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Learning and Motivation 85 (2024) 101957

Contents lists available at ScienceDirect

Learning and Motivation

journal homepage: www.elsevier.com/locate/l&m

Do I want to learn today? Day-to-day variations in adolescents' academic motivation and effort

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ARTICLE INFO

Keywords:
Academic motivation
Need satisfaction
Social support
Diary method
Secondary education

ABSTRACT

In this preregistered study, we examined factors influencing academic motivation among secondary school students (aged 13 – 15) on a day-to-day basis. Using cognitive effort-discounting (Cog-ED) as behavioral manifestation of motivation and self-report for internal motivational state, we utilized a daily diary method (two-week protocol, $N = 39$, total $N = 342$ diaries) to explore how these measures relate to daily experiences of need satisfaction (i.e., autonomy, competence, relatedness), social support, invested homework hours, stress and physical (versus online) school attendance both at within- and between-person levels. Employing Bayesian hierarchical modeling, we found that motivation to invest effort in learning (Cog-ED) and self-reported academic motivation were higher on days when students experienced greater competence. In addition self-reported academic motivation was higher on days when students experienced more social support from classmates and teachers, invested more effort in homework and physically attended school, but lower on days when students experienced more stress. Additionally, both motivation to invest effort in learning (Cog-ED) and self-reported academic motivation were higher for those with greater average levels of perceived autonomy and support from parents. Moreover, students who, on average, dedicated more time to homework, reported elevated stress levels, and received greater support from teachers reported higher academic motivation. Conversely, those with greater support from classmates reported lower academic motivation. These findings stress the importance of cultivating feelings of competence, supportive environments and stress reduction on a daily basis, while highlighting the importance of perceived autonomy, adult social support and physical school attendance for academic motivation. Importantly, the current study contributes by assessing motivation both behaviorally and via self-report, and fills a gap by extending trait-level motivation research to the daily-level.

1. Introduction

Academic motivation has consistently been shown to be an influential factor in student's learning (Eccles & Wigfield, 2002;

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https://doi.org/10.1016/j.lmot.2023.101957
Received 22 August 2023; Received in revised form 29 November 2023; Accepted 21 December 2023
Available online 6 January 2024

Richardson et al., 2012; Vu et al., 2022). In the context of self-regulated learning, the most well-known precursors of academic motivation are autonomy, competence and relatedness (Deci & Ryan, 2000; Ryan & Deci, 2020). Broadly, motivation refers to the processes that invigorate and sustain goal-directed activities (Schunk et al., 2014). In this conceptualization, motivation comprises internal states that manifest themselves in overt goal-directed actions (Schunk & DiBenedetto, 2020). Within an academic context, an example would be to manifest the intention to pass an exam into the goal-directed action of investing effort in studying. Although many studies assess internal motivational states via self-report, assessing behavioral manifestations of motivation is surprisingly rare. Furthermore, much of the existing research focuses on relationships between motivation and its precursors from a long-term stable between-person perspective, neglecting short-term within-person fluctuations (Vu et al., 2022; Mouratidis et al., 2017). In the current study, we try to fill those two gaps by assessing motivation both as behavioral manifestation (with a decision-making task) and as internal state (with self-report) using a daily-diary method, exploring both between- and within-person variation. Indeed, recent accounts of motivation are situated ones, calling attention to situational fluctuations in motivation (for a review, see Vu et al., 2022). Investigating such fluctuations in motivation is especially relevant in educational research, as fluctuating constructs can be more easily changed and are therefore more effective targets for intervention compared to stable trait-level constructs. Motivational fluctuations can span various time scales. On a macro level (months to years), an example is the continuous decline observed in student motivation during secondary education (OECD, 2016; Scherrer & Preckel, 2019; Bouffard et al., 2003; Gnambs & Hanfstingl, 2016). On a micro level (minutes to hours), fluctuations can occur within days, hours or even within a class (Waninge et al., 2014). The meso level, in between, examines day-to-day fluctuations in academic motivation, an area that lacks research (Ketonen et al., 2018; Mouratidis et al., 2017; Murayama et al., 2017). Here, we are interested in precursors of day-to-day fluctuations in academic motivation. While academic motivation can also vary within individual days, the factors we opted to explore as its precursors (i.e., need satisfaction) have previously been identified as susceptible to day-to-day fluctuations (Bellhäuser et al., 2019; Quested et al., 2013) rather than fluctuations occurring within the same day (Neubauer et al., 2018).

1.1. Precursors of motivation: self-determination theory

According to self-determination theory (SDT; Deci & Ryan, 2000; Ryan & Deci, 2020), the precursor of self-regulated motivation is the fulfillment of basic psychological needs. As briefly mentioned in the first paragraph, these needs include autonomy, competence and relatedness. Autonomy refers to the feeling of initiative, purpose and meaningful choice in one's actions. Competence refers to the feeling of mastery, a sense that one's behavior is effective in order to succeed and grow. Relatedness refers to a sense of belonging and the experience of social connectedness with others (e.g., with peers, classmates, parents and teachers). SDT acknowledges that humans are motivated by different factors, yet that all humans have basic psychological needs, and that the satisfaction of those needs is vital to achieve self-regulated motivation. In line with STD, earlier studies have shown positive relationships between students' academic motivation and their need satisfaction on a between-person level (Guay, 2022; Guo, 2018; Holzer et al., 2021). Here, we are interested in whether day-to-day fluctuations in academic motivation can also be predicted by day-to-day fluctuations in need satisfaction variables on a within-person level. The current study was conducted amid the COVID-19 pandemic. Therefore, the study incorporated need satisfaction variables along with additional significant factors potentially affecting academic motivation at that time, including social support, stress, and physical (versus online) school attendance. That is, recent research indicated that parental support was found to be positively related to day-to-day reports of academic motivation among secondary school students' (aged 12 – 16), particularly during school closings (Klootwijk et al., 2021). Specifically, it was found that adolescents' academic motivation was lower on online (versus physical) school days when they experienced low levels of social support from parents (Klootwijk et al., 2021). Another study found that both parent and teacher support positively predicted academic motivation for secondary school students' (aged 13 −15), while peer support acted as a buffer against maladaptive motivation and stress (Song et al., 2015), emphasizing the various roles of different social support sources. Relatedly, while social support may positively impact academic motivation, earlier self-report studies have repeatedly shown that stress negatively impacts secondary students' academic motivation (for a review see Pascoe et al., 2020). Importantly, stress was already highly prevalent amongst secondary school students, with more than 60% regularly experiencing stress about grades and testing (OECD, 2017), and stress levels have only risen further over the course of the COVID-19 pandemic (Pieh et al., 2021). In addition, partial school closings offered us the opportunity to test effects of physical (versus online) school attendance on academic motivation. Together, the current study tested whether fluctuations in secondary school students' day-to-day academic motivation are predicted by day-to-day fluctuations in need satisfaction variables along with social support, stress and physical school attendance both on a within- and between-person level.

