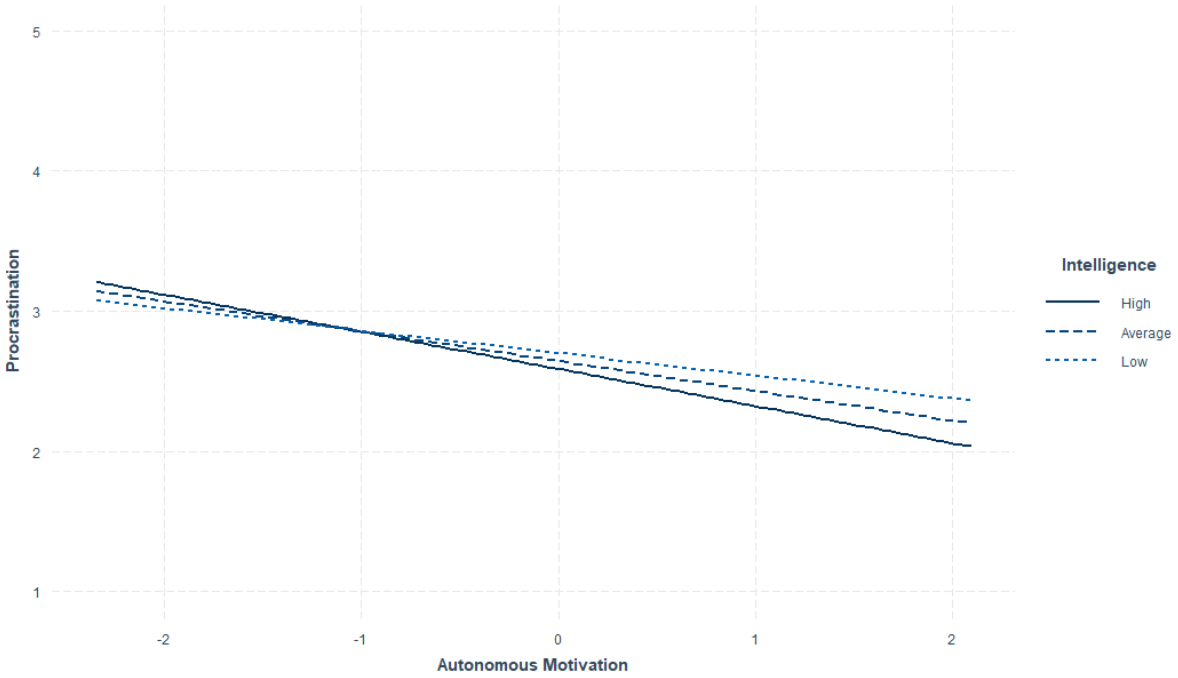
Interaction between Controlled Motivation and Fixed Mindset on Behavioral Engagement at the Between-Person Level.



Note. Slope of fixed mindset at low levels of controlled motivation: B = -0.05*, at moderate levels of controlled motivation: B = -0.02*, at high levels of controlled motivation: B = 0.00. * p < .05.

Figure 3A

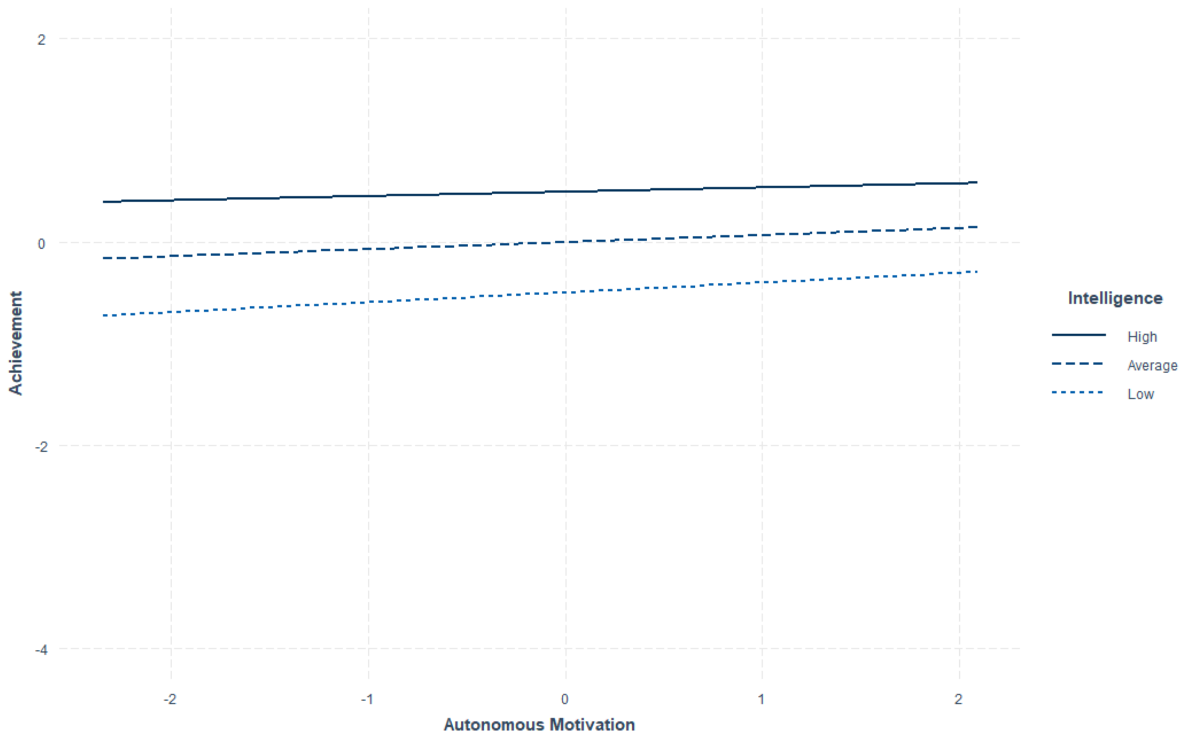
Cross-level Interaction between Intelligence and Autonomous Motivation on Procrastination (Within-Person Level).



Note. Slope of autonomous motivation at low levels of intelligence: B = -0.16*, at moderate levels of intelligence: B = -0.21*, at high levels of intelligence: B = -0.26*. * $p < .05$.

Figure 3B

Cross-level Interaction between Intelligence and Autonomous Motivation on Achievement (Within-Person Level).



Note. Slope of autonomous motivation at low levels of intelligence: B = 0.10*, at moderate levels of intelligence: B = 0.07*, at high levels of intelligence: B = 0.04*. * $p < .05$.