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Getting along and feeling good: Reciprocal associations between student-teacher relationship quality and students' emotions

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ABSTRACT

Relationship quality and emotional experience are both important constructs in learning environments but the question of how they are linked requires more attention in empirical research. We hypothesized reciprocal associations between student-teacher relationship quality (i.e., interpersonal closeness) and students' emotions in the classroom (i.e., enjoyment, pride, anxiety, anger, boredom, and shame). Data from a two-wave longitudinal study with annual assessments in grade 10 (Time 1) and 11 (Time 2) were used to test this hypothesis (N = 535; mean age at Time 1: 16.7 years, SD = 0.6). Student-perceived relationship quality and students' emotions were assessed in the academic domains of mathematics, German, English, and French. In line with our hypothesis, cross-lagged panel models showed reciprocal associations: Higher relationship quality was associated with stronger positive emotions and weaker negative emotions over time. In turn, lower negative emotions and higher positive emotions were associated with higher relationship quality. The association between initial emotions and student-teacher relationship quality one year later was stronger than the reverse association. Further, the links between relationship quality and emotions were largely equivalent across school domains but differed in strength across emotions. Implications for future research and educational practice are discussed.

The quality of our relationships with other people, such as feeling interpersonally close, can shape our emotional experiences. Vice versa, our emotions may play a crucial role in shaping our relationships. Such a direct and strong connection between relationship quality and emotional experiences is well-established in social-functional theories of emotions (Frijda, 1986; Keltner & Haidt, 1999; Parkinson, 1996). The educational context is not an exception and similar mechanisms can be expected to be at work with respect to student-teacher relationships. For example, not feeling connected to the teacher may contribute to students' boredom in classes, and being bored, in turn, may lead to not feeling connected to the teacher. In line with this reasoning, reciprocal associations between the learning environment – with student-teacher relationships being a crucial aspect of this environment (Wubbels et al., 2015) – and emotions are proposed in Pekrun's (2006) control-value theory (CVT), with the possibility of detrimental downward spirals (e.g., poor relationship quality and boredom) but also beneficial upward spirals (e.g., positive relationship quality and enjoyment) developing over time. Formal schooling unfolds over a long period of our lives, so these cumulative effects across our school career can have strong effects on relationships and emotions. It is therefore paramount from both a theoretical and a practical point of view to understand the association between relationship quality and emotions in educational settings. This becomes especially evident when considering that both constructs are known to contribute to a range of important achievement outcomes (e.g., well-being, interest, dropout, and academic achievement; Goetz & Hall, 2013; Wubbels et al., 2015) and can thus be of crucial relevance to individuals' academic and life success.

It is therefore unfortunate that the substantial research into both student-teacher relationships and students' emotions has mostly been conducted with a focus on either one or the other construct, leaving

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their association understudied (Mainhard, Oudman, Hornstra, Bosker, & Goetz, 2018). This is not to say, however, that no studies on the association between aspects of student-teacher relationship and emotional experience exist. For instance, research has focused on student-teacher relationships to understand students' emotional engagement (Christenson, Reschly, & Wylie, 2012; Fredricks, Reschly, & Christenson, 2019), which revolves around feelings of enjoyment and excitement. Moreover, a recent meta-analysis of 65 studies on teacher support and emotions (Lei, Cui, & Chiu, 2017) reported a positive correlation of support with positive emotions ($r = .34$) and a negative correlation with negative emotions ($r = -.22$). This supports our assumption of associations between student-teacher relationship and emotional experience. However, several issues remain unaddressed in the meta-analyzed studies. (1) Only few studies (i.e., 15 out of 65): presented longitudinal data and even those studies did not necessarily measure the relevant constructs of relationship quality and emotional experience over time (e.g., Lazarides & Ittel, 2013). (2) The focus in many studies was on unidirectional rather than on reciprocal associations between relationship quality and emotional experience (Liu, Mei, Tian, & Huebner, 2016), and (3) often on the teachers' perspective on their relationships with students rather than on the students' perceptions (e.g., Diaz et al., 2017). (4) All but two of the longitudinal studies investigated the quality of students' relationships with all of their teachers rather than the quality of dyadic relationships with a specific teacher (e.g., Van Ryzin, Gravely, & Roseth, 2009). (5) None of the longitudinal studies and only two cross-sectional studies (Burić, 2015; King, McInerney, & Watkins, 2012) covered a broad range of discrete academic emotions rather than focusing on single emotions like enjoyment and anxiety or emotional disorders like depression. (6) Finally, systematic domain-specific investigations of relationship-quality and emotions seem to be missing completely in the literature. The goal of the present study, therefore, was to advance previous research by examining reciprocal links between student-teacher relationship quality and a range of students' discrete academic emotions over time and across different academic domains.

The importance of interpersonal closeness is rather unambiguous for both student and teacher outcomes (Wenzel & Ramani, 2016), hence, the current study conceptualized student-teacher relationship quality in terms of closeness. In regard to emotions, we focused on six core positive and negative emotions (i.e., enjoyment, pride, anxiety, anger, boredom, and shame; see Pekrun, 2006). We investigated whether relationship quality and emotions were linked by reciprocal associations, and, if so, whether these links were similar in strength in both directions. In doing so, we also examined whether associations were equivalent for the different achievement emotions and across school domains (mathematics, German, English, and French; c.f., Goetz, Sticca, Pekrun, Murayama, & Elliot, 2016). Drawing upon previous studies (reviewed below), we assumed differences with respect to emotions but equivalence across academic domains.

1. Student-teacher relationships and students' emotions in the classroom

Interpersonal closeness and achievement emotions: Conceptual definitions. Interpersonal closeness is one of the fundamental aspects of the quality of human relationships (Baumeister & Leary, 1995). Closeness is centrally featured in core theories on human relations, including attachment theory (Bowlby, 1982; see Davis, 2003), interpersonal theory (e.g., friendliness or communion; Horowitz & Strack, 2010; Wubbels, Brekelmans, Mainhard, den Brok, & van Tartwijk, 2016), self-determination theory (e.g., relatedness; Deci & Ryan, 1985), and ecological systems theory (Bronfenbrenner, 1979). In research on teacher-student relationships in educational settings, different labels have been used to denote this aspect, such as relatedness, belongingness, interpersonal support, and warmth (Furrer & Skinner, 2003). In line with interpersonal theory, Mainhard et al. (2018) argue that a certain level of closeness is conveyed in essentially all behavior a teacher shows in class, even if this is not explicitly intended or labeled as such (c.f., Watzlawick, Bavelas, & Jackson, 1967).

