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It's more about a lesson than a domain: Lesson-specific autonomy support, motivation, and engagement in math and a second language

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ABSTRACT

Expanding research on the relative impact of different autonomy-supportive strategies employed by teachers across domains, the present study investigated the variation in 4 lesson-specific autonomy-supportive strategies (providing choices, rationales, accepting frustration, and stimulating interests) and 6 aspects of students' motivation and engagement in 2 domains with a repeated measurement design. For 3 weeks, 202 Dutch students from 8 eighth grade classes and 1 ninth-grade class and 12 teachers completed lesson-specific measures at the end of Math and German lessons. Students' perceptions of teachers' autonomy support and their motivation and engagement varied considerably across lessons within a domain (variance at the within-student level ranged from 19% to 51%). In random intercept-random slope models, we found that all autonomy-supportive strategies showed meaningful associations with aspects of students' motivation and engagement. We did not find substantial domain-dependency in the associations between autonomy support and the outcomes.

1. Introduction

The potential of teachers' autonomy support to promote students' motivation and engagement has been highlighted in many studies (for reviews see Stroet, Opdenakker, & Minnaert, 2013; Su & Reeve, 2011). Yet, two critical underexamined areas remain: the impact of lesson-specific autonomy support and the domain-specificity of the effects of autonomy support. That is, there might be large differences in autonomy support across lessons (e.g., the teacher does not explain the relevance of the topic in every lesson) and across domains (e.g., some content might lend itself better to autonomy-supportive strategies).

Specifically, students' motivation and engagement can exhibit substantial fluctuations over short periods of time (e.g., Heemskerk & Malmberg, 2020; Martin et al., 2015; Patall et al., 2018). Students might be motivated in one lesson but not in the next lesson in the same subject domain. In order to explain these differences, more attention needs to be paid to students' lesson-specific or momentary motivation (e.g., Reeve, 2016) and its association with teachers' lesson-specific autonomy support (e.g., Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008). Autonomy support seeks to promote students' sense of self-determination: Ideally, students will experience learning as a self-chosen activity that meets their own needs (Stroet et al., 2013).

It is still an understudied issue in educational research whether the impact of autonomy support differs across domains. Tsai et al. (2008) found that lesson-specific autonomy support promoted students' experienced interest in all the domains they investigated: German, a second language, and Math. However, the study by Tsai et al. (2008) only considered the overall autonomy-supportive atmosphere in lessons and did not differentiate between distinct autonomy-supportive strategies. Teachers can use different strategies to support students' autonomy (e.g., Assor et al., 2002; Su & Reeve, 2011). Hence, it needs to be examined whether different autonomy-supportive strategies are equally effective for enhancing students' motivation and engagement in distinct domains. To shed more light on this issue, the current study investigated between-domain differences in the associations between distinct lesson-specific autonomy-supportive strategies and a variety of aspects of students' motivation and engagement.

1.1. Teachers' autonomy support

The self-determination theory (SDT; Deci & Ryan, 1985, 2000) can

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be used as a theoretical framework to derive assumptions about the hypothesized impact of teachers' autonomy support on students' outcomes. SDT assumes that students' motivation and engagement increase when three basic psychological needs are supported: Competence (the need to feel capable of achieving desired learning outcomes), relatedness (the need to be connected to other people and belong), and autonomy (the need to be free from control and have optional choices; Assor, 2012; Deci & Ryan, 2000). In the school context, fostering a feeling of autonomy among students is of particular importance, given that schools implement and impose rules and tasks that have to be followed. Accordingly, previous research has shown that students who perceived their teachers as autonomy-supportive were more engaged (Reeve, Jang, Carrell, Jeon, & Barch, 2004), showed higher academic achievement (Flink, Boggiano, & Barrett, 1990), reported greater enjoyment (Black & Deci, 2000) and intrinsic motivation (Guay, Boggiano, & Vallerand, 2001).

Teachers' autonomy support refers to instructional styles directed towards the goal that students feel they can act in ways that are consistent with their authentic values and goals (Assor, 2012). One autonomy-supportive strategy is offering choices, which involves providing different options and encouraging students to make choices and take initiative (Katz & Assor, 2007). Another autonomy-supportive strategy is providing rationales and speaking to the relevance of a task (Reeve, 2006). This refers to providing an explanation for why completing a given task will be useful for students (Su & Reeve, 2011). Teachers can also try to take students' perspectives, acknowledge their questions and feelings, and accept their frustrations during the learning process (Su & Reeve, 2011). Stimulating students' interests by offering interesting activities is also considered an autonomy-supportive strategy (Su & Reeve, 2011). Given that autonomy support can be provided through several, distinguishable instructional strategies (Patall et al., 2018), research on the relative impact of these different autonomy-supportive strategies on student outcomes is needed (Patall, Cooper, & Wynn, 2010).

1.2. Aspects of motivation and engagement

Grounded in SDT, previous research has indicated that teachers' autonomy support is associated with several components of students' lesson-specific motivation and engagement (e.g., Patall et al., 2018). Previous findings suggest that students develop parallel motivation and engagement structures (i.e., students' motivation and engagement are highly correlated; e.g., Martin, Malmberg, & Liem, 2010). The Situated-Expectancy-Value theory (S-EVT, Eccles & Wigfield, 2020) can help to understand the discriminant validity of motivation and engagement, because S-EVT outlines the different factors and processes through which engagement is energized and conceptualizes motivation as a key factor driving engagement (see also Schunk & Mullen, 2012). Therefore, when targeting the relative effectiveness of distinct autonomy-supportive strategies in the classroom, it is valuable to consider students' motivation and engagement as distinct outcomes. In our study, we focused on the behavioral aspect of engagement (effort), and the values/reasons that are endorsed for engaging in a domain (motivation).

1.2.1. Aspects of motivation

Students' motivation can range from intrinsic motivation to non-self-determined motivation (Ryan & Deci, 2000). Intrinsic motivation means that an action or behavior is performed for its own sake (i.e., for the pleasure experienced during its execution; Ryan & Deci, 2000). Extrinsic motivation refers to performing an activity to achieve external rewards or reinforcements (e.g., Deci & Ryan, 1985). Three different components of extrinsic motivation can be differentiated based on their degree of internalization and integration (Koestner & Losier, 2002; Ryan & Deci, 2000). Integrated regulation refers to executing a task because it is understood as important for oneself and part of the identity (e.g., Sheldon, Osin, Gordeeva, Suchkov, & Sychev, 2017). Identified regulation refers to executing a task because the activity is accepted as relevant for the self (Ryan & Deci, 2000). Introjected motivation can be observed when a student is motivated by internalized rewards or punishments such as shame and guilt (e.g., Sheldon et al., 2017). Students might find parts of a lesson intrinsically intriguing, and value other parts for identified, introjected or fully extrinsic reasons..

Several studies using within-person designs have shown that teachers' lesson-specific autonomy support promoted students' respective intrinsic motivation (Patall et al., 2018; Tsai et al., 2008), while no association was revealed between lesson-specific autonomy support and students' controlled motivation (a composite variable that averaged students' reports on introjected and extrinsic motivation; Patall et al., 2018). However, there are open questions concerning (1) the empirical separability of intrinsic, integrated, and identified motivation, and (2) the associations between the distinct aspects of motivation, such as introjected motivation, and its consequences/antecedents, including autonomy support.