1.2. Assessing academic motivation as internal state and behavioral manifestation

Supporting need satisfaction not only facilitates emotional and cognitive outcomes, but also yields behavioral consequences for students and their academic motivation (Ng et al., 2012; Radel et al., 2014). However, academic motivation is often assessed with self-reports measured at one time-point. Despite their evident psychometric benefits, self-reports of motivation may suffer some inherent issues. First, self-report questionnaires might not reliably capture motivational constructs that are subject to situational fluctuations. Second, questionnaires are subjective and rely on the assumption that behavioral motives are consciously accessible and declarative, while motivation often arises from partially inaccessible and non-declarative cognitions and emotions (Fulmer & Frijters, 2009). In addition, questionnaires suffer from individual differences in introspection ability (Lumley et al., 2005). Therefore, besides assessing motivation as internal state with self-report, we additionally searched for a measure that could serve as behavioral manifestation of motivation. In searching for a behavioral manifestation of motivation, the field of neuroeconomics offers a promising

framework called cognitive effort-discounting (Cog-ED) (Westbrook et al., 2013). The key focus within this Cog-ED framework is on value-based decision-making, in which individuals are given a choice between performing two tasks: a low-effort task for a small (variable) amount of money (e.g., 1 euro) or a high-effort task for a larger (fixed) amount of money (e.g., 2 euros). After each choice-trial, the amount of money offered for the low-effort task is adjusted: the amount increases after individuals choose the high-effort option and decreases after individuals choose the low-effort option. After multiple of such choice-trials, the amount of money offered for the low-effort option is taken as the indifference point: the point where individuals are indifferent between the two effort-reward combinations. This way, Cog-ED assess how much reward individuals are willing to give up in order to avoid performing an effortful task. For example, when an individual indicates to be indifferent between performing a low-effort task for 1.41 euros and a high-effort task for 2 euros, then they are willing to give op 0.59 euros in order to avoid the more effortful task. In this example, the final reward offered for the low-effort task (i.e., 1.41 euros) is taken as the indifference point and quantifies an individuals' motivation to invest effort in the high-effort task. The higher this so-called indifference point, the more motivated someone is to invest effort (i.e. the less reward they are willing to give up in order to avoid effort). Earlier studies using Cog-ED showed that adults' (Westbrook et al., 2013), adolescents' (Kramer et al., 2021) and children's (Chevalier, 2018) motivation to invest effort decreases as a function of the required effort. Therefore, we believe that this measure has the potential to serve as behavioral manifestation of motivation, as it reflects an individual's readiness and inclination to allocate cognitive resources toward the goal-directed action of effort investment. This behavioral aspect then provides observable evidence of an individual's internal motivational state. However, limited research has been conducted on this recently introduced measure in its relation to academic motivation. One previous study revealed a connection between adolescents' motivation to invest effort in Cog-ED (indifference points) and their intrinsic motivation for cognitively demanding tasks (Kramer et al., 2021). In addition, another study observed that young adults displaying higher motivation to invest effort in Cog-ED reported greater involvement in cognitively demanding activities on a day-to-day basis (Culbreth et al., 2020). These findings suggest that Cog-ED may capture cognitive motivational processes in everyday life. We aim to extend this finding by assessing day-to-day fluctuations in secondary school student's motivation to invest effort in learning tasks (using Cog-ED), and by testing whether these fluctuations are predicted by day-to-day variations in basic need satisfaction variables, social support, stress, homework hours (as academic effort measure), and physical school attendance both at the within- and between-person level. To summarize, the current study examines factors predicting day-to-day fluctuations in secondary school students' academic motivation. We utilized two daily measures of motivation: 1) the Cog-ED task for behavioral manifestation, and 2) self-report for internal motivational state. Participants engaged in a two-week daily-diary protocol, completing the Cog-ED task, self-report on academic motivation, and other daily self-reports including need satisfaction (autonomy, competence, relatedness), social support, stress, homework hours, and physical school attendance. Based on previous studies, we expected that day-to-day fluctuations in academic motivation would be positively predicted by experienced feelings of autonomy, competence, relatedness, social support, invested homework hours, and physical school attendance, while negatively impacted by experienced stress.

2. Method and materials

This study was preregistered at https://osf.io/af29e/. All methods follow preregistration, unless indicated otherwise. The preregistration was published after data collection was completed. To avoid preregistration after analyses were conducted, data were saved as individual daily files from Qualtrics (a separate datafile for each assessment day). However, to extract any meaningful patterns, the data should have been merged into one datafile, which occurred only subsequent to the preregistration.

2.1. Participants

Thirty-nine secondary-school students between 13 and 15 years old (M_{age} = 14.07 years, SD_{age} = 0.74 years, 19 female) from average (i.e., pre-vocational; more than 50% of students in the Netherlands attend this level) educational backgrounds participated in this study. The current study was part of a larger study. Participants were recruited via a study conducted at the school of the participants (part 1). This sample was willing to also partake in the current daily diary study (part 2), and active informed consent was obtained from participants and from their parents. One week after the first part of the study, participants started the daily assessments. For full details about part 1 of the study, see Kramer et al. (2023). This study was approved by the ethical review board of the Department of Developmental Psychology of the University of Amsterdam.