With respect to emotions, numerous definitions have been proposed over the years (see Kleinginna & Kleinginna, 1981; Lewis & Haviland-Jones, 2000). Prominent definitions entail a componential perspective (Damasio, 2004; Scherer, 1984), in which emotions are viewed as multi-component, coordinated processes of psychological subsystems including affective, cognitive, motivational, expressive, and peripheral physiological processes. A subset of emotions, called achievement emotions, can be defined as emotions related to achievement activities or achievement outcomes (Pekrun, 2006). According to the perspective of the circumplex model of emotions (Watson & Tellegen, 1985), they can be categorized along the dimensions of valence (pleasant vs. unpleasant) and activation (activating vs. deactivating), making it possible to distinguish four broad groups of emotions: positive activating, (e.g., enjoyment, pride), positive deactivating (e.g., relief, relaxation, nostalgia), negative activating (e.g., anxiety, anger, and shame), and negative deactivating (e.g., boredom, hopelessness). In the present study we focus on students' achievement emotions across a range of different academic domains.

Reciprocal relations between student-teacher relationships and students' emotions. In Frijda's (1986) seminal work on emotions, relational and interactive behaviors correspond to and are triggered by emotions, arise from interpersonal relations, and have the purpose of changing and establishing interpersonal relations. Interpersonal relations and emotions have also been linked more directly. Parkinson (1996) describes emotions as also stemming from interpersonal experiences that are generalized to the relationship level or the 'generalized other'. That is, emotions do not only affect interaction or arise during interaction, but emotions also result from remembered outcomes of interpersonal relationships.

Reciprocal associations between relationships and emotions in the academic domain can be assumed based on Pekrun's (2006) control-value theory (CVT), a comprehensive and prominent account of the antecedents and effects of achievement emotions. According to CVT, the learning environment is a core antecedent of students' emotions in the classroom, which are, by virtue of reciprocal links between antecedents and consequences, assumed to have an impact on the learning environment. It is plausible that student-teacher relationship quality represents an important facet of learning environments (Wubbels et al., 2015). Assuming that, CVT can be taken to suggest reciprocal relations between relationship quality and students' achievement emotions in the classroom.

As far as we know, there is currently a lack of quantitative longitudinal studies that investigated the assumed reciprocal associations between student-teacher relationship quality and students' emotions. However, there are cross-sectional investigations that demonstrate an impact of student-teacher relationship on students' emotions. For example, in a sample of secondary school students Mainhard et al. (2018) found that relatively higher levels of teacher interpersonal closeness were associated with lower student anxiety and higher enjoyment. In earlier studies, Den Brok, Levy, Brekelmans, and Wubbels (2005) reported positive associations between the interpersonal closeness teachers fostered in class and their students' enjoyment of the subject taught. These results are in line with a recent meta-analysis on mostly cross-sectional studies by Lei et al. (2017), which featured next to enjoyment and anger also the few studies focusing on other discrete emotions and studies using more general affective constructs.

Longitudinal studies on the associations between student-teacher relationship and academic emotions are scarce. Moreover, the existing studies rarely focus on discrete academic emotions or dyadic (subject-specific) relationships. For example, Diaz et al. (2017) report a longitudinal study with two measurement points. Positive and negative emotions were measured via observations of kindergardeners, and student-teacher relationship was assessed via teacher ratings. Further,

students' effortful control was gauged via teacher ratings. Negative emotional experience was analyzed by building an overall score across all negative emotions assessed. This aggregated score was negatively related to student-teacher closeness (i.e., levels of conflict) at low and moderate levels of effortful control, but not for students with high effortful control. An analogously constructed positive emotional experience score was not related to student-teacher relationship quality. The authors assumed that negative student emotions might be more noticeable and impactful for teachers than positive emotions.

Taking a broader perspective on the construct of student-teacher relationships, that is, by taking into account constructs that are not explicitly labeled as "relationship" (see Mainhard et al., 2018, for such an argumentation), more studies can be identified that indicate associations between student-teacher interaction and students' emotions in the classroom. Studies presented evidence showing that teacher behavior that may promote closeness were related to students' emotions. For example, teacher enthusiasm, positive reinforcement of achievement (Becker, Goetz, Morger, & Ranellucci, 2014; Frenzel, Goetz, Lüdtke, Pekrun, & Sutton, 2009; Goetz, Lüdtke, Nett, Keller, & Lipnevich, 2013; Goetz, Pekrun, Hall, & Haag, 2006), monitoring, and clarity of instruction (Kunter, Baumert, & Köller, 2007) were associated with higher positive emotions in students. Unpleasant emotions, such as anxiety, occur more frequently when students perceive teachers as punishing (Frenzel, Pekrun, & Goetz, 2007) or enforcing achievement (Goetz et al., 2006), that is, exhibiting behaviors that are not conducive to closeness. Trickett and Moos (1974) found that students in classrooms that emphasized closeness in personal relationships (e.g., student involvement, affiliation, teacher support) showed higher levels of positive and lower levels of negative moods (i.e., higher levels of feeling secure and interested, lower levels of anger). Thus, although somewhat indirectly, these studies consistently indicate that student-teacher interpersonal closeness goes in line with pleasant emotional experiences in the classroom, whereas behavior signaling low interpersonal closeness goes together with unpleasant emotions.

In sum, links between teacher-student relationships and the range of students' discrete academic emotions still need more attention in empirical research, especially with regard to associations over time, because both constructs are of crucial relevance for various outcomes in school. These links are plausible when considering previous empirical research and are also compatible with relevant theories like CVT, which assumes reciprocal associations between aspects of the learning environment and emotions.

Equivalence of associations between student-teacher relationship quality and students' emotions across emotions. The hypothesized reciprocal association between student-teacher relationship quality and students' emotions may differ in strength depending on the direction (i.e., relationship → emotion; emotion → relationship) with respect to specific emotions, even for emotions of the same valence (i.e., within the group of positive and negative emotions). Assuming that relationship quality constitutes a social facet of the learning environment (Wubbels et al., 2015), CVT can be used to make more specific assumptions about these associations.