1.2.1.1. Differentiating between intrinsic and identified motivation: considering subjective task values. Prior research has shown that intrinsic and identified motivation cannot consistently be separated (Lonsdale, Sabiston, Taylor, & Ntoumanis, 2011). Moreover, the measurement of integrated motivation is problematic, given that, in empirical research, integrated motivation has been found to be indistinguishable from identified or intrinsic motivation and had no unique predictive power for outcomes when identified or intrinsic motivation were considered (e.g., Gagné et al., 2015). Integrated and identified motivation are assumed to partially or fully trigger actions that express subjective values (Sheldon et al., 2017). However, students value multiple aspects, such as the personal utility of a domain, or the extent to which a domain helps them confirm important aspects of the self (e.g., Eccles, 2005). Specifically, four subjective task values (rooted in S-EVT, e.g., Eccles & Wigfield, 2020) are considered to be central to achievement-related motivation: Three positive value facets (intrinsic value, which resembles intrinsic motivation (Eccles, 2005), utility and attainment value) and one negative value facet (cost). The personal utility attributed to an action may be related to both identified and integrated regulated motivation: "utility value is similar (…) to the self determination theory construct of identified regulation because when doing an activity out of utility value, the activity is a means to an end rather than an end in itself (see Ryan & Deci, 2000). However, (…) utility value also can reflect that the activity ties to some important goals that the person holds deeply, such as attaining a certain occupation. In this sense, utility value also connects to personal goals and sense of self, and so has some ties to intrinsic motivation or integrated regulation" (Wigfield & Cambria, 2010, p. 4).

Rather than assessing identified motivation as one general factor referring to personal meaningfulness, importance, or valuation (e.g., Ryan & Connell, 1989; Sheldon et al., 2017), subjective task values, which can be defined as the motivating forces underlying identified motivation (e.g., Patall, Dent, Oyer, & Wynn, 2013), should receive more attention: Considering students' subjective value beliefs makes it possible to distinguish more clearly between what students enjoy and what they value for other reasons (Lonsdale et al., 2011). In a cross-sectional study with 278 high school students from grades 9 to 12, Patall et al. (2013) found positive associations between students' perceptions of several autonomy-supportive strategies by their teachers in a course and the utility value students ascribed to that course. By studying the effects of teachers' different autonomy-supportive strategies on students' utility value, more can be learned about why students attribute value to instructional content that is not inherently enjoyable but still relevant for them.

1.2.1.2. Introjected motivation and autonomy support. How autonomy support is associated with students' introjected motivation is an open question. Assor, Vansteenkiste, and Kaplan (2009) found that identified

motivation showed stronger correlations with mastery goals, positive affect, and engagement than introjected motivation. However, they mainy focused on introjected motivation with respect to self-worth and self-approval (e.g., "I do the classwork because I want to feel satisfied with myself"). Introjected motivation can also refer to seeking the approval of important others (e.g., Ryan & Connell, 1989), and this might vary in reaction to teachers' instructional styles. That is, teachers' autonomy support, such as acknowledging students' perspectives, might encourage students to invest more in their classwork to show their teachers that they are making an effort, and thus promote introjected motivation with respect to the teacher's approval.

1.2.2. Adaptive and maladaptive academic effort

Students can exhibit both adaptive and maladaptive forms of academic effort. Academic effort is understood as active behavioral engagement in school (e.g., Fredricks, Blumenfeld, & Paris, 2004). Specifically, academic effort is defined as students' engaged investment in learning and working on domain material to the best of their abilities (Trautwein, 2007). Disengagement refers to the use of maladaptive behavioral strategies or problem behavior in school (e.g., Wang, Ye, Hofkens, & Linn, 2017). For example, students might not pay sufficient attention because they are too easily distracted from the lesson. Certain styles of engagement, particularly actions directed towards trying to affect a change, are constrained in class and might even be thwarted by teachers (see Patall et al., 2019, for information on the associations between students' agentic engagement and teachers' need thwarting behaviors). To avoid punishment by the teacher, students might seek to make their disengagement in the classroom unobservable as a problematic behavior. That is, students might invest effort in navigating classroom requirements with as little effort as possible yet in a way that remains unnoticeable to the teacher (i.e., minimalistic effort, see Flunger et al., 2015). Moreover, they might even apply strategies to pretend engagement in order to avoid trouble at school, despite not actually putting any effort into classwork (i.e., pretended effort).

An earlier study found a positive association between teachers' daily autonomy support and students' engagement but could not confirm an association of autonomy support with disengagement (a composite score of behavioral and emotional disengagement, Patall et al., 2018). Yet, it can also be assumed that autonomy support "promotes the endorsement of their classroom activities, so that students engage (…) in a more volitional way" (Sierens, Vansteenkiste, Goossens, Soenens, & Dochy, 2009, p. 60) which might reduce their efforts in using strategies to actively disengage (such as minimalistic and pretending effort). Taking a more fine-grained perspective on the specific behaviors students show to withdraw in a lesson, we assumed to be able to yield evidence that teachers' endeavors to render a lesson more autonomy-supportive can help to trigger students' effort and simultaneously reduce their minimalistic and pretended effort.

1.3. Between-domain differences

Previous findings suggest that students do not like or value every domain in the same way (Chanal & Guay, 2015; Green, Martin, & Marsh, 2007): They tend to report higher intrinsic motivation for English as a second language, compared to other domains (Bong, 2001), and attribute higher utility value to English and Math (Bong, 2001; Gaspard, Häfner, Parrisius, Trautwein, & Nagengast, 2017). Consequently, students can be expected to differ in their intrinsic motivation concerning domains they perceive as relevant for their future, or which they feel align better with their personal interests.

The school-subject-specific differences in students' motivation could stem from between-domain differences in the effectiveness of autonomy support (e.g., Chanal & Guay, 2015), which is of particular importance for educational practice, because teachers want to know whether they can trust that the same autonomy-supportive strategies will be equally effective across domains. Content differences between dissimilar domains may affect teachers' choices about the use of different strategies (e.g., Prange, 2011). For example, common ways to provide meaningful rationales include (1) discussing how students can use the information in the future and (2) making a connection between the classroom and the real world (Steingut, Patall, & Trimble, 2017). Studies have shown that teachers find it hard to connect Math to students' lives (e.g., Gainsburg, 2008), which could imply that even if teachers try to create a link between learning abstract mathematical concepts and real-world experiences, their examples remain complex, with the end result that the provision of rationales might have weaker effects in Math than in German. Focusing explicitly on the effectiveness of autonomy support for students' interest, Tsai et al. (2008) found no evidence for between-domain differences across German, English (a second language), and Math.

Yet, the evidence on between-domain differences in autonomy support suggests that teachers tend to offer greater support in domains in which students show lower motivation (Math, Sierens et al., 2009; German as a first language, Praetorius et al., 2015) compared to domains for which students already hold high motivation (such as English, Gaspard et al., 2017). Specifically, using secondary school students' reports, Sierens et al. (2009) found that Dutch (first language) teachers were perceived to provide less autonomy support than Math teachers. A study by Praetorius and colleagues (2015) in the domains of German (first language) and English (a second language) revealed that the majority of teachers tended to provide more motivational support in German than in English.