2.2. Procedure

In part 1 of the study, participants completed six word-learning tasks differing in the amount of required effort (easy, medium, hard; see below) and completed Cog-ED afterwards. The first study included 195 participants, was a one-time experiment at the school of the participants and examined whether we could probe effort-discounting for word-learning and whether both effort-discounting as well as word-learning would be affected by feedback valence in the word-learning task (positive versus negative feedback). In the current daily diary part of the study, participants completed Cog-ED (and not the feedback-learning tasks) in addition to several questions on a daily basis for two weeks excluding weekends (i.e. 10 days). Each day of our 10-day protocol, participants received a Qualtrics link on their phones. To reduce the likelihood of participants communicating with each other and to not disturb them during classes, we sent the daily link after school time at 6 pm. For each day they completed all questions (before 9 pm), participants received monetary compensation of 1 euro. In total, they could earn 10 euros.

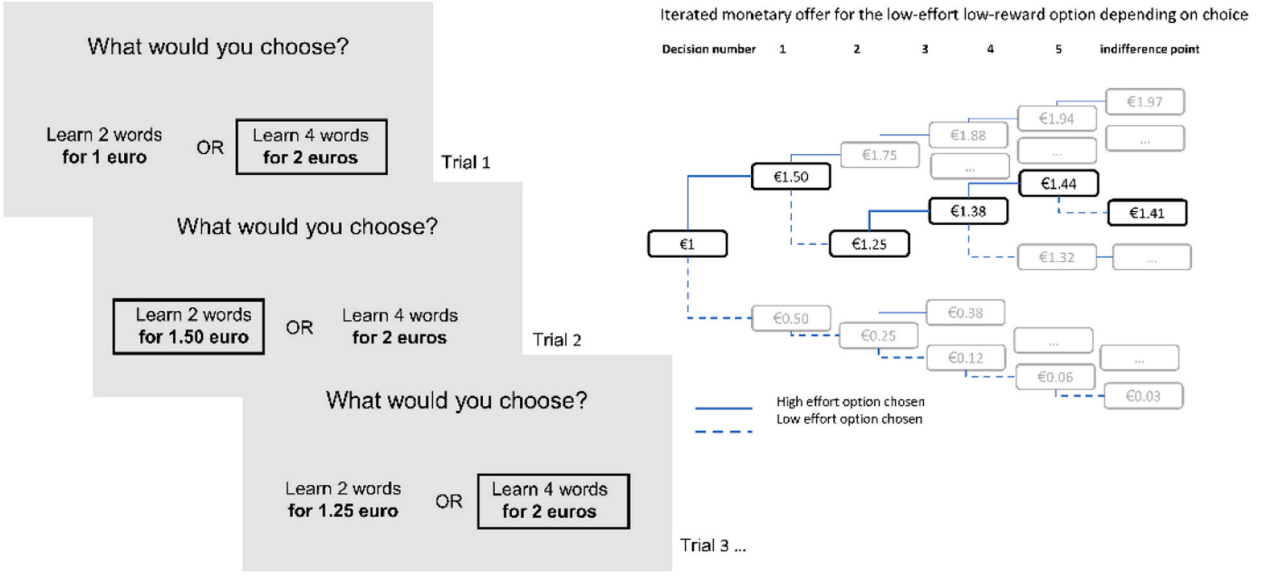

Fig. 1. Example of choice trials in Cog-ED with boxes indicating chosen options (left), and a hypothetical decision tree leading to an indifference point of €1.41 after one run of 5 choice trials (right).

2.3. Materials

2.3.1. First part of the study: word learning tasks differing in effort requirements

Our daily Cog-ED task lets participants repeatedly choose between performing a low-effort word-learning task for a small amount of money and a high-effort word-learning task for a larger amount of money. These word-learning tasks were administered in the first part of the study. Although performing the word-learning tasks is not included in the current daily diary study, explaining them facilitates understanding of our daily Cog-ED measure. Therefore, we first shortly describe these word-learning tasks. In the word-learning tasks (administered in part 1; one week before the daily diary study) participants were instructed to learn the spelling of pseudo-words. On each trial, participants were presented with two pseudo-words and had to choose the ''correctly'' spelled word. In the positive condition, participants earned 10 points for correct answers and 0 points otherwise. In the negative condition, participants lost 0 points for correct answers and lost 10 points for incorrect answers. Participants performed 3 word-learning tasks in each condition. The tasks varied in difficulty such that participants had to learn 2 (easy), 3 (medium), or 4 (difficult) pseudo-words in parallel. In total, all participants performed 2 (feedback valence: positive and negative) x 3 (difficulty: 2, 3, 4 pseudo-words) = 6 word-learning tasks. Each word-learning task consisted of 48 trials.

2.3.2. Daily measures: outcome measures

Motivation to invest effort for learning: indifference points from Cog-ED task Each day we asked participants to think back about the word-learning tasks they performed in part 1 of the study, and we asked them to make choices about which word-learning task they would now prefer to repeat for a monetary reward. The choices concerned repeating the baseline low-effort word-learning task for a small (variable) reward (i.e., 2-word task for 1 euro) versus a high-effort word-learning task for a larger (fixed) reward (i.e., 3- or 4-word task for 2 euros). When participants selected the high-effort option, the amount offered for the baseline low-effort option on the next choice trial increased (e.g., from 1 euro to 1.50 euros), but decreased after choosing the low-effort option (e.g., from 1 euro to 0.50 euro). The in- or decrease on a given trial was always half as much as the in- or decrease on the previous trial. The resulting reward offered for the low-effort option after one run of 5 choices (i.e., 5 choice-trials) was adjusted one final time (by 0.03 euros) to get a more fine-tuned measure and this was taken as the indifference point (see Fig. 1). The higher the indifference point, the more motivated to invest effort in the high-effort learning task. Each day, participants performed 4 effort-discounting runs consisting of 5 choices (i.e. a total of 20 choices) in a randomized order, resulting in 4 indifference points (i.e. 5 choices to learn 2- versus 3 words and 5 choices to learn 2- versus 4 words in both the positive and negative condition). Because differences between these conditions were not the main focus of the current study, we used the average of the 4 indifference points on each day as an indicator of a participants' motivation to invest effort for learning that day.

Academic motivation: self-report Each day we asked participants about their general motivation for school (i.e. "How motivated were you today to invest effort in schoolwork?") rated on a 5-point Likert scale from 1 = no motivation at all to 5 = very motivated. This academic motivation variable is used later as daily self-report outcome variable in addition to the daily task-related indifference point resulting from the Cog-ED task.