Accordingly, the effect of relationship quality on emotions might differ in strength across emotions due to the mediating variables of control and value (e.g., value enhancing anxiety but reducing boredom; e.g., Goetz, Krannich, & Hall, 2019; Pekrun, 2006). With regard to the impact of emotions on relationship quality, emotions may have an impact on relationship quality via achievement outcomes, with high achievement being likely to contribute to positive student-teacher relationships. Due to the fact that specific emotions differ in the relative strength of their impact on achievement outcomes, they may consequently differ in their impact on relationship quality. For example, boredom may be detrimental for achievement due to its negative effects on learning behavior and motivation (i.e., negative effect on motivational orientations; Pekrun, Hall, Goetz, & Perry, 2014). Further, the effects of anxiety on achievement are often relatively low as anxiety reduces achievement due to its effects on intrinsic motivation but at the same time enhances achievement due to its positive effects on extrinsic motivation – resulting in weak average anxiety/achievement relations (e.g., positive effect on extrinsic types of motivation; Pekrun, 2006).

In addition to differential effects of relationship quality on discrete emotions and vice versa via mediating variables, direct effects may also differ across emotions. For example, a student may enjoy a close relationship with the teacher but not feel proud about it. An example for the reversed direction of effects is that students' boredom (i.e., showing not to like the class – expressive component of boredom) may be more damaging for the quality of teacher-student relationship than anxiety. No specific assumptions concerning differences in associations (in both directions, i.e. relationship → emotion; emotion → relationship) with respect to different discrete emotions can be deduced from CVT, which makes it rather difficult to formulate hypotheses about differences in the strength of relations with respect to discrete emotions.

To our knowledge there is no study focusing on the equivalence of those associations across emotions. However, there is empirical evidence showing that the relations between discrete achievement emotions and other constructs differ across emotions. For example, Goetz, Cronjaeger, Frenzel, Lüdtke, and Hall (2010) found that the strength of associations (i.e., absolute value) between self-concept and emotions varied across the specific emotions assessed. Further, associations between academic achievement and emotions differed across emotions in this study, corroborating previous findings by Goetz, Frenzel, Pekrun, Hall, and Lüdtke (2007). However, all of these studies did not investigate relationship quality, were not longitudinal in nature, and did not examine reciprocal effects. Thus, these studies indirectly indicate that the strength of the relations between relationship quality and emotions may differ as a function of discrete emotions.

Equivalence of associations between student-teacher relationship quality and students' emotions across academic domains. Even though levels of student-teacher relationship quality and levels of emotions might differ across academic domains, the associations between those constructs may be equivalent across domains. This pattern of associations can be concluded from the CVT, which explicitly states that the basic structures as well as functional mechanisms of emotions follow general nomothetic principles (i.e., relative universality assumption; Pekrun, 2006; Pekrun, 2018). To date, no study has investigated this structural equivalence of the associations between student-teacher relationship quality and students' emotions across different academic domains. However, with respect to other variables, scattered evidence indicates that associations between achievement emotions and other constructs seem to be rather domain equivalent (e.g., Goetz et al., 2010, for academic self-concept and emotions).

In sum, based on assumptions of the CVT, reciprocal links between teacher-student relationship and students' emotions can be assumed. Empirically, it is an open question whether the associations are unidirectional or reciprocal in nature. Further, if there are indeed reciprocal associations, the relative strength of both effects is unclear: Does relationship quality mainly affect emotions or do emotions mainly affect relationship quality, or are both associations equal in size? Further, in regards to the equivalence of associations between student-teacher relationship quality and achievement emotions it can be assumed that those associations should be rather different across discrete emotions. Scattered empirical findings in related fields are in support of this assumption. Finally, according to the relative universality hypothesis outlined by the CVT, links between student-teacher relationship and students' emotions should be virtually equivalent across different academic domains. The limited findings so far are in support of this structural equivalence assumption.

2. The present study

In this longitudinal study we investigated associations between two core constructs in educational psychology, namely, student-teacher relationship quality, operationalized through student-teacher closeness, and students' emotions in the classroom. We hypothesized reciprocal

links between student-teacher relationship and students' emotions and further assumed that the strength of associations differed for discrete emotions but was rather equivalent with respect to different school domains. We assessed relationship quality as student-teacher closeness as well as a range of core achievement emotions relevant to the classroom context (i.e., enjoyment, pride, anxiety, anger, boredom, and shame) with respect to four core school domains (i.e., mathematics, German, English, and French). Two selection criteria were used to identify emotions to be assessed in the current study. First, we aimed to assess emotions that are conceptually distinct, as specified in the circumplex model of emotions (Watson & Tellegen, 1985; see above). Second, we chose emotions that are particularly salient in academic settings (Goetz et al., 2007; Pekrun, Goetz, Titz, & Perry, 2002). Positive deactivating emotions (e.g., relief, relaxation, nostalgia) were not assessed in this study because these emotions tend to occur after as opposed to during academic situations (see Pekrun et al., 2002).

The current study used students' perceptions of their individual closeness with their teachers rather than perceptions of the relation between the teacher and the whole class to assess the quality of student-teacher relationships across different academic domains and across different teachers per student. This is consistent with Bronfenbrenner (1979; Bronfenbrenner & Morris, 2006), who argued that dyadic relationships were the key to developmental changes in children and adults, and is in line with corresponding evidence in many educational studies. We tested cross-lagged panel models while accounting for the domain-specificity of emotions. Student gender, age, and academic achievement from student records were controlled for in the analysis to adjust for potential differences in these variables (Frenzel, Pekrun, & Goetz, 2007; Goetz, Bieg, Lüdtke, Pekrun, & Hall, 2013; Goetz et al., 2007, 2010; Pekrun et al., 2014; Pekrun, Lichtenfeld, Marsh, Murayama, & Goetz, 2017).

3. Method

3.1. Sample and procedure

We used a sample drawn from seven different schools from the upper track (Gymnasium) in the German-speaking part of Switzerland. All students from the participating classes took part in the study. Data were collected during the second term of the school year (between February and April) in a total of 37 10th grade (T1) and 11th grade (T2) classrooms, with an interval of 12 months between T1 and T2. This means that data collection took place in the middle of the academic year, after students had received their mid-term grades in January. There were 728 students in Wave 1 of whom 666 also participated in Wave 2.[1] Data on the relationship quality and emotional experience at both measurement points were available from 535 students (55.9% female) with a mean T1 age of $M = 16.65$ ($SD = 0.62$). We assessed all data for four compulsory school subjects (mathematics, German, English, and French) that were taken by all students.