Concerning engagement, there is evidence that students reporting high agentic engagement (i.e., students working proactively to initiate a change in teachers' instruction) tend to receive greater autonomy support while students with high behavioral engagement (i.e., effort) do not affect a change in their teachers' autonomy support (Matos, Reeve, Herrera, & Claux, 2018). It could be that teachers observe students' motivation and engagement levels and aim to intervene through offering greater support if they perceive low motivation and low engagement. Thus, teachers' provision of autonomy support and the effectiveness of autonomy support for promoting students' outcomes in a given domain could depend on students' domain-specific motivation and engagement.

1.4. Student heterogeneity and teachers' autonomy support

There are several studies showing that students who perceive low autonomy support from their teachers report lower intrinsic motivation as well as engagement (e.g., persistence) than students who perceive high autonomy support (e.g., Vansteenkiste et al., 2012). Yet, questions remain about the underlying mechanisms at play, and it is therefore important to investigate whether students with low initial motivation or engagement thrive more or less from autonomy support than students with high initial motivation or engagement.

The effects of autonomy support can vary considerably between students (e.g., Tsai et al., 2008). Thus, it needs to be studied whether different autonomy-supportive strategies have the same beneficial effects for every student and whether differential effects are moderated by students' initial motivation or engagement. For example, stimulating interest in the content matter could be most effective for students who previously considered it uninteresting, because they receive new information. Flunger, Mayer, and Umbach (2019) found conditional effects of an autonomy-supportive intervention in the classroom context for three out of 12 outcomes under study. Students' grades and prior autonomy were found to be moderators; for example, the effect of teachers' autonomy support (i.e., the experimental condition) on students' perceived autonomy was higher among students with generally high perceived autonomy in physics compared to students with low autonomy. By comparison, Tsai et al. (2008) found that students with generally high interest were less affected by autonomy support than students with low interest.

Thus, two potential patterns could emerge in the interaction between

general motivation or engagement and autonomy support: a so-called "Matthew effect" (Walberg & Tsai, 1983) implying that students with generally high motivation thrive more from receiving autonomy support in a lesson than students with generally low motivation (see Flunger et al., 2019) or a so-called "Robin hood effect" (Häfner et al., 2017). Robin hood effects occur if students with low motivation benefit more from motivational support than students with high motivation. Specifically, Robin Hood effects imply that students in need (i.e., students with low motivation) receive essential resources that students with high motivation already have (Häfner et al., 2017). This effect can occur if students with low motivation receive new information in a lesson, e.g., through their teachers' motivational support, about aspects such as the relevance (Häfner et al., 2017) or interestingness of a domain (Tsai et al., 2008) that is already clear to students with high motivation. It needs to be studied whether specific autonomy-supportive strategies, such as providing rationales and stimulating interest, trigger "Robin hood effects" rather than "Matthew effects".

1.5. Current study

The main objective of the present study was to examine the associations between distinct autonomy-supportive strategies and students' lesson-specific outcomes during a 3-week period, thereby accounting for the variability in autonomy support and students' outcomes over short time periods. We used an intra-person analysis, because it allowed us to consider several autonomy-supportive strategies teachers use at once. Moreover, the design allowed us to analyze the predictive effects of the autonomy-supportive strategies on the motivation and engagement of the same student from a longitudinal perspective, in an ecologically valid manner and in a relatively short time interval. For understanding classroom processes emerging when specific teachers teach the same classroom of students across a longer period of time, within-subject studies can be particularly useful to derive findings on the real-life impact of the autonomy-supportive strategies teachers use on students' lesson-specific outcomes.

Assessing the associations between teachers' autonomy support and students' outcomes represents the investigation of the correlation on the between-student level and cannot inform about the meaning of the association of autonomy support and the motivation and engagement of individual students (see e.g., Asendorpf, 2000). However, it is relevant to study whether different autonomy-supportive strategies have the same beneficial effects for every student. Random slopes can show whether the predictive effects of the autonomy-supportive strategies on students' motivation and engagement differ across students. In this case, further variables in which students vary, such as their general motivation and engagement in a given domain, might explain the fluctuation in slopes across students. Therefore, we studied the interaction between students' baseline motivation and engagement and teachers' lesson-specific autonomy support in predicting students' respective state outcome.

We tested three research questions in a domain for which students report relatively higher intrinsic motivation (a second language, e.g., Tsai et al., 2008) and a core domain to which students attribute relatively higher extrinsic motivation (Math, Gaspard et al., 2017):

(1) What is the association between distinct lesson-specific autonomy-supportive strategies and different aspects of students' lesson-specific motivation and engagement?
(2) Are there between-domain differences in the associations between teachers' lesson-specific autonomy support and students' motivation and engagement?
(3) Are there individual differences in the associations between teachers' lesson-specific autonomy support and student outcomes? If so, do students' prior motivation or engagement explain the variability between students?

2. Methods

2.1. Sample and design

For the present study, a correlative, repeated measurement design was implemented. Assessing the perspective of students does not represent the whole classroom environment, which can be understood to be shaped by shared perceptions of the students and their teachers (e.g., Könings, Seidel, Brand-Gruwel, & van Merriënboer, 2014). Moreover, it could yield common-method bias and an overestimation of the true association between teachers' autonomy support and student outcomes when focusing only on the perspective of students; consequently, it has been advised to gather measures from two distinct perspectives (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003), such as students and their teachers. Yet, several studies have revealed that the student and teacher perspective show low correspondence (e.g., Könings et al., 2014), also concerning autonomy support (e.g., Hornstra, Stroet, & Weijers, 2021). Furthermore, it is assumed that students' own perceptions are closest indicators of students' experiences of the interactions with their teacher, and hence, the key factors underlying their motivation and engagement (Fraser & Walberg, 1981). That is, teacher perceptions on their behavior can be considered as a proximal predictor of students' perceptions of their teachers' support, and as a distal predictor of students' motivation and engagement: Skinner and Belmont (1993) only found a statistically significant association between teachers' and students' perceptions of teacher involvement, but not autonomy support in a longitudinal study of 14 teachers and 144 students. Likewise, when comparing the perspectives of observers, students and teachers on teacher behaviors, Donker, Vemde, Hessen, Gog, and Mainhard (2021) revealed that student ratings of teacher behaviors were stronger predictors of student outcomes (in this case emotions), while teacher ratings of teacher behaviors were stronger predictors of teacher outcomes. Moreover, for student outcomes, the observer perspective did not explain much additional variance in outcomes compared to only focusing on the student or teacher perspective. Accordingly, we focused primarily on the predictive effects of students' perceptions in this study but also assessed the role of teacher ratings on their autonomy support and assessed their predictive effects on student outcomes as a validity check (see Supplemental Material).

For students, a pre-test was implemented via a student questionnaire. Both students and their German and Math teachers were asked to complete online lesson-specific measures at the end of each German or Math lesson across three weeks in March and April 2017. The 3-week period of lesson-specific measurements took place after Spring break (February 25 – March 5, 2017) and before May break (April 22 – April 30, 2017).

A total of 202 Dutch students (91 female; 104 male; $M_{age} = 13.80$, $SD = 0.67$) from nine classes (eight eighth-grade classes and one ninth-grade class) in four different secondary schools in the regions of Zuid-Holland and Noord-Brabant were surveyed. The eighth-grade classes (mix of higher general secondary education and pre-university education, the 'HAVO' or 'VWO' tracks) consisted of 171 students, and the ninth-grade class (pre-university education) consisted of 27 students. These two tracks are the two highest tracks in Dutch secondary education and are attended by approximately 44% of secondary school students in the Netherlands (Dutch Inspectorate of Education, 2019). Students rated a total of 146 lessons. The teacher sample consisted of five German (three females) and eight Math teachers (three females); one German teacher taught two classes and one German teacher taught three classes. Twelve of the 13 teachers completed lesson-specific measures in a total of 92 lessons.