2.3.3. Daily measures: predictor variables

2.3.3.1. Need satisfaction: autonomy, competence, and relatedness. To assess students' experienced autonomy, competence, and relatedness on a daily basis we administered the Balanced Measure of Psychological Needs (BMPN; Sheldon & Hilpert, 2012). This scale consists of three subscales: 1) Autonomy, 2) Relatedness, and 3) Competence. Each scale consists of 6 statements that are answered on a 5-point scale from 1 = "very true for me" to 5 = "very true for me". An example of the autonomy scale is: "I was free to do things my own way". Participants were explicitly instructed to think of how these needs were met that day when they were at school. To minimize participants' time investment that could lead to higher dropout in daily diary studies, we used a planned missingness design (Silvia et al., 2014), such that each subscale consisted of four instead of six items, see Supplementary Online Materials (SOM). We used the sum score of each subscale as a daily index of autonomy, relatedness and competence.

2.3.3.2. Social support. To assess daily experienced social support, we asked the following four questions:

Today I felt understood and supported by my 1) parents, 2) friends, 3) teachers, and 4) classmates. Participants answered each question on a 5-point scale from 1 = "not at all true for me" to 5 = "very true for me". We used the sum score of all four questions as index of daily experienced social support.

2.3.3.3. Stress. Each day, we asked to what extent participants experienced stress at 1) school, 2) home, 3) other situations. Participants answered each question on a 5-point Likert scale from 1 = "no stress at all" to 5 = "a lot of stress". We used the sum score of all three questions as index of daily experienced stress.

2.3.3.4. Homework hours. As in index of daily spent academic effort, we asked how many homework hours students spent each day (0, 1, 2, 3, 4, or more than 4 h).

2.3.3.5. Physical school attendance. As data collection occurred during the covid-19 pandemic, leading to a higher than normal number of days when students could not attend school, we included physical school attendance as predictor.

2.3.4. Covariates

2.3.4.1. Age. As changes in our measures of interest may be subject to age-related differences, we included age in years as a linear covariate in all analyses.

2.3.4.2. Day of assessment. We included the (within-person centered) day of assessment as a linear covariate in all analyses.

2.3.4.3. Sex. Finally, as sex differences may occur in our measures of interest (e.g. Bugler et al., 2015), we included sex as a nominal covariate in our analyses.

2.4. Analysis plan

Our data follows a hierarchical structure as days are nested within participants. We fitted our hierarchical analyses in a Bayesian framework.

Our main variables of interest are the mean indifference point (resulting from Cog-ED) – reflecting a participants' motivation to invest effort in learning on a certain day –, and the self-report question about academic motivation – reflecting a participants' academic motivation on a certain day. To better compare effects between both outcome variables, we standardized both outcome variables before model fitting. The goal of our analyses is to examine what variables predict daily motivation to invest effort in learning (Cog-ED) and academic motivation (self-report). We investigate within-subject effects: i.e., whether the indifference point and self-reported academic motivation are predicted by daily assessed (1) need satisfaction measures, (2) social support measures, (3) stress measures, (4) invested homework hours, and (5) physical school attendance. In addition, we added (within-person centered) day of assessment as within-subjects predictor.

For each daily assessed predictor variable, we calculated a standardized within-person variable (examining within-person fluctuating effects) and a standardized between-person variable representing each participants' mean over days (examining between-person stable effects). To examine between-person effects, these calculated means were reintroduced as level 2 variables. Thus, between-person effects examined effects of participants' average scores on (1) need satisfaction measures, (2) social support measures, (3) stress measures, and (4) invested homework hours on their indifference points and self-reported academic motivation across days. Additional between-person effects included mean-centered age, sex and physical school attendance. Note that we pre-registered to also include trait-variables that were assessed once (i.e., need for cognition scale (Cacioppo et al., 1984), academic self-regulation questionnaire (Vansteenkiste et al., 2009), a shortened version of Raven's standard progressive matrices (Langener et al,. 2022; Kramer & Huizenga, 2023), Raven and need satisfaction and frustration scale (Longo et al., 2016)) as additional predictors. However, because not all participants completed this trait-questionnaire, including those variables would lead to a loss of 9 participants in our already modest sample. In addition there would be considerable overlap between these variables and other variables. To retain power, we therefore decided to not include these trait measures, but instead to split our daily measured variables in within and between variance.

Sex and physical school attendance were contrast coded (sex: 1 = male, −1 = female, physical school attendance: 1 = yes, −1 = no).

Thus, this results in the following model where the suffix *_m* signifies that this variable is a calculated subject-specific mean and is included at the second level of the model, and subscript *d* denotes the nesting of day in participant *p*:

Level 1 (within-persons)

$$\begin{aligned} indifferencepoint_{pd} = {} & \beta_{0p} + \beta_{1p} * autonomy_{pd} + \beta_{2p} * competence_{pd} + \beta_{3p} * relatedness_{pd} + \beta_{4p} * socialsupport_{pd} + \beta_{5p} * stress_{pd} + \beta_{6p} \\ & * homeworkhours_{pd} + \beta_{7p} * physicalschoolattendance_{pd} + \beta_{8p} * time_{pd} + \varepsilon_{pd} \end{aligned}$$

Level 2 (between-persons)

$$\begin{aligned} \beta_{0p} = {} & \gamma_{00p} + \gamma_{01p} * autonomy\_m_p + \gamma_{02p} * competence\_m_p + \gamma_{03p} * relatedness\_m_p + \gamma_{04p} * socialsupport\_m_p + \gamma_{05p} * stress\_m_p + \gamma_{06p} \\ & * homeworkhours\_m_p + \gamma_{07p} * sex_p + \gamma_{08p} * age_p + \mu_p \end{aligned}$$

We fit the same model on self-reported academic motivation. For model fitting, we used the *brms* package (Bürkner, 2017) in R version 4.1.3 (R Core Team, 2020), using a first-order autoregressive covariance structure (ar1()) to account for correlated errors over time. In the models, we included fixed effects for all our predictor variables and a random intercept varying over participants. To guard against overfitting, we implemented lasso shrinkage priors. That is, small effects will be shrunk to zero while large effects will be maintained. All models were run with 10000 iterations half of which were warmup iterations (as is standard in brms model fitting). We considered effects significant whose 95% CI did not include zero, and considered effects trending whose 90% CI did not include zero. Our code is publicly available at https://osf.io/af29e/.