To adequately analyze potential links between student-teacher relationship quality and emotions, it was a prerequisite that students had the same teacher at T1 and T2 in a given school domain (i.e., mathematics, German, English, and French). We therefore asked students at T2 whether they had their current teacher last year (i.e., since T1) with the following item stem: "I have my teacher in *[school domain]* since *[the last school year/this school year/this term]*." Of the 2140 possible answers (i.e., 535 students × 4 school domains), 1794 (83.8%) indicated the same teacher across the two academic years, 324 (15.1%) indicated changing teachers either across school years or within the school year, and 22 (1.0%) answers were missing. Only data for those students who explicitly reported to have had the same teacher at T1 and T2 in a given domain were used in the analyses, the remaining data was coded as missing.[2]

3.2. Measures

In this study we focused on four different school domains, so we assessed all constructs four times. Thus, with the aim to maintain the validity of our assessments in spite of repetitiveness, we decided to use short scales consisting each of one or two items. Reliability and validity of such measures have been supported by findings from Wanous, Reichers, & Hudy (1997) and an analysis by Gogol et al. (2014) that focused on motivational and emotional constructs and their assessment in education.

Student-teacher relationship quality. Based on the aforementioned propositions of CVT (Pekrun, 2006) and Bronfenbrenner's (1979) ecological systems theory, we focused on dyadic relationships between teachers and students. We measured interpersonal closeness in student-teacher relationships with two items from Klassen, Perry, and Frenzel's (2012) "relatedness with students" scale (for psychometric properties of this scale see also Baard, Deci, & Ryan, 2004; and Deci et al., 2001). The two original items from this scale were adapted to students' self-reported perspective on the relationship with their teachers in the school domains of mathematics, German, English, and French: "I feel connected to my [school domain] teacher" and "I have a good relationship with my [school domain] teacher." Answers were given on 5-point Likert scales ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). We averaged the answers on both items into a single variable *relationship quality*, with higher values reflecting strong interpersonal closeness in student-teacher relationship in a specific school domain. Reliabilities (Cronbach's α) for the school domains of mathematics, German, English, and French was .84, .83, .82, and .79 at T1 and .81, .81, .83, and .78 at T2, respectively.

Students' emotions. We measured enjoyment, pride, anxiety, anger, boredom, and shame with single items adapted from the Achievement Emotions Questionnaire (Pekrun, Goetz, Frenzel, Barchfeld, & Perry, 2011). Emotions in each school domain were assessed using a generic item stem: "In *[school domain]* classes I usually experience *[emotion]*." Answers were given on 5-point Likert scales ranging from 1 (*not at all*) to 5 (*very strongly*).

In our analyses, we aimed to investigate the associations between relationship quality and emotions. We were interested in looking at these links across as well as within academic domains and discrete emotions. We thus represented all emotion ratings by one single, non-aggregated variable that comprised all 24 assessments per student as

[1] Participants who dropped out in between T1 and T2 did not differ from the remaining participants in terms of age or gender, $p > .60$. There were also no differences in relationship quality in German, English, and French classes, $p > .18$, but students who dropped out reported a worse relationship quality to their math teachers, $p < .01$. There were no significant differences for any of the six emotions in German and English. However, students who dropped out reported less enjoyment, $p = .037$, and more shame, $p = .044$, in French classes and more anger, $p < .02$, less enjoyment, $p < .001$, and less pride, $p < .02$, in math classes. Finally, students who dropped out had worse grades in all four school subjects, math, $p < .001$, German, $p < .02$, English, $p < .001$, and French, $p < .005$. Taken together, students who dropped out after T1 had lower grades, which might have caused them to leave school or to repeat the school year. These students also reported lower relationship quality and emotional experience in their math classes as well as poorer emotional experience in their French class. We therefore re-ran our analyses (Models 1 to 9) with data from all participants, irrespective of whether they dropped out or failed to provide relevant data in any other way (e.g., due to teacher changes), and used FIML to deal with missing values. This had negligible effects on our results, however, and left the pattern of significance virtually unchanged compared to the analysis reported in the manuscript.

[2] Note that multiple assignments of teachers to classes are in general possible but, according to information from the schools, should be a negligible exception in our dataset. For instance, only very few teachers at the schools we surveyed taught more than one of the four core subjects under investigation (i.e., mathematics, German, English, and French).

repeated measurements within students (i.e., 6 emotions in each of 4 school domains) accompanied by additional dummy variables identifying the domain and emotion to which a particular observation belonged. To facilitate the interpretation of this variable, we reversed participants' answers to negative emotion items (i.e., anxiety, anger, boredom, and shame). Accordingly, higher values of the resulting *positive emotional experience* variable reflect high levels of positive emotions and high levels of inverted negative emotions (i.e., low levels of negative emotions).

Covariates – gender, age, academic achievement. As covariates for our analyses, we assessed self-reported gender and age at T1 and obtained students' midyear grade in each of the four school domains from student records at T1 and T2. These grades reflect an objective measure of students' academic achievement during the first term of the school year and thus the last grade prior to data collection, which took place during the second term. Grades in the Swiss school system range from 1 (*poor*) to 6 (*excellent*).

3.3. Analytic approach

We were interested in examining reciprocal associations between student-teacher relationship quality and students' emotional experiences. Thus, we focused on two main variables in our analyses: *relationship quality*, operationalized as students' interpersonal closeness with a specific teacher, and *positive emotional experience*, which comprised high levels of positive as well as high levels of inverted negative achievement emotions. To test the reciprocal associations between these two variables, we estimated cross-lagged panel models (Selig & Little, 2012) within a structural equation modeling framework using Mplus 8.1 (Muthén & Muthén, 1998-2017). Mplus was implemented into the statistical software environment R (version 3.5.0; R Core Team, 2018) via the package MplusAutomation (version 0.7–2; Hallquist & Wiley, 2018), which facilitates model interpretation and comparison by providing functions for summarizing and visualizing Mplus output. Cross-lagged panel models capture both the stability of two variables X and Y and their reciprocal effects on each other over time. In all models, we used the "ESTIMATOR = MLR" option to conduct maximum likelihood estimation, which makes the standard error estimation robust against non-normally distributed data. Moreover, we used a full information maximum likelihood (FIML) approach to deal with missing data and accounted for clustering with the "TYPE = COMPLEX" command in Mplus with students as the unit of clustering.