2.2. Measures

We used a student questionnaire at pre-test, and surveyed teachers' and students' lesson-specific assessments at the end of Math and German

lessons. The internal consistencies of all scales were satisfactory to good (see Table 2). Information on tests of construct and convergent validity can be found in the supplementary material.

2.2.1. Student questionnaire

At pre-test, aspects of students' motivation, effort and general perceptions of their teachers' autonomy support were assessed (see https://osf.io/x5jgb/?view_only=373f5b96c46243ac8663e9a1e484e3d5 for an overview on all constructs assessed). All items were answered on a four-point Likert scale (1 = completely disagree, 4 = completely agree).

2.2.1.1. Aspects of motivation. A Dutch version of the Self-Regulation Questionnaire-Academic (SRQ-A, Ryan & Connell, 1989) with four items for each subscale, which had been translated by Sempels (2014), was used to measure intrinsic (e.g., "Why do you participate in German? Because it is fun") and introjected motivation. The latter was measured with two items directed towards concerns about approval by oneself ("Because I will be ashamed if I don't finish my exercises") and by others ("Because I want the teacher to think I'm a good student").

We also assessed utility value with three items focusing on utility for daily life (e.g., "German/Math comes in handy in everyday life and leisure time") adapted from Gaspard et al. (2015).

2.2.1.2. Aspects of effort. Academic effort was assessed with four items (e.g., "I work seriously on assignments in German") adapted from Trautwein and Köller (2003). Minimalistic effort was assessed with six self-developed items (e.g., "I try to get away with as little effort as possible during Math") based on Flunger et al. (2015). Pretending effort was assessed with four self-developed items (e.g., "In German, I pretend to work hard").

2.2.1.3. Autonomy support. Students' perceptions of their teachers' general use of the four autonomy-supportive strategies of providing choices, providing meaningful rationales, accepting frustration and stimulating interest were assessed with three items each based on Aelterman et al. (2019), and Flunger et al. (2019). All items are listed in the Appendix.

2.2.2. Students' lesson-specific assessments

Students' lesson-specific assessments were measured with one item each adapted from the pre-test measures (for an overview on all lesson-specific measures see Supplementary Material). Most of the items were assessed with the preliminary question "How did you find the lesson?". To assess reliability, we conducted stability analyses (following procedures by Liborius, Bellhäuser, & Schmitz, 2019), and computed means for the first (German: lessons 1 to 4; Math: lessons 1 to 5) and second half (German: lessons 5 to 9; Math: lessons 6 to 12) of the lesson-specific measurements. Subsequently, we calculated the correlations of these means across students; these split-half coefficients are reported in parentheses in Table 1.

2.2.2.1. Aspects of motivation. Intrinsic motivation was measured with the question "Why did you participate in this lesson? Because the lesson was fun". Introjected motivation was measured with the item "Why did you participate in this lesson? Because I wanted to show my best for the teacher". Utility value was measured with the item "How did you find the lesson? I found it useful".

2.2.2.2. Aspects of effort. Effort was assessed with the item "I did my best". Minimalistic effort was assessed with the item "I invested as little effort as possible in the tasks". Pretending effort was assessed with the item "I pretended to work hard".

2.2.2.3. Autonomy support. Providing choices was assessed with "The teacher gave us choices and options". Providing meaningful rationales was assessed with the item "The teacher explained the relevance of the subject matter". Accepting frustration was assessed with "The teacher tried to understand how I see things when I had a question or complaint". Stimulating interest was assessed with "The teacher tried to make the lesson interesting today".

2.2.3. Teachers' lesson-specific assessments

Teachers completed several lesson-specific measures, e.g., on lesson characteristics (activities and topics discussed), and the autonomy support they provided.

Table 1
Descriptive statistics (Means, standard deviations, ICCs and reliabilities) on lesson-specific measures.

	German					Math				
	N	*M*	*SD*	*ICC*		*N*	*M*	*SD*	*ICC*	
Student self-report										
Intrinsic motivation	884	2.83	0.87	.60	(.80)	822	2.61	0.91	.56	(.80)
Introjected motivation	884	2.41	0.95	.63	(.82)	822	2.34	0.98	.64	(.82)
Utility value	877	2.68	0.89	.36	(.66)	813	2.68	0.92	.46	(.66)
Effort	878	3.12	0.72	.47	(.73)	813	3.15	0.77	.55	(.73)
Minimalistic effort	878	1.73	0.81	.54	(.72)	812	1.66	0.79	.45	(.72)
Pretending effort	878	1.51	0.71	.64	(.74)	813	1.48	0.70	.53	(.74)
Teacher report: Whole class assessment										
Intrinsic motivation	658	2.72	0.69			561	3.12	0.64		
Effort	658	2.88	0.80			561	3.42	0.75		
Student report: autonomy support										
Offering choices	882	2.73	0.96	.50	(.78)	827	2.55	0.92	.44	(.88)
Providing rationales	882	2.47	0.93	.45	(.78)	827	2.35	1.02	.59	(.78)
Accepting frustration	882	2.82	0.86	.53	(.77)	827	2.73	0.94	.54	(.77)
Stimulating interest	882	2.94	0.83	.50	(.73)	827	2.57	0.91	.51	(.74)
Teacher report: autonomy support										
Offering choices	658	1.87	1.08			561	2.88	0.91		
Providing rationales	658	2.07	0.91			561	3.38	0.79		
Accepting frustration	658	2.87	0.95			561	3.79	0.41		
Stimulating interest	658	2.55	0.69			561	3.04	0.70		
Teacher report: lesson characteristics	N_l					N_l				
Classroom instruction	48	7.48	6.50			44	12.84	8.79		
Questions/homework	46	11.80	9.77			44	9.66	7.50		
Individual work	43	11.16	10.34			44	16.59	13.37		
Collaboration	42	15.02	12.23			40	7.88	9.73		

Note. The standard deviations were generated across all data points. N_l = Number of lessons. Teacher reported on the lesson characteristics in minutes.

Table 2
Descriptive statistics (Means and standard deviations) on students' pre-test measures and internal consistencies (Cronbach alpha reliabilities).

	German				Math			
Variables	*N*	*M*	*SD*	α	*N*	*M*	*SD*	α
Pre-test (motivation/engagement)								
Intrinsic motivation	196	2.21	0.62	0.84	193	2.38	0.85	0.94
Introjected motivation (teacher-related)	194	2.54	0.92	-	192	2.35	0.96	-
Utility value	196	2.16	0.60	0.75	196	2.77	0.71	0.83
Effort	195	3.00	0.59	0.81	195	3.02	0.66	0.85
Minimalistic effort	193	2.30	0.64	0.82	195	2.20	0.68	0.85
Pretending effort	193	1.67	0.61	0.80	195	1.62	0.62	0.84
Pre-test (autonomy support)								
Offering choices	196	2.51	0.73	0.61	196	2.34	0.73	0.76
Providing rationales	196	1.78	0.65	0.80	196	2.14	0.82	0.85
Accepting frustration	196	2.44	0.75	0.51	196	2.02	0.75	0.67
Stimulating interest	196	2.61	0.80	0.86	196	2.31	0.87	0.90

Table 3
Students' perception of teachers' autonomy support and lesson-specific outcomes: Results from random intercept-random slope models.