3. Results

A total of 342 diaries (87.69%) was filled out (see SOM for more descriptives).

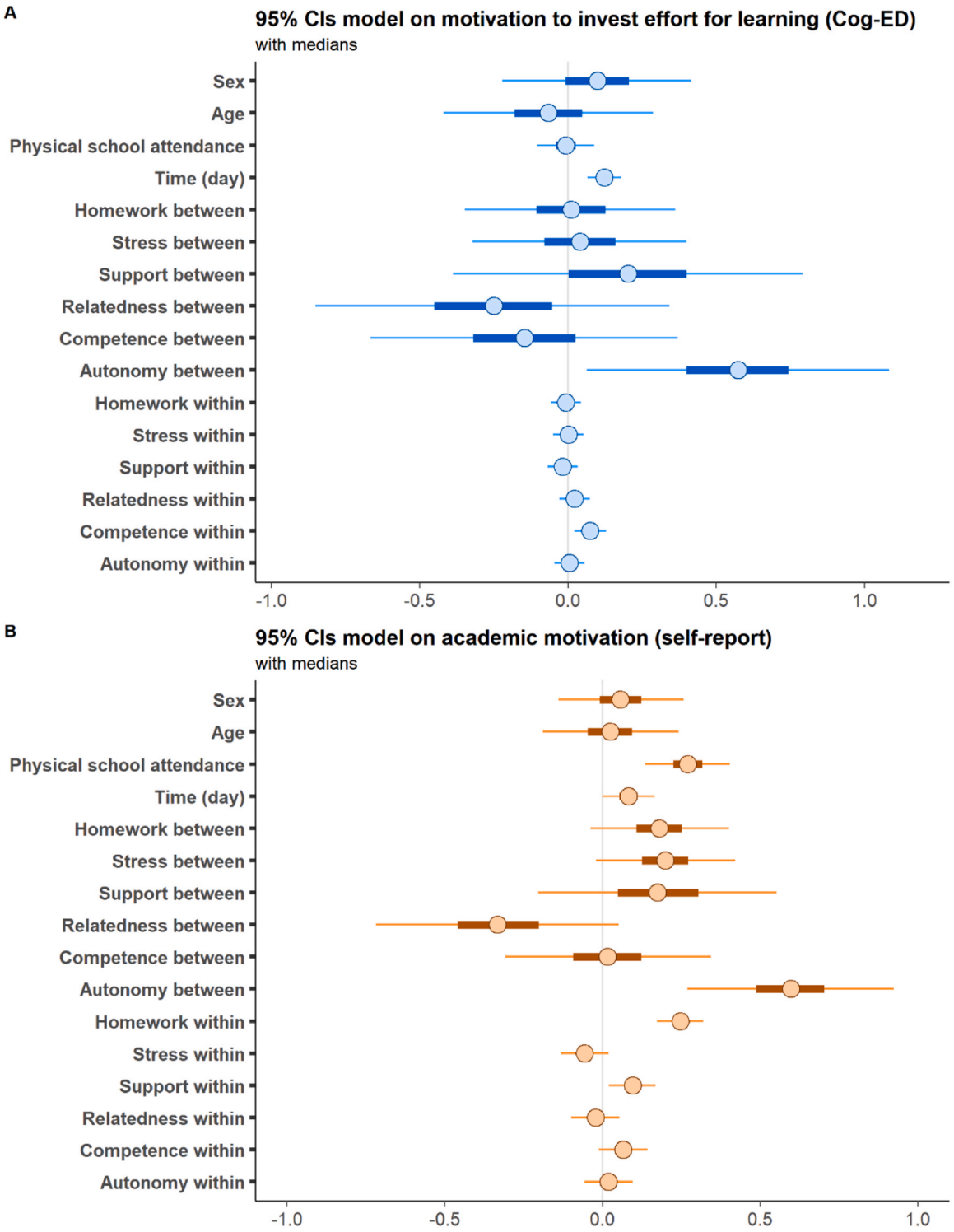

Fig. 2. Parameter estimates and 95% credibility intervals for the model on (A) motivation to invest effort in learning (Cog-ED) and the model on (B) self-reported academic motivation.

3.1. Model fit on motivation to invest effort for learning (Cog-ED)

Fig. 2 summarizes the results (for all parameter estimates see SOM). For the model fit on the indifference point, we found a positive within-person effect of daily experienced feelings of competence ($\beta = 0.08$, 95% CI = [0.02, 0.13]). Next, we found a positive between-person effect of experienced feelings of autonomy ($\beta = 0.56$, 95% CI = [0.05, 1.09]). Finally, we found a positive effect of time (day) ($\beta = 0.12$, 95% CI = [0.06, 0.18]).

3.2. Model fit on self-reported academic motivation

For the model fit on self-reported academic motivation, we found a positive within-person trend effect of daily experienced feelings of competence ($\beta = 0.07$, 90% CI = [0.01, 0.13]), and positive within-person effects of daily experienced social support ($\beta = 0.10$, 95% CI = [0.02, 0.17]) and daily reported number of invested homework hours ($\beta = 0.25$, 95% CI = [0.17, 0.32]). We also found a negative within-person trend effect of stress ($\beta = -0.06$, 90% CI = [−0.13, −0.01]). Next, we found a positive between-person effect of experienced feelings of autonomy ($\beta = 0.60$, 95% CI = [0.27, 0.92]). We also found trending between-person effects of stress, ($\beta = 0.20$, 90% CI = [0.01, 0.38]), homework hours, ($\beta = 0.18$, 90% CI = [0.01, 0.37]), and time (day) ($\beta = 0.08$, 90% CI = [0.01, 0.15]). Finally, we found a positive between-person effect of physical school attendance ($\beta = 0.27$, 95% CI = [0.14, 0.40]).