Data structure. We assessed the reciprocal associations between relationship quality and positive emotional experience a total of 24 times for each student, once for each combination of 4 school domains and 6 emotions (e.g., the association between relationship quality and anxiety in math classes). These associations are thus clustered within students (see Fig. 1). We accounted for this structure as in similar previous research (Becker et al., 2014; Goetz et al., 2016) by specifying school domains and discrete emotions as fixed factors (Cohen, Cohen, West, & Aiken, 2003). Due to the fact that these factors were categorical, doing so required the introduction of $J - 1$ dummy variables for each factor, with J denoting the number of factor levels. In our case, the four school domains were thus represented by 4–1 = 3 dummy variables and the six emotions were represented by 6–1 = 5 dummy variables. We specified math as a reference domain and anxiety as a reference emotion. Accordingly, the three dummy variables representing academic domains were German, English, and French (e.g., the German dummy was coded 1 if the school domain was German and 0 otherwise) and the five dummy variables representing emotions were enjoyment, pride, anger, boredom, and shame (e.g., the enjoyment dummy was coded 1 if the emotion was enjoyment and 0 otherwise). This approach has two crucial advantages for our analyses: First, it allowed us to fully account for the clustering of school domains and emotions within students by specifying the dummy variables as covariates in our models (Huang, 2016; Möhring, 2012). Second, the dummy variables identify the domain and emotion to which a particular association between relationship quality and emotional experience belongs. Therefore, adding interactions between these dummy variables and our T1 predictors (i.e., relationship quality and positive emotional experience), allowed us to examine the equivalence of these associations across school domains and emotions (e.g., whether the association between relationship quality at T1 and positive emotional experience at T2 differed between domains, emotions, or both).

Besides the clustering of domains and emotions within students, students were additionally nested in classes. Class differences in relationship quality and emotional experience did exist (ICCs ranged from .172 (in German) to .382 (in Math) for relationship quality and from .021 (pride in German) to .300 (boredom in English) for emotional experience) and might obscure conclusions about their dyadic associations if not accounted for. To hedge against this, we class-mean centered all continuous variables at T1 and T2. As a consequence, these variables can be interpreted as an individual student's deviation from her or his class average at the corresponding time point. We thus examined, for instance, how a deviation from the class-mean centered T1 relationship quality influenced class-mean centered T2 positive emotional experience. This approach removes any potential variance resulting from differences between classes and is ideally suited for examining research questions at the student level when influences of the class level are plausible but not part of the hypotheses (Enders & Tofighi, 2007; Raudenbush & Bryk, 2002), as it was the case in the present research.

Model building. The focus of all cross-lagged panel models was on predicting T2 relationship quality and positive emotional experience. As the associations between relationship quality and positive emotional experience were hypothesized to be reciprocal in nature, we first built a model with both autoregressive and reciprocal effects (Model 1; see Mplus input file in the appendix). In this baseline model, we regressed T2 relationship quality, positive emotional experience, and academic achievement on T1 relationship quality, positive emotional experience, and academic achievement. This model thus comprises a total of three regressions, in which we additionally specified T1 age and gender as covariates and included the eight dummy variables representing school domains and discrete emotions. Finally, we specified interaction effects between the predictors (i.e., T1 positive emotional experience as predictor of T2 relationship quality and T1 relationship quality as predictor of T2 positive emotional experience) and the dummy variables, and fixed them to 0. Accordingly, the reciprocal effects in Model 1 were not allowed to differ between school domains or discrete emotions. All of our models were nested, which in turn facilitated model comparisons (see below).

We then examined the direction and the significance of the standardized path coefficients. In addition, we used the phantom variable approach (Cheung, 2009) to compare the sizes of the standardized reciprocal effects. This approach involved to re-estimate the baseline model (i.e., Model 1) and to additionally create a new variable that represented the difference between the standardized effects (i.e., difference = effect of T1 positive emotional experience on T2 relationship quality − effect of T1 relationship quality on T2 positive emotional experience). A significant difference variable indicates that the two standardized reciprocal effects differ from each other, which in turn allows for drawing conclusions about the relative strength of reciprocal associations between relationship quality and positive emotional experience.

Next, we tested baseline Model 1 against more parsimonious models, in which we restricted some of the reciprocal effects to zero. First, we compared Model 1 to a model in which the effect of T1 positive emotional experience on T2 relationship quality was restricted to zero (Model 2). Second, we compared Model 1 to a model in which the effect of T1 relationship quality on T2 positive emotional experience was restricted to zero (Model 3). Finally, we compared Model 1 to a model in which both of these effects were simultaneously restricted to

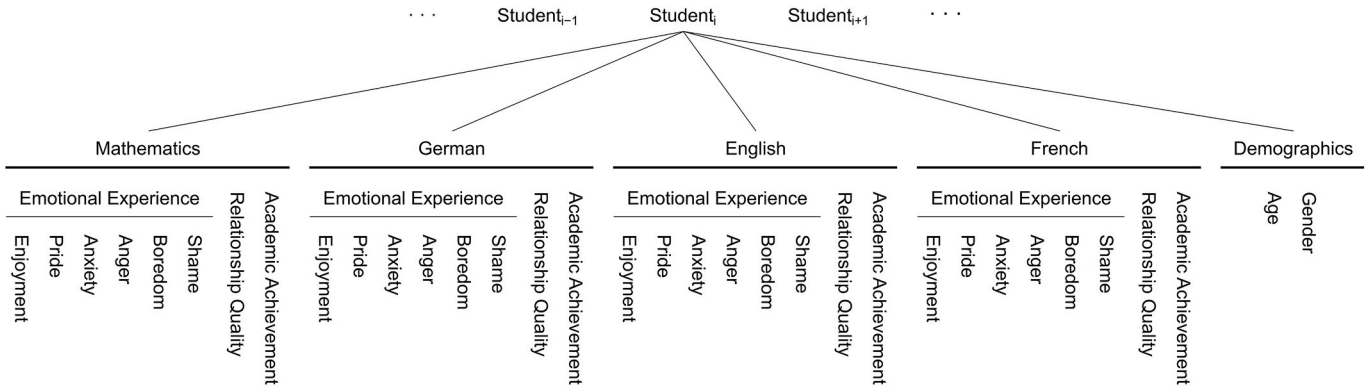

Fig. 1. Schematic illustration of the data structure within each student. We measured six discrete emotions, interpersonal closeness, and academic achievement in each school domain, as well as age and gender. Accordingly, we assessed relationship quality and academic achievement a total of 4 times per student, whereas emotional experience was measured a total of 24 times per student. The nested structure of discrete emotions and school domains within students was accounted for by specifying these variables as fixed factors represented by dummy variables.

zero (Model 4). As the baseline Model 1 is more complex than Models 2, 3, and 4, significant differences indicate that Model 1 should be preferred, whereas non-significant comparisons indicate no statistical advantage of Model 1 over the alternative models.