	Intrinsic motivation				Introjected motivation				Utility value			
	German		Math		German		Math		German		Math	
	Est.	*SE*	*Est.*	*SE*	*Est.*	*SE*	*Est.*	*SE*	*Est.*	*SE*	*Est.*	*SE*
Within-student level												
Offering choices	0.17 ***	0.04	0.11 **	0.04	0.02	0.03	0.07	0.04	-0.04	0.05	-0.01	0.04
Providing rationales	0.07 *	0.04	0.05	0.05	0.06 ^{t}	0.03	0.04	0.05	0.16 **	0.05	0.15 **	0.05
Accepting frustration	0.05	0.03	0.08 *	0.03	0.08 *	0.04	0.10 **	0.04	0.13 **	0.05	0.06	0.05
Stimulating interest	0.28 ***	0.04	0.25 ***	0.04	0.08 ^{t}	0.04	0.07 ^{t}	0.04	0.16 ***	0.05	0.19 ***	0.05
Between-student level												
Pre-test	0.48 ***	0.05	0.36 ***	0.05	0.25 ***	0.06	0.41 ***	0.06	0.15 **	0.05	0.23 ***	0.06
Random effects												
Offering choices	0.04 ^{t}	0.02	0.02	0.02			0.07 **	0.03	0.03	0.03		
Providing rationales	0.04 ^{t}	0.02	0.09 **	0.03			0.05 ^{t}	0.03	0.04	0.03	0.03	0.04
Accepting frustration	0.05 *	0.02										
Stimulating interest			0.05 ^{t}	0.03	0.03	0.02						
Cross-level interactions												
Pre-test X Providing choices	-0.04	0.04	0.01	0.04			0.07	0.04	-0.03	0.05		
Pre-test X Providing rationales	0.16 ***	0.04	0.02	0.05			-0.01	0.05	0.02	0.04	0.00	0.05
Pre-test X Accepting frustration	0.01	0.04										
Pre-test X Stimulating interest			-0.02	0.04	0.11 **	0.04						
Variance decomposition												
Marginal *R2* (fixed effects)	0.30		0.19		0.05		0.14		0.06		0.08	
Conditional *R2* (fixed & random effects)	0.74		0.70		0.66		0.71		0.44		0.50	
	Effort				Minimalistic effort				Pretending effort			
	German		Math		German		Math		German		Math	
	Est.	*SE*	*Est.*	*SE*	*Est.*	*SE*	*Est.*	*SE*	*Est.*	*SE*	*Est.*	*SE*
Within-student level												
Offering choices	-0.00	0.05	0.05	0.05	0.05	0.05	0.01	0.04	0.01	0.04	-0.03	0.04
Providing rationales	0.17**	0.05	0.05	0.04	0.01	0.04	0.00	0.05	-0.02	0.03	0.03	0.05
Accepting frustration	0.11 **	0.04	0.06	0.04	-0.04	0.05	-0.03	0.05	0.02	0.04	-0.03	0.05
Stimulating interest	0.10 *	0.05	0.13 **	0.04	0.03	0.04	**-0.13** *	0.05	0.01	0.04	**-0.11** *	0.05
Between-student level												
Pre-test	0.49 ***	0.05	0.47 ***	0.06	0.52 ***	0.05	0.34 ***	0.06	0.49 ***	0.06	0.37 ***	0.06
Random effects												
Offering choices	0.05 ^{t}	0.03	0.07 *	0.03	0.07 *	0.03			0.06 *	0.02		
Providing rationales	0.09 *	0.04										
Accepting frustration							0.04	0.04				
Stimulating interest	0.06 *	0.03					0.07	0.05			0.07 *	0.04
Cross-level interactions												
Pre-test X Providing choices	0.06	0.04	-0.02	0.05	0.09 ^{t}	0.05			0.05	0.05		
Pre-test X Providing rationales	0.00	0.05										
Pre-test X Accepting frustration							-0.11 ^{t}	0.06				
Pre-test X Stimulating interest	0.04	0.05					-0.08	0.06			-0.02	0.05
Variance decomposition												
Marginal *R2* (fixed effects)	0.23		0.19		0.24		0.10		0.18		0.12	
Conditional *R2* (fixed & random effects)	0.61		0.62		0.58		0.50		0.66		0.57	

Note. $^{t}p < .10$, $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$. (Marginally) significant between-domain-differences are highlighted in bold.

2.2.3.1. Lesson characteristics. Teachers reported the content of the lesson they were teaching. They also rated the time spent on different lesson activities in minutes with the question "How many minutes were spent on the following activities?": Classroom instruction, discussing questions/homework, individual work, student collaboration.

2.2.3.2. Lesson-specific perception of their classes. Teachers rated the overall intrinsic motivation ("To what extent were the students

intrinsically motivated?") and effort ("To what extent did this class do its best in this lesson?") of their classes.

2.2.3.3. Autonomy support. Teachers rated their provision of choices with the item "I gave choices and options". Providing meaningful rationales was assessed with the item "I explained the relevance of the subject matter". Accepting frustration was assessed with "I tried to understand how students see things when they had a question or complaint". Stimulating interest was assessed with "I tried to make the lesson interesting".

2.3. Procedure

All participating teachers provided active informed consent. The recruitment of participants and the data collection strictly adhered to the ethical and data-management protocol of the university; at the moment of the data collection no formal approval was required. Approximately one week before data collection began, information letters for parents and passive informed consent forms were distributed to the students. If parents did not want their child to participate, they could indicate so on the form and their child did not take part in the study. The parents of two students refused participation.

Students and teachers were informed that their participation in all assessments was entirely voluntary. To motivate the students to fill in all measurements across the three weeks, all participants were entered into a raffle in which 10 students received cinema tickets. Students who were absent at pre-test completed the questionnaire later (e.g., at home) and returned it in a closed envelope. One week after the pre-test, data collection for the lesson-specific measures started. Over the course of three weeks, the students and teachers filled out lesson-specific questionnaires via LimeSurvey at the end of every German or mathematics lesson. Limesurvey is an open source survey application for online assessments, which was linked to a secure university server (Limesurvey, 2020).

Students had to attend Math 3–4 h per week, and German 2–4 h per week (see Table S1). The teacher had been asked to remind the students to fill in the online questionnaire at the end of each lesson.

2.4. Data-analysis

For assessing the lesson-specific associations, we specified two-level models with lesson-specific responses (Level 1) nested within students (Level 2) in SPSS Statistics 23.0. Data with a nested structure violate the assumption of independent data (Hox, 2013).

Multilevel analyses without predictors (unconditional models) were modelled for both domains to obtain the within-student and between-student variance concerning the outcome measures. To examine research questions 1 and 3, we estimated random intercept-random slope models.