3.3. Exploratory analyses: effects of different sources of social support

To guard against overfitting, we initially did not separately model the different sources of social support. However, since we found a

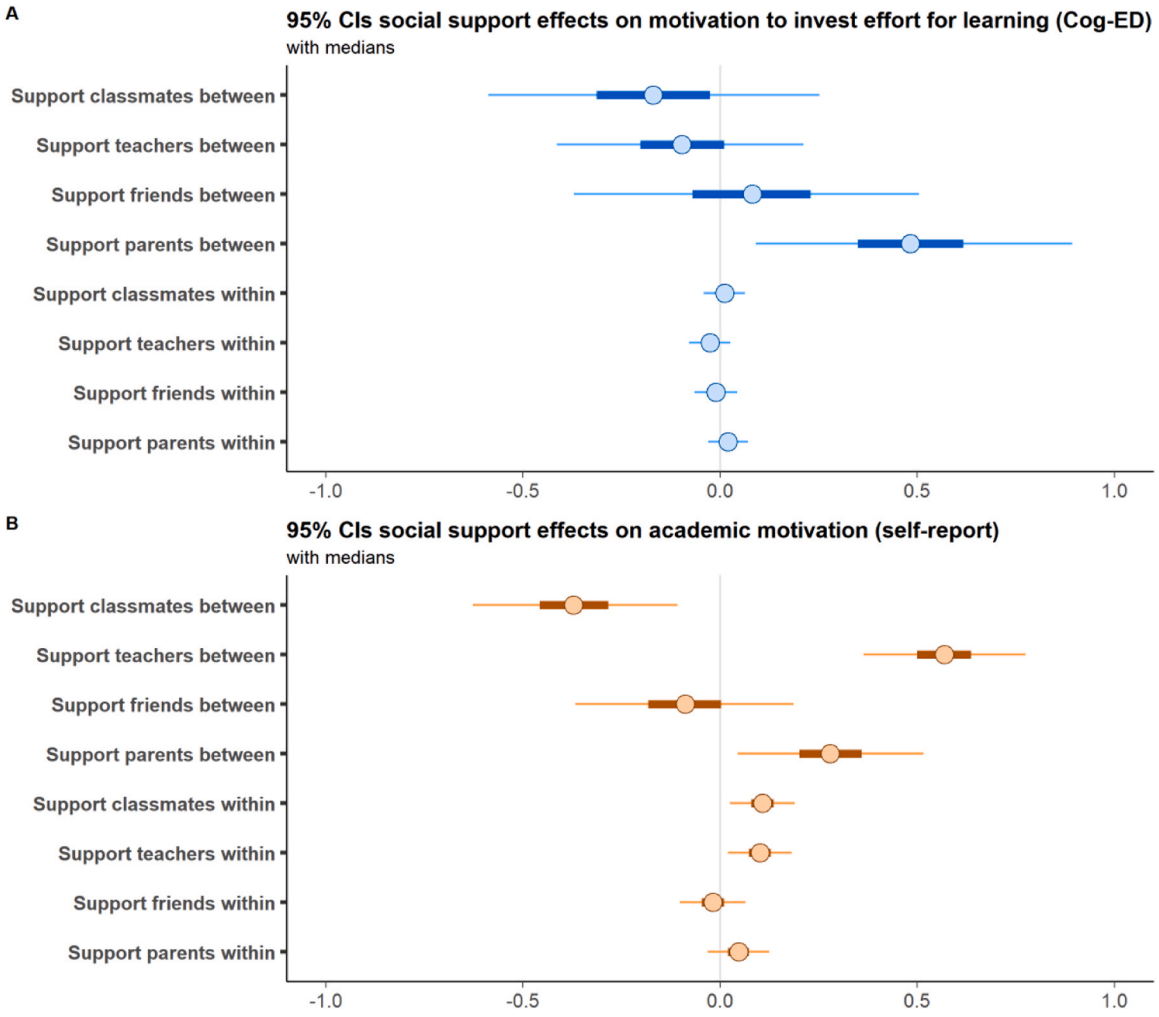

Fig. 3. Parameter estimates and 95% credibility intervals for social support effects on A) motivation to invest effort for learning (Cog-ED) and B) self-reported academic motivation.

positive within-person effect of social support on self-reported academic motivation, we decided to explore whether disparate sources of social support differentially affected both Cog-ED and self-reported academic motivation and whether this differed for within- and between-person effects. That is, within-person effects indicate whether participants reported higher academic motivation on days when they experienced less/more social support, while between-person effects indicate whether participants reported higher academic motivation in relation to their overall levels of experienced social support. Apart from (within-person centered) day of assessment, we did not include any other variables in these exploratory models.

Fig. 3A shows that participants who experienced greater average social support from parents reported higher motivation to invest effort for learning in Cog-ED [$\beta = 0.49$, 95% CI = 0.10, 0.89].

Next, Fig. 3B shows that, on days when participants reported more social support from teachers ($\beta = 0.10$, 95% CI = [0.02, 0.18]) and classmates ($\beta = 0.11$, 95% CI = [0.03, 0.19]) their self-reported academic motivation was also higher (within-person effects). Next, it shows that when participants' overall experienced social support from parents ($\beta = 0.28$, 95% CI = 0.04, 0.52]) and teachers ($\beta = 0.57$, 95% CI = 0.36, 0.77]) was higher, they also experienced higher academic motivation (between-person effects). Receiving more overall social support from classmates ($\beta = -0.37$, 95% CI = −0.62, −0.11]), however, was negatively related to self-reported academic motivation (between-person effect).

4. Discussion

In the current study, we tested whether day-to-day fluctuations in high-school students' motivation to invest effort in learning (assessed by Cog-ED) and academic motivation (assessed by self-report) were predicted by need satisfaction variables (autonomy, competence, and relatedness), social support, stress, invested homework hours and physical (versus online) school attendance. Participants completed a two-week daily diary protocol, in which they completed Cog-ED in addition to self-reports. Based on earlier research, we expected that day-to-day variations in motivation to invest effort in learning as well as in self-reported academic motivation would be positively predicted by experienced feelings of autonomy, competence, relatedness, social support, invested homework hours and physical school attendance, but negatively by experienced stress.

4.1. Need satisfaction

In line with our expectations, we found that both students' motivation to invest effort in learning (Cog-ED) and their self-reported academic motivation were higher on days when they experienced greater feelings of competence. Contrary to our expectations, we did not find these day-to-day effects for feelings of autonomy and relatedness, possibly because of our modest sample size. That is, the current results align with earlier large-scale (i.e. $N > 30{,}000$) research reporting that amongst autonomy, competence and relatedness, experienced feelings of competence were the strongest predictor of motivated behavior amongst students, while effects of autonomy were weak and effects of relatedness were non-significant (Yu & Levesque-Bristol, 2020). Our finding on the importance of competence in driving academically motivated behavior also aligns with the perspective of competence taking a most pivotal position in educational psychology, with close relations to self-efficacy and self-confidence (Schunk et al., 2014). While a within-person effect of competence is evident, the lack of a corresponding between-person effect suggests that experienced feelings of competence are not consistent over time, and may therefore be suitable targets for intervention.