Finally, we tested the baseline Model 1 against less parsimonious models, in which we freely estimated interactions between the T1 predictors and the dummy variables. In particular, we gradually allowed for interactions between T1 relationship quality and positive emotion and the dummy variables representing school domains and discrete emotions. This was done by removing the restrictions imposed on these interactions (which were fixed to 0 in Model 1, see above) and thus allowing the reciprocal effects to differ across domains and emotions (McNeish & Kelley, 2019). In Models 5 and 6, the effect of T1 positive emotional experience on T2 relationship quality could vary across school domains (e.g., anger in Math classes affects relationship quality differently than in German classes) or emotions (e.g., anger affects relationship quality differently than boredom), respectively. In Models 7 and 8, the effect of T1 relationship quality on T2 positive emotional experience could vary across school domains (e.g., relationship quality in Math classes affects emotional experiences differently than in German classes) or emotions (e.g., relationship quality has different effects on anger than on boredom), respectively. In Model 9, all of the above interactions were freely estimated, allowing both reciprocal effects to vary across domains and emotions simultaneously (e.g., the association between relationship quality and anger in Math classes differs from the association between relationship quality and boredom in German classes).

To assess the goodness of fit of the different models, we determined the root mean square error of approximation (RMSEA), the standardized root mean square residual (SRMR), the comparative fit index (CFI), and the Tucker-Lewis index (TLI). Good model fit can be assumed if RMSEA ≤ 0.06 and SRMR ≤ 0.08, and CFI and TLI ≥ 0.95 (Hu & Bentler, 1999). To directly compare the baseline Model 1 to the other models, we used the Satorra-Bentler scaled χ^2 difference test (Satorra & Bentler, 2001). A significant χ^2 difference test indicates that the more complex model should be preferred.

4. Results

4.1. Descriptive analyses

Descriptive statistics are presented in Table 1. It contains the more intuitive original negative emotion scores rather than inverted scores. Zero-order correlations among variables are presented in Table 2. At concurrent time points, relationship quality (i.e., student-teacher interpersonal closeness) was positively associated with positive emotional experience (i.e., positive and inverted negative emotions), $r = .24$ and $r = .25$. Moreover, at concurrent time points, better relationship quality was associated with higher academic achievement ($r = .21$ and $r = .28$), and positive emotional experience was also associated with higher academic achievement ($r = .12$ and $r = .15$). Age and gender were neither correlated with relationship quality nor with emotional experience. Finally, Table 3 shows the correlations between the six discrete emotions at T1 and T2.

4.2. Cross-lagged model analysis

Estimating baseline Model 1 and comparing the reciprocal effects. All estimated path coefficients of Model 1 were in line with our hypotheses regarding their size and direction (see Fig. 2). We found similar autoregressive effects of relationship quality, $\beta = 0.500$, $SE = 0.022$, $p < .001$, and positive emotional experience (i.e., positive and inverted negative emotions), $\beta = 0.474$, $SE = 0.016$, $p < .001$. Importantly, the hypothesized reciprocal effects were also significant: T1 positive emotional experience was associated with T2 relationship quality, $\beta = 0.088$, $SE = 0.017$, $p < .001$, and a weaker but still significant association between T1 relationship quality and T2 positive emotional experience was shown as well, $\beta = 0.027$, $SE = 0.011$, $p = .011$. Besides these effects of interest, we observed that academic achievement had a substantial autoregressive effect, $\beta = 0.635$, $SE = 0.018$, $p < .001$. Moreover, T1 academic achievement predicted T2 positive emotional experience, $\beta = 0.045$, $SE = 0.009$, $p < .001$, as well as T2 relationship quality, $\beta = 0.099$, $SE = 0.021$, $p < .001$. In turn, T1 positive emotional experience predicted T2 academic achievement, $\beta = 0.060$, $SE = 0.014$, $p < .001$, while T1 relationship quality did not significantly predict T2 academic achievement, $\beta = 0.033$, $SE = 0.019$, $p = .095$.

Next, we compared the standardized reciprocal effects using the phantom variable approach. That is, we re-estimated Model 1 and created a new variable that captured the difference between the two observed effects. As described above, the observed effect of T1 positive emotional experience on T2 relationship quality (i.e., $\beta = 0.088$) was larger than the effect of T1 relationship quality on T2 positive emotional experience (i.e., $\beta = 0.027$). Consequently, the difference variable was $\beta = 0.088–0.027 = 0.061$. This value was significantly different from zero, $\beta = 0.061$, $SE = 0.020$, $p = .003$, indicating that

Table 1
Means and standard deviations of the variables measured for each of the four school domains.

	Mathematics				German				English				French			
	T1		T2		T1		T2		T1		T2		T1		T2	
	M	(*SD*)	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)
Relationship quality	2.83	(1.02)	2.91	(1.02)	3.08	(1.00)	3.27	(0.98)	3.08	(0.98)	3.14	(0.98)	2.77	(0.94)	2.83	(0.92)
Discrete emotions																
Enjoyment	2.68	(1.14)	2.73	(1.10)	2.86	(1.08)	2.86	(1.07)	3.09	(1.01)	3.00	(1.06)	2.76	(0.90)	2.64	(0.94)
Pride	2.28	(1.12)	2.32	(1.13)	2.19	(1.09)	2.18	(1.14)	2.35	(1.14)	2.43	(1.20)	2.28	(0.99)	2.28	(1.02)
Anxiety	1.65	(0.96)	1.53	(0.88)	1.40	(0.80)	1.27	(0.63)	1.39	(0.79)	1.30	(0.67)	1.68	(1.02)	1.70	(1.02)
Anger	2.29	(1.17)	2.33	(1.13)	1.95	(1.10)	1.88	(1.06)	1.85	(1.04)	1.97	(1.12)	2.24	(1.06)	2.37	(1.12)
Boredom	2.68	(1.11)	2.75	(1.09)	2.84	(1.21)	3.00	(1.17)	2.62	(1.13)	2.80	(1.13)	2.85	(0.99)	3.08	(1.05)
Shame	1.55	(0.88)	1.50	(0.82)	1.37	(0.73)	1.30	(0.67)	1.47	(0.84)	1.40	(0.76)	1.64	(0.91)	1.64	(0.91)
Academic achievement	4.47	(0.80)	4.39	(0.88)	4.67	(0.51)	4.74	(0.54)	4.67	(0.64)	4.65	(0.61)	4.51	(0.68)	4.48	(0.69)

Note. $N = 535$. T1 = Time Point 1, T2 = Time Point 2. The original scores of negative emotions are reported rather than the inverted scores used in the analyses to ease interpretation of the table. Answers were given on 5-point Likert scales for relationship quality (1 = *strongly disagree*, 5 = *strongly agree*) and achievement emotions (1 = *not at all*, 5 = *very strongly*). Academic achievement represents grades ranging from 1 (*poor*) to 6 (*excellent*).