At the within-student level, students' lesson-specific outcomes were predicted by their perception of the four autonomy-supportive strategies used by teachers in the same lesson. Students' respective pre-test was included as a Level 2 predictor to examine the between-student effects. All continuous variables were z-standardized across individuals, considering the total variance of the variables. This transforms the variance of the predictors to become equal as a means to avoid non-convergence, which is more likely if variances are unequal and differ between variables. Given that we standardized all continuous variables prior to the analyses, the coefficients reported can be interpreted as effect sizes (Ferron et al., 2008). Yet, these coefficients are dependent on the standard deviation of each variable in our sample (e.g., Lorah, 2018). To facilitate the interpretation of the results, we also report the mean raw scores and variances for the variables (Table 1). Raw scores can inform about students' perceptions on the extent of autonomy support they received, relative to the response scale and particular to the sample (e.g., Moeller, 2015). Although a student might report much higher or lower values than her classmates, the level of the construct might be objectively moderate. On the other hand, the students might endorse some of the indicators used to measure autonomy support in a more extreme or parsimonious way than others, which could e.g., be due to the wording of the item.

The within-level predictors were then group-mean centered (i.e., person-mean centered), to analyze the unconfounded within-person effects (Wang & Maxwell, 2015), in order to preserve the estimates from bias due to systematic variation in mean across time (Hamaker & Muthén, 2020; Raudenbush and Bryk, 2002).

With random intercept models, the average effect of autonomy support on students' lesson-specific outcomes is estimated, e.g., implying that students on average show higher intrinsic motivation and effort in lessons in which teachers implemented autonomy support. However, autonomy support might have a stronger or weaker impact on the motivation and engagement of some students. In order to estimate this type of variability (Research Question 3), our models treated the intercept and the Level 1 slopes as random effects, which yields the slope variances $\tau 2$. The random slopes for the four lesson-specific predictors represent between-student differences from the average effect of each autonomy-supportive strategy. It has been advised to estimate the maximal random effects structure when supported by the design and the data (Barr, Levy, Scheepers, & Tily, 2013). Yet, the maximal random effects structure might be too complex and fail to converge (Bates, Kliegl, Vasishth, & Baayen, 2015). If there were warning messages indicating non-convergence due to small, non-significant random slope variances, we reduced the complexity of our models through selectively removing the redundant parameters (Matuschek, Kliegl, Vasishth, Baayen, & Bates, 2017). Consequently, we report different random effects for each outcome.

The moderating effects of students' pre-test values on the associations between teachers' autonomy support and the lesson-specific outcomes were investigated with cross-level interactions. We evaluated the statistically significant cross-level interactions with simple-slope plots (Preacher et al., 2019) for values of the moderator at the mean and 1 and 2 standard deviations below and above the mean.

To estimate the explained variance, we calculated the marginal (fixed-effects only) R2 and conditional R2 (for fixed and random effects; following Nakagawa and Schielzeth, 2013).

To explore whether the associations between the four autonomy-supportive strategies and students' lesson-specific outcomes differed between German and Math (Research Question 2), z-scores for the difference between the regression coefficients of predictor pairs were calculated via the following equation (e.g., Paternoster, Brame, Mazerolle, & Piquero, 1998):

$$Z = \frac{b_{predictor\ German} - b_{predictor\ Math}}{\sqrt{\left(SE_{predictor\ German}\right)^2 + \left(SE_{predictor\ Math}\right)^2}} \quad (1)$$

2.4.5. Missing data

Students who had missing data on the Level 2 predictors (i.e., pre-tests) were excluded (listwise deletion in SPSS). Four students completed the pre-test but did not complete any of the lesson-specific assessments. A total of six students had missed the pre-test measurement but had participated in the lesson-specific assessments. All students were surveyed in both Math and German lessons. On average, the students participated in 4.57 measurements in both German (with a range of 1–9) and in Math lessons (with a range of 1–12, see Table S1 in the Supplementary Material).

The considerable number of missing values was due to time management problems or students' absence during some of the lesson-specific assessments. This high level of missingness is common in lesson-specific assessments and not necessarily problematic, given that multilevel analyses account for missingness and do not require an equal

number of measurements per individual (Hox, 2013). Given the large sample size at Level 2, our sample has sufficient power to derive even small effects at Level 1, because samples of ≥30 at Level 2 and ≥3 at Level 1 yield sufficient power according to a sensitivity analysis of sample size combinations by Arend and Schäfer (2019).

3. Results

Descriptive statistics for the pre-test and lesson-specific measures are reported in Tables 1 and 2. The variance on both the between-student level and the within-student level differed for each variable (see the ICCs reported in Table 1), indicating that a substantial proportion of the total variability in the outcomes are attributable to the between-student level.

3.1. Lesson-specific autonomy support and students' motivation and engagement

To answer the first research question, we tested the unique associations between students' perceptions of the four lesson-specific autonomy-supportive strategies and their lesson-specific outcomes, controlling for the respective pre-test(s) (see Tables 3 and S4).

Teachers' lesson-specific autonomy support was associated with all aspects of student motivation and engagement. In German, students reported more intrinsic motivation in lessons in which they perceived that their teachers provided choices ($b = 0.17$, $p < .001$), rationales ($b = 0.07$, $p = .038$), or stimulated their interests ($b = 0.28$, $p < .001$). In Math, students reported more intrinsic motivation in lessons in which they perceived that their teachers provided choices ($b = 0.11$, $p = .007$), accepted their frustration ($b = 0.08$, $p = .033$) or stimulated their interests ($b = 0.25$, $p < .001$). Variation in introjected motivation from lesson to lesson was associated with teachers' acceptance of frustration in German ($b = 0.08$, $p = .025$) and Math ($b = 0.10$, $p = .009$). Moreover, in German, students reported higher utility value in lessons in which they perceived their teachers to provide rationales ($b = 0.16$, $p = .001$), accept their frustration ($b = 0.13$, $p = .005$) or stimulate their interests ($b = 0.16$, $p < .001$). In Math, meanwhile, lesson-specific fluctuations in utility value were associated with rationale provision ($b = 0.15$, $p = .006$) and the stimulation of interests ($b = 0.19$, $p < .001$).

In line with our assumptions, students reported greater investment of effort in German lessons in which they perceived that their teachers provided rationales ($b = 0.17$, $p = .001$), and accepted their frustration ($b = 0.11$, $p = .008$), and in which their interests were stimulated ($b = 0.10$, $p = .035$). In Math, variations in effort from lesson to lesson were positively associated with teachers' stimulation of interests ($b = 0.13$, $p = .002$); and variations in minimalistic ($b = -0.13$, $p = .021$) and pretending effort ($b = -0.11$, $p = .039$), were negatively associated with teachers' stimulation of interests.

3.2. Between-domain differences in the predictions by teachers' autonomy support

We conducted post-hoc coefficient comparison tests (Paternoster et al., 1998) to investigate between-domain differences in the effects of teachers' autonomy support on students' lesson-specific outcomes (Research Question 2). The predictive effect of teachers' lesson-specific stimulation of students' interest on their minimalistic effort ($b = -0.13$, $p = .021$) was statistically significantly different from the non-significant effect in German on minimalistic effort ($b = 0.03$, $p = .451$; $Z = 2.35$, $p = .019$). Moreover, there was a marginally significant difference between the effect of lesson-specific stimulation of interest on pretended effort in Math ($b = -0.11$, $p = .039$) and in German ($b = 0.01$, $p = .701$; $Z = 1.92$, $p = .055$). Overall, we only found two (marginally) significant between-domain differences, which do not seem to indicate systematically different patterns in the effectiveness of different autonomy-supportive strategies in the two domains.

3.3. Student heterogeneity and teachers' autonomy support

We found several statistically significant random slope variances and cross-level interactions (Table 3).