In addition, our findings indicate that students who report greater *overall* feelings of autonomy, though not competence and relatedness, demonstrated elevated levels of motivation to invest effort in learning (Cog-ED) as well as self-reported academic motivation. This aligns with earlier research reporting stable trait-level effects of autonomy on academic motivation and academic effort in secondary school students (León et al., 2015), and demonstrates the importance of secondary school student's need to find some degree of initiative, purpose and meaningful choice in their academic endeavors.

Together, day-to-day fluctuations both in self-reported academic motivation as well as in behaviorally assessed motivation to invest effort in learning seem to be a function of day-to-day fluctuations in perceived competence and stable variations in perceived autonomy. Notably, we did not observe any effects of perceived relatedness, possibly because its variance may be accounted for by the social support variables that we describe next.

4.2. Social support

Participants reported higher academic motivation on days when they experienced greater levels of social support. Exploratory analyses revealed that students reported higher levels of academic motivation on days when they experienced greater levels of social support from *classmates*. This could be explained by the importance of in-class peer interactions for self-regulation (for a review see Rubin et al., 2006). For instance, research indicates that adolescents who receive peer support at school exhibit more effective self-regulation across behaviors, encompassing emotions and academic effort (Wentzel, 1999; Song et al., 2015). This concept finds support in our current finding that students also expressed heightened academic motivation on days when they could attend school in person, further aligning with prior daily diary research that indicated greater motivation among secondary school students on days of physical as compared to online school attendance (Klootwijk et al., 2021).

Additionally, students reported higher levels of academic motivation on days when they experienced greater levels of social support from *teachers*. Further, students who experienced greater *overall* levels of social support from *teachers and parents* also reported higher academic motivation. The strong contribution of teacher support on academic motivation is not surprising, given teachers' role in promoting learning and achievement. Current results also align with earlier findings demonstrating that parent and teacher support

were positively related to day-to-day reports of secondary school students' academic motivation (Klootwijk et al., 2021; Song et al., 2015; for a review, see Klauda, 2009). On the other hand, students who experienced higher average levels of social support from *classmates* reported lower levels of academic motivation. A possible explanation includes that high levels of peer support may provide for more opportunities to engage in other activities with those peers (e.g. hanging out) as opposed to academic activities (Wentzel, 2017). This can be understood through the concept of opportunity costs (Kurzban et al., 2013). Opportunity costs are rewards that are foregone when choosing one option over another (Otto & Daw, 2019; Braver et al., 2014). In this context, the negative relation between social support from classmates and academic motivation could be attributed to the opportunity cost of time spent socializing with peers, which is likely perceived as more rewarding than focusing on academic tasks like homework. Thus, when deciding between studying and engaging in other activities, students with more peer support may experience greater opportunity costs compared to students with less peer support. Yet, we found no relation between social support from *friends* and academic motivation. One potential explanation for this could be that, at this developmental stage, classmates are a more dominant reference frame than friends (Wouters et al., 2013). An alternative explanation includes the restricted opportunities participants had to socialize with friends other than classmates due to the pandemic.

Unlike self-reported academic motivation, motivation to invest effort in learning (Cog-ED) was unaffected by most social support measures except for average experienced social support from parents. This could be due to Cog-ED capturing a more specific motivational construct in a given moment as opposed to more general academic motivation. That is, when students contemplate their overall academic motivation on a given day, it could link to circumstances in which social support was influential (e.g., when they were at school). However, when considering their present motivation to invest effort in a learning task, this might be less influenced by social situations (e.g., perhaps due to being alone at home).

Together, day-to-day fluctuations in self-reported academic motivation seem to be a function of day-to-day fluctuations in social support from classmates and teachers and stable variations in social support from classmates, teachers and parents, while day-to-day fluctuations in motivation to invest effort in learning (Cog-ED) were only affected by stable variations in social support from parents. Curiously, while social support from classmates has an overall negative impact on academic motivation, it exhibits a positive influence on a day-to-day basis. This finding also underlines the strength of the daily diary method as being able to capture independent and sometimes even opposite features of variables on within- and between-person levels (Murayama et al., 2017).

4.3. Academic effort and stress

As expected, students who reported to invest more hours in homework (academic effort) both on a day-to-day basis and on average reported heightened self-reported academic motivation. This suggests a strong connection between students' internal motivational state and their effort-related behaviors (though we assessed invested homework hours with self-report), aligning with prior research demonstrating links between academic motivation and homework efforts (e.g., Feng et al., 2019; Trautwein et al., 2006). Enhancing academic motivation could thus prove effective in boosting secondary school students' (daily) dedication to homework. However, in contrast to self-reported academic motivation, motivation to invest effort in learning (Cog-ED) exhibited no relation with hours devoted to homework. This is surprising, given that both invested homework hours as well as indifference points resulting from Cog-ED can be regarded as behavioral manifestations of motivation. A potential explanation includes that Cog-ED captures a more specific construct. Homework, often linked to academic outcomes, may not be as intertwined with investing effort in a word-learning task that, in the current study, lacked a connection to academic outcomes. Subsequent research could tailor Cog-ED to better align with school outcomes. For instance, Cog-ED might incorporate choices between homework exercises of varying effort levels or include academic consequences such as linking effort choices with grade increments.

Additionally, on a day-to-day basis stress negatively, yet, on average, positively impacted self-reported academic motivation. While prior studies have established a negative relation between stress and academic motivation on a trait-level (for a review see Pascoe et al., 2020), our current study adds that this relation also holds true within day-to-day fluctuations. The result that greater average stress was related to higher academic motivation does not align with Pascoe and colleagues (2020), yet aligns with other research stating that some degree of stress may actually be beneficial to activate motivated behavior (for a review see Seery, 2011). This finding emphasizes the importance of implementing measures to reduce stress on a daily basis for students in secondary education in order to improve academic motivation, and again underlines the strength of the daily diary method as being able to capture independent and sometimes even opposite features of variables on within- and between-person levels (Murayama et al., 2017).