Table 2
Descriptive statistics of and zero-order correlations among variables and covariates.

		M	*SD*	1.	2.	3.	4.	5.	6.	7.
1.	T1 Relationship Quality	2.93	1.00							
2.	T2 Relationship Quality	3.04	0.99	.57***						
3.	T1 Positive Emotional Experience	3.54	1.32	.24***	.20***					
4.	T2 Positive Emotional Experience	3.52	1.33	.16***	.25***	.71***				
5.	T1 Academic Achievement	4.59	0.67	.21***	.23***	.12***	.11***			
6.	T2 Academic Achievement	4.58	0.71	.19***	.28***	.13***	.15***	.68***		
7.	T1 Age	16.65	0.62	.01	-.02	-.01	-.01	-.06°	-.11**	
8.	T1 Gender	0.56	0.50	-.04	-.01	.01	.00	-.16***	-.15***	-.20

Note. $N = 535$. T1 = Time Point 1, T2 = Time Point 2. Gender is coded as 0 = male and 1 = female. Positive emotional experience represents a combined score of positive emotions and inverted negative emotions. Tests of significance are corrected for the nesting of students within classes.
° $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

positive emotional experience affected relationship quality significantly more strongly than relationship quality affected positive emotional experience.

Evaluating models without reciprocal effects. In the next step, we tested whether models with the reciprocal effects restricted to zero would provide a better fit to the data (see Table 4). To this end, we conducted χ^2 difference tests comparing Model 1 to models in which the effect of T1 positive emotional experience on T2 relationship quality (Model 2), the effect of T1 relationship quality on T2 positive emotional experience (Model 3), or both of these effects (Model 4) were restricted to zero. We found that constraining either one or both reciprocal effects in such a way significantly impaired model fit, $ps \leq .012$. Taken together with the evaluation of Model 1, these findings supported our hypothesis that student-teacher relationship quality and students' emotional experience were reciprocally associated with each other.

Table 3
Zero-order correlations among discrete emotions at T1 and T2.

		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1.	T1 Enjoyment											
2.	T1 Pride	.55***										
3.	T1 Anxiety	-.18***	.01									
4.	T1 Anger	-.50***	-.11**	.41***								
5.	T1 Boredom	-.44***	-.12**	.14***	.51***							
6.	T1 Shame	-.13***	.02	.54***	.35***	.16***						
7.	T2 Enjoyment	.63***	.40***	-.14***	-.33***	-.32***	-.13***					
8.	T2 Pride	.39***	.68***	-.02	-.10*	-.11**	-.02	.58***				
9.	T2 Anxiety	-.12***	-.01	.37***	.24***	.04	.30***	-.13***	.03			
10.	T2 Anger	-.32***	-.05	.24***	.59***	.35***	.23***	-.41***	-.09*	.32***		
11.	T2 Boredom	-.34***	-.11**	.04	.34***	.60***	.07*	-.45***	-.14***	.05	.50***	
12.	T2 Shame	-.11***	-.02	.33***	.25***	.09**	.35***	-.12***	-.02	.44***	.31***	.13***

Note. $N = 535$. T1 = Time Point 1, T2 = Time Point 2. The original scores of negative emotions are reported rather than the inverted scores used in the analyses to ease interpretation of the table. Answers were given on 5-point Likert scales for relationship quality (1 = *strongly disagree*, 5 = *strongly agree*) and achievement emotions (1 = *not at all*, 5 = *very strongly*). Tests of significance are corrected for the nesting of students within classes.
* $p < .05$. ** $p < .01$. *** $p < .001$.