3.3.1. Random slope variances

We identified statistically significant between-student differences in the effects of choice provision on students' introjected motivation in Math ($\tau^2 = 0.07$, $p = .005$; Table 3), implying that different students reacted with relatively higher or lower introjected motivation to teachers' use of this strategy in a lesson. Moreover, there were between-student differences in the effects of choice provision on effort in Math ($\tau^2 = 0.07$, $p = .046$), and minimalistic effort ($\tau^2 = 0.07$, $p = .025$) and pretending effort ($\tau^2 = 0.06$, $p = .016$) in German.

In addition, we found statistically significant between-student differences in the predictions of provision of rationales on intrinsic motivation ($\tau^2 = 0.09$, $p = .008$) in Math. Teachers' lesson-specific acknowledgement of student frustration differentially predicted intrinsic motivation in German ($\tau^2 = 0.05$; $p = .023$).

3.3.2. Cross-level interactions

We found statistically significant cross-level interactions for intrinsic and introjected motivation in German (Table 3). The effect of teachers' provision of rationales was moderated by students' baseline intrinsic motivation in German ($b = 0.16$, $p < .001$). The simple-slope plots (Fig. 1) revealed that teachers' provision of rationales positively predicted lesson-specific intrinsic motivation in German for students with relatively high or medium baseline intrinsic motivation, but not for students with relatively low intrinsic motivation. Concerning the cross-level interaction of stimulating interests and baseline introjected motivation on lesson-specific introjected motivation ($b = 0.11$, $p = .004$), students with relatively high baseline introjected motivation profited from stimulating interests, but not students with relatively medium and low introjected motivation (Fig. 1).

4. Discussion

The present study examined how offering choices, providing meaningful rationales, accepting frustration, and stimulating interest by teachers predicted variations in a variety of aspects of students' motivation and engagement from lesson to lesson. In order to explore between-domain differences in the effects of the four autonomy-supportive strategies, the study was conducted in two domains: German (a second language) and Math.

Students' perceptions of their teachers' autonomy support as well as their own motivation and engagement varied considerably across different lessons within the same domain. Our study provides further evidence that the different autonomy-supportive strategies are associated with distinct aspect of students' motivation and engagement. Moreover, even though the descriptive statistics showed mean-level differences in autonomy support, motivation, and engagement across the two domains, we did not identify substantial domain-dependency in the effects of autonomy support in the two domains. However, we found some between-student differences in the associations between autonomy support and students' motivation and engagement, which were partially explained by students' baseline motivation.

4.1. Autonomy-supportive strategies and multiple dimensions of motivation and effort

In this study, we provide new evidence on previously unrecognized associations between autonomy support and different aspects of students' lesson-specific motivation (introjected motivation with respect to the teacher's approval, utility value) and disengagement (minimalistic and pretending effort). We found that all autonomy-supportive strategies exhibited meaningful associations with different aspects of student

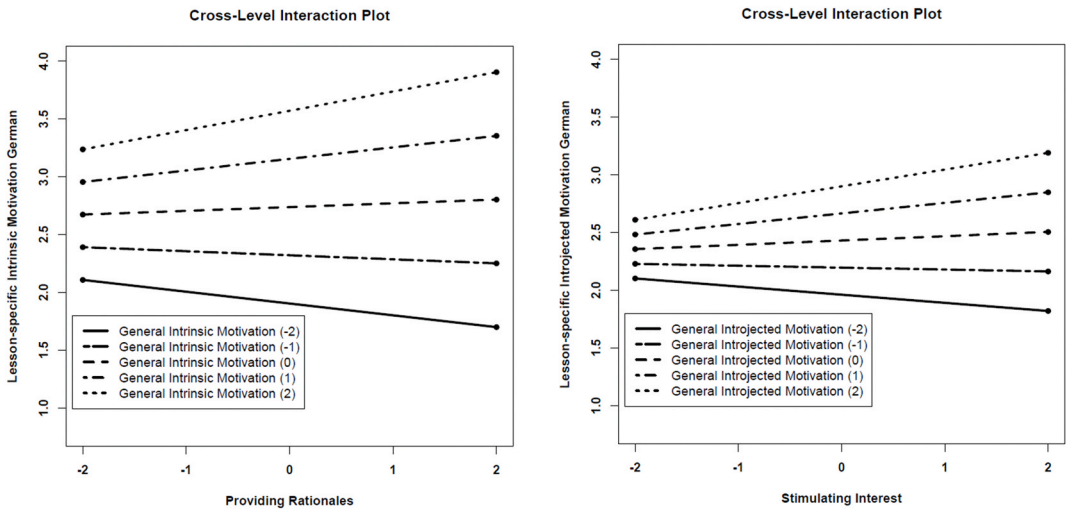

Fig. 1. Simple-slope plots for the cross-level interactions concerning students' intrinsic and introjected motivation in German.

motivation and engagement (see Table 3). Following Ferguson (2009), the effect sizes can be interpreted as small (≥0.20), conform with earlier research (e.g., Tsai et al., 2008). Given that we standardized all continuous measures across individuals (Ferron et al., 2008; Lorah, 2018), the coefficients cannot be directly interpreted as measures of the effect sizes at the within-person or between-person level (Schuurman, Ferrer, de Boer-Sonnenschein, & Hamaker, 2016).

First, providing rationales was effective in promoting utility value beliefs in Math and German but affected further outcomes in German only. Previous research has shown that teachers use different types of rationales (e.g., autonomous and prosocial rationales), and that prosocial rationales might be more effective (Yeager et al., 2014). Autonomous rationales are self-focused ("It will be beneficial for you to master this knowledge or skill"), whereas prosocial rationales are other-focused or self-transcendent ("It will be beneficial for others if you master this knowledge or skill"). It is reasonable to think that social rationales are easier to convey for learning a second language ("You can help your friends find their way when traveling"). Yeager et al. (2014) note that it can be difficult to explain how learning concepts like algebra can help students benefit others. This finding suggests that Math teachers might use student-focused rationales more often than social rationales.

Second, this study also produced initial findings that teachers can counteract students' withdrawal from a lesson by stimulating their interest. We found that stimulating interest in a lesson reduced variations in minimalistic and pretending effort in Math. Thus, teachers might be able to reduce students' inclinations towards minimalistic effort, and their investment of effort in pretending to work hard by stimulating their interest, leading them to start working seriously.

Overall, it should be kept in mind that not every aspect of student motivation and engagement could be promoted to the same degree with each of the strategy considered, which implies that teachers should draw on a wide set of strategies to yield optimal outcomes for their students.

4.2. Differences between domains and students

With respect to between-domain differences, our findings do not seem to indicate substantial domain-dependency of the benefits of an autonomy-supportive strategy, given that there were only two cases in which a strategy had a positive effect in one domain but not in the other, and there were no effects in opposite directions (positive versus negative).

Concerning differences between students, we found some differential associations between teachers' lesson-specific use of autonomy-supportive strategies and students' motivation and engagement in terms of statistically significant random slopes. Moreover, the cross-level interactions showed differential patterns for students' intrinsic and introjected motivation (see Fig. 1). Students with relatively high baseline intrinsic motivation (in comparison to other students) profited more from German lessons in which rationales were given than students with relatively low intrinsic motivation, and students with relatively high baseline introjected motivation profited more from lessons in which their interest was stimulated than students with low introjected motivation, confirming "Matthew effects" (i.e., already motivated students benefited more, Walberg & Tsai, 1983). Thus, the overall pattern of cross-level interactions revealed that relatively high initial motivation can function as a motivational resource, so that students with relatively high baseline motivation experience higher gains from lessons that provide autonomy support than their peers with low motivation (see also Flunger et al., 2019).