Together, results show that day-to-day fluctuations in self-reported academic motivation are positively predicted by day-to-day fluctuations in invested homework hours, negatively by day-to-day fluctuations in stress, and positively by average levels of invested homework hours and stress.

4.4. Limitations and strengths

The current study knows some potential limitations. First, it is important to note that we sometimes describe results in terms of causality (i.e., we call our variables 'predictors'). However note that our design is correlational and thus does not allow for causal conclusions. Second, individual differences in learning ability may have affected motivation to invest effort within the Cog-ED task. That is, students could have shown greater motivation to invest effort in the learning tasks if they previously performed well on those learning tasks, as is sometimes observed in studies utilizing Cog-ED (Kramer et al., 2021; Dreisbach & Jurczyk, 2022). However, we consider this scenario unlikely as we found no effect of learning performance on effort-discounting (see SOM). Second, even though we included students from average (i.e., pre-vocational) educational backgrounds, representing the largest group (over 50%) of students

in the Netherlands, replication studies with students from diverse educational backgrounds would enhance the robustness of the current findings.

Another limitation includes the restriction of range in the Cog-ED outcome variable (i.e., indifference points) as within-person variability across days in the Cog-ED variable was relatively small as compared to the self-report motivation measure (see SOM Figure S4). This may have led to more difficulty in detecting true relations between Cog-ED and other variables. Future studies could consider varying the amount of reward against which effort is discounted as to increase variance. Relatedly, as Cog-ED uses rewards to quantify motivation to invest effort, part 1 of this study also asked participants to fill out the BAS reward-sensitivity scale (Carver & White, 1994). Results from study 1 showed that Cog-ED outcomes were unaffected by individual differences in reward sensitivity (Kramer et al., 2023). Therefore, we did not include this scale in the current study.

In addition, participants were not required to invest the effort indicated by their choice, as is standard in the effort-discounting literature (e.g., Westbrook et al., 2013; Westbrook & Braver, 2015; Kramer et al., 2021). Therefore, offers were not completely aligned with incentives, as economists believe is necessary to reveal people's true valuations. However, we chose not to because of practical reasons. That is, we could not let participants perform the learning tasks or provide incentives on a daily basis. The fact that participants were not required to invest effort on a daily basis could also explain the relatively large time effect (where participants were increasingly likely to select the high-effort high-reward options with each passing day) as the temporal distance between the effort exertion and choice moments increased over time.

Further, while Cog-ED adeptly captured variations in need satisfaction measures, it was unaffected by measures of social support, stress and homework investment. Although the current results offer promise, we cannot yet recommend using Cog-ED in its current configuration as a pure behavioral manifestation of academic motivation. Still, the advantage of employing Cog-ED in addition to self-report lies in its potential for straightforward manipulations within the task. For example, future research could incorporate a variety of academic exercises (instead of the word-learning tasks used in the current study) into Cog-ED to assess (day-to-day) variations in motivation for those specific assignments students encounter in their schoolwork. Conversely, the advantage of using the self-report question lies in its connection to a broader range of constructs believed to underlie academic motivation. The current results also suggest that repeated self-reports can serve as a means to capture daily fluctuations in academic motivation, as evidenced by the observed within-person effects.

The current study also possesses several notable strengths. First, while previous studies employing Cog-ED have typically used working memory tasks, our approach centered on word-learning tasks. This choice stems from the alignment between word-learning and the academic situations encountered by secondary school students in their real-life contexts. In addition, the current study contributes by assessing motivation both via self-report and behaviorally, and fills a gap by extending trait-level motivation research to the daily-level. That is, this is one of few studies that extends research on factors underlying trait levels of academic motivation to the level of daily experiences. This aspect is crucial, since constructs that exhibit short-term fluctuations are more effective targets for intervention.

5. Conclusion

To summarize, the current study examined factors predicting day-to-day fluctuations in secondary school students' academic motivation. We utilized two daily measures of motivation: 1) the Cog-ED task for behavioral manifestation, and 2) self-report for internal motivational state, and tested whether both measures were predicted by day-to-day variations in experienced feelings of autonomy, competence, relatedness, stress, invested homework hours, and physical school attendance both at the within- and between-person level.

Results showed that both self-reported academic motivation as well as motivation to invest effort in learning were higher on days when students experienced greater competence. In addition self-reported academic motivation was higher on days when students experienced more social support from classmates and teachers, invested more effort in homework and physically attended school, but lower on days when students experienced more stress. Additionally, both motivation to invest effort in learning (Cog-ED) and self-reported academic motivation were higher for those with greater average levels of perceived autonomy and support from parents. Moreover, students who, on average, dedicated more time to homework, reported elevated stress levels, and received greater support from teachers reported higher academic motivation. Conversely, those with greater overall support from classmates reported lower academic motivation.

Together, results underline the need for creating academic settings that boost student's feelings of competence, foster a social supportive environment at school (with classmates and teachers), and lower stress on a day-to-day basis. Further, results demonstrate the importance of perceived autonomy, social support from adults (parents and teachers), and physical school attendance for secondary school student's academic motivation. In addition, the current study fills a gap by extending trait-level motivation research to the daily-level.

Funding

AK was supported by the Start Impulse grant to NeuroLabNL from the Dutch National Science Agenda (NWA) [grant number 400.17.602]. LK has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement n° 648082). AvD was supported by an ORA-grant [grant number 464-15-176] (partly) financed by the Dutch Research Council (NWO) and by the Social Resilience and Security program (Leiden University). The funding source had no role in the study design, collection, analysis or interpretation of the data, writing the manuscript, nor the decision to

submit the paper for publication.

CRediT authorship contribution statement

Kramer Anne-Wil: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Visualization, Writing – original draft. **Huizenga Hilde M.:** Funding acquisition, Methodology, Supervision, Writing – review & editing, Conceptualization. **van Duijvenvoorde Anna C. K.:** Conceptualization, Funding acquisition, Methodology, Supervision, Writing – review & editing. **Krabbendam Lydia:** Conceptualization, Funding acquisition, Methodology, Resources, Supervision, Validation, Writing – review & editing.

Declaration of Competing Interest

None.

Acknowledgements

The authors thank Rebecca van Rijn for her helpful efforts in data collection.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.lmot.2023.101957.

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