4.3. Limitations

The current study's strengths include its intensive repeated measurement design with a pre-test in two domains, which allowed us to simultaneously examine the within-student level and between-student level. However, there are some limitations that must also be considered.

First, our sample was limited to eight and ninth-grade students in a small sample of classes in the academic track in the Netherlands, and our study observed three weeks of lessons out of a whole school year in two domains. Second, the sampling relied on the network of the researchers and it is possible that the teachers participating in the study were generally more motivated and provided greater motivational support than the average teacher. Our results might also be biased through attrition rates and the resulting pattern of missing data, because not all teachers and students completed the lesson-specific surveys consistently. The responses could be affected by social desirability response bias, e.g., because teacher confirming motivational support in their instructional styles might aim to conform to socially acceptable standards (e.g., Krumpal, 2013). In order to assess whether our findings replicate across contexts, teachers and domains, future research needs to study the associations between teachers' autonomy support and students' motivation and engagement in further domains and populations, using larger sample sizes of teachers.

Third, although we considered a wide range of outcomes, future research on lesson-specific motivation and engagement could still add several further dimensions. Specifically, previous research has shown that students develop subjective values concerning life domains, such as school-related utility or job-related utility, or, concerning attainment

value, the importance of achievement (e.g., Gaspard et al., 2015). According to SDT (e.g., Deci & Ryan, 1985), the partial or full endorsement of subjective values is important for understanding the quality of students' motivation. Therefore, future research should aim for a more fine-grained assessment of partially endorsed utility for extrinsic or autonomous reasons, and full endorsement of personal utility or prosocial utility (see Yeager et al., 2014) with respect to different life domains, such as school, job, and one's future in general. These measures could also be used in intervention studies to study how autonomy support affects the endorsement of values, and whether specific autonomy-supportive strategies improve the endorsement of subjective values partially (e.g., provision of autonomous rationales) or fully (e.g., provision of prosocial rationales).

Fourth, we relied on teachers "whole-class assessment" rather than creating aggregates of teachers' perceptions of individual students. Future research should study whether teachers' whole-class perception of their overall class' motivation corresponds with their perception of individual students (Friedrich, Flunger, Nagengast, Jonkmann, & Trautwein, 2015), for example in order to investigate to which degree teachers' observations rely on the motivation of a few students.

4.4. Implications for future research

The within-person design of the present study focused on the ongoing dynamics in the classroom, through simultaneously considering teachers' autonomy supportive styles in a lesson and students' concurrent motivation and engagement. Within-person studies focus on (highly) variable processes and constructs. On the one hand, intra-individual research can be better suited to study causal inference than between-subject research, because it can eliminate time-invariant confounders (Usami, Murayama, & Hamaker, 2019). On the other hand, our study on associations between autonomy support and students' motivation and engagement is correlational, and does not enable to assess the causal direction of the predictive effects. Yet, our study can help to draw several implications for the design of (intraindividual) research on the impact of teachers' lesson-specific autonomy support on students' concurrent motivation and engagement.

First, experimental studies have shown that manipulating teachers' autonomy support can positively affect students' motivation and engagement (for a review, see Su & Reeve, 2011; Stroet et al., 2013). However, there is growing evidence that students who ask for greater autonomy support also receive it (Matos et al., 2018; Patall et al., 2019). To investigate how heterogeneous students can benefit from autonomy support, future studies could design experimental studies with conditions in which teachers are trained to deliver autonomy support and students' possibilities for seeking autonomy support are manipulated.

Second, recent research raised the importance of replication in studies focusing on intra-individual differences and adopting means to enable this, such as pre-registration (e.g., see Kirtley, Lafit, Achterhof, Hiekkaranta, & Myin-Germeys, 2021; Lafit et al., 2021). Therefore, it is important to ensure the replicability of the current findings and future research should test it using a similar design (and ideally pre-registration). Concerning the pre-registration of intraindividual designs, researchers need to consider (e.g.) the degree of the fluctuations of the target construct over time (e.g., within a week), the necessary sampling rate, and the total number of measurements (e.g., Timmons & Preacher, 2015). To this end, future research could study how many measurements are necessary by how many students and teachers to yield a reliable picture of the autonomy support in a lesson (e.g., using new shiny apps, Lafit et al., 2021). It could also be interesting to focus on within-lesson variation (e.g., Boiché, Escalera, & Chanal, 2020), which has implications for the timing of the measurement prompts (interval-contingent, event-contingent, or signal-contingent; Kirtley et al., 2021). Research on students' motivation and respective support in specific situations and tasks within a lesson (see e.g., Dietrich, Viljaranta, Moeller, & Kracke, 2017) could inform on what students need to become motivated.

Third, we used student and teacher measures of teachers' autonomy support and found substantial variability concerning the autonomy support observed by students and teachers, in line with earlier research (e.g., Skinner & Belmont, 1993). It might be worthwhile to implement objective measures of teachers' autonomy support, such as observer ratings, e.g., via video observations (Ruzek & Pianta, 2015). Yet, in a recent study, observer ratings of teacher behaviors did not explain meaningful additional variance in student outcomes over and above students' own perceptions (Donker et al., 2021). It is possible that students primarily report on the individual support they experience, and put less weight on their teachers' autonomy support directed towards the whole class or their classmates (Chatzisarantis et al., 2019). In the multilevel classroom context, the effects of teachers' lesson-specific autonomy support should be examined at all potential levels (see e.g., Stapleton, Yang, & Hancock, 2016), to understand between-classroom and between-student differences regarding students' individual and shared perceptions of their teachers' individual and class-directed autonomy support. Future research could assess the individual autonomy support students receive, and the autonomy support that is directed towards the whole class or students' classmates, using observers', teachers', and students' perspective. This could improve our understanding on the impact of teachers' autonomy support in the multilevel classroom context and yield new information on why students and teachers perceptions on autonomy support differ.

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CRediT authorship contribution statement

Barbara Flunger: Conceptualization, Methodology, Supervision, Formal analysis, Writing – original draft, Writing – review & editing. **Lissa Hollmann:** Project administration, and, Data collection, Formal analysis, Writing – original draft, Writing – review & editing. **Lisette Hornstra:** Conceptualization, Methodology. **Kou Murayama:** Methodology, Writing – review & editing.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.learninstruc.2021.101500.

Appendix

Items of the Autonomy-supportive Measures at Pre-test

Providing Choices
In German/math, I get a lot of choices.
I have little to say about the things we do in class.
During German/math, I can often make my own decisions about the tasks.

Providing Meaningful Rationales
During German/math, the teacher often explains to me how important German/math is in my daily life.
During German/math, the teacher often explains to me that I will need German/math in my future life.

During German/math, the teacher encourages me to think about how German/math can be used in real life.

Accepting Frustration

During German/math, my teacher understands and relates to when I am sad, nervous or angry.
During German/math, my teacher asks if I want to talk about it, if I am nervous, stressed or bored.
During math/German, I try not to show it to my teacher if I am worried or bored.

Stimulating Interest

During German/math, the teacher shows me that German/math is interesting.
During German/math, the teacher is constantly looking for new ways to make German/math lessons more interesting for me.
During German/math, my teacher makes sure that I find German/math fascinating.

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