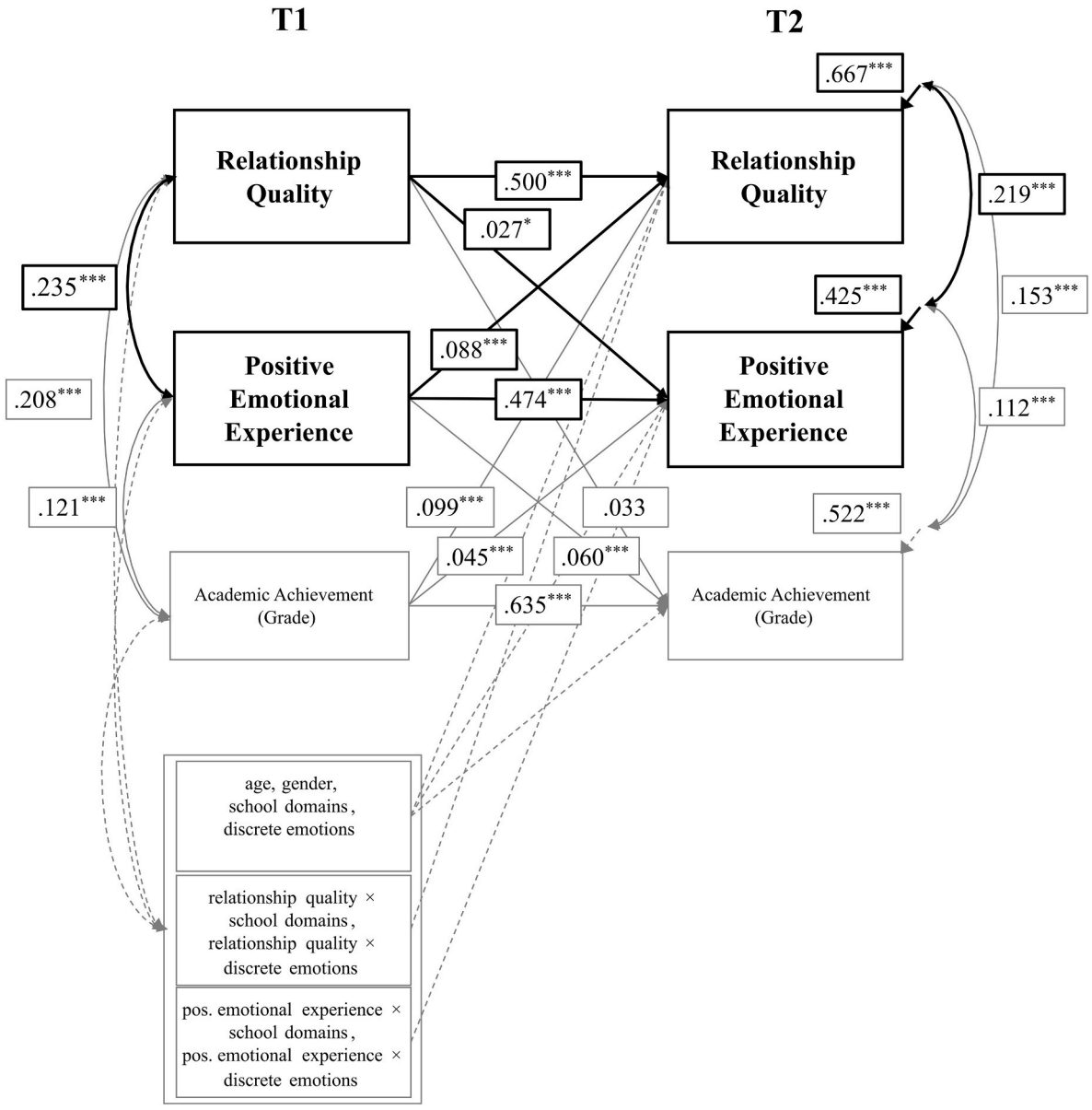

Fig. 2. Structural overview of the cross-lagged panel models M1 to M9. The autoregressive and reciprocal associations between relationship quality and positive emotional experience (i.e., positive emotions and inverted negative emotions) at T1 and T2 are highlighted. All values represent standardized path coefficients from Model 1. Also shown are the additional variables used in the different models (academic achievement, age, gender, the dummy variables representing school domains and discrete emotions, and interactions). For ease of interpretation, some of the additional variables and their associations among each other and with the remaining variables are only sketched.

Table 4
Model fit statistics and χ^2 difference tests for the cross-lagged panel models.

Model and Description	RMSEA	SRMR	CFI	TLI	χ^2 (*df*)	$\Delta\chi^2$ (*df*)	*p*
Model 1: Cross-lagged model with $EMO_1 \rightarrow REL_2$ and $REL_1 \rightarrow EMO_2$	0.008	0.003	0.996	0.993	82.42 (48)	–	–
Models restricting the reciprocal effects to zero:							
Model 2: $EMO_1 \rightarrow REL_2$ restricted to 0	0.012	0.005	0.992	0.985	122.22 (49)	29.70 (1)	< .001
Model 3: $REL_1 \rightarrow EMO_2$ restricted to 0	0.009	0.003	0.995	0.991	91.13 (49)	6.30 (1)	.012
Model 4: $EMO_1 \rightarrow REL_2$ and $REL_1 \rightarrow EMO_2$ and restricted to 0	0.012	0.005	0.991	0.983	133.10 (50)	36.47 (2)	< .001
Models allowing interactions between predictors and dummy variables:							
Model 5: interactions between EMO_1 and school domains	0.008	0.003	0.996	0.993	79.20 (45)	2.89 (3)	.408
Model 6: interactions between EMO_1 and achievement emotions	0.008	0.003	0.996	0.992	70.03 (43)	15.39 (5)	.009
Model 7: interactions between REL_1 and school domains	0.008	0.003	0.997	0.994	75.25 (45)	6.93 (3)	.074
Model 8: interactions between REL_1 and achievement emotions	0.008	0.003	0.997	0.993	71.70 (43)	11.83 (5)	.037
Model 9: all interactions simultaneously	0.007	0.002	0.998	0.995	49.20 (32)	35.76 (16)	.003

Note. $N = 535$. Reference model for all comparisons is Model 1. REL_1 = T1 relationship quality, EMO_1 = T1 positive emotional experience, REL_2 = T2 relationship quality, EMO_2 = T2 positive emotional experience.

Evaluating models with interactions between T1 predictors, domains, and emotions. In the next step, we investigated the equivalence of our findings across academic domains and discrete emotions. To this end, we estimated five additional models (i.e., Models 5 to 9, see Table 4), in which we gradually allowed for interactions between T1 relationship quality and positive emotional experience and the dummy variables representing domains and emotions. We then used χ^2 difference tests to compare each of these models to baseline Model 1, in which these interactions were all fixed to zero (see above).

Model 5 allowed interactions of T1 positive emotional experience and dummy variables representing school domains but did not fit better than Model 1, $\Delta\chi^2(3) = 2.89$, $p = .408$. Model 6 allowed interactions of T1 positive emotional experience and dummy variables representing discrete emotions and fitted our data significantly better than Model 1, $\Delta\chi^2(5) = 15.39$, $p = .009$. This suggested that the reciprocal effect of T1 positive emotional experience on T2 relationship quality was equivalent across school domains but varied across emotions. Model 7 allowed interactions of T1 relationship quality and dummy variables representing school domains but did not fit better than Model 1, $\Delta\chi(3) = 6.93$, $p = .074$. Model 8 allowed interactions of T1 relationship quality and dummy variables representing discrete emotions and fitted our data significantly better than Model 1, $\Delta\chi^2(5) = 11.83$, $p = .037$. This suggested that the reciprocal effect of T1 relationship quality on T2 positive emotional experience was equivalent across school domains but varied across emotions. Taken together, this pattern of results suggested that the reciprocal associations between relationship quality and positive emotional experience observed in Model 1 were virtually equivalent across school domains but differed across discrete emotions.

To further examine this pattern of results, we estimated Model 9 with all of the above interactions estimated simultaneously. This allowed us to gauge the reciprocal associations between relationship quality and emotional experience for each of the 24 combinations of the four academic domains (mathematics, German, English, French) and the six discrete emotions (i.e., enjoyment, pride, anxiety, anger, boredom, and shame). The resulting standardized reciprocal effects from this model are plotted in Fig. 3 (using the more intuitive original rather than inverted negative emotion scores), along with their 95% confidence intervals and the resulting significance level. Examining these results revealed that significant associations between T1 relationship quality and T2 positive emotional experience (upper panel) were present mainly in the domain of positive emotions: better initial relationships were associated with more enjoyment in math, German, and French classes and with more pride in German and French classes one year later. Regarding negative emotions, better initial relationships were associated with less anger and shame in French classes one year later. No such associations were observed for anxiety and boredom.

Turning to the association between T1 positive emotional experience and T2 relationship quality (lower panel), we found significant effects in the domains of positive and negative emotions. Regarding positive emotions, more initial enjoyment was associated with better relationship quality across academic domains one year later, while no associations between pride and relationship quality were found. In the domain of negative emotions, lower initial anger and boredom were associated with better relationship quality across school domains one year later. Moreover, less initial shame was associated with better relationship quality in math and French classes one year later, and less initial anxiety was associated with better relationship quality in French classes. Taken together, these results again showed that the reciprocal associations between relationship quality and positive emotional experience varied considerably across achievement emotions but were mostly equivalent across academic domains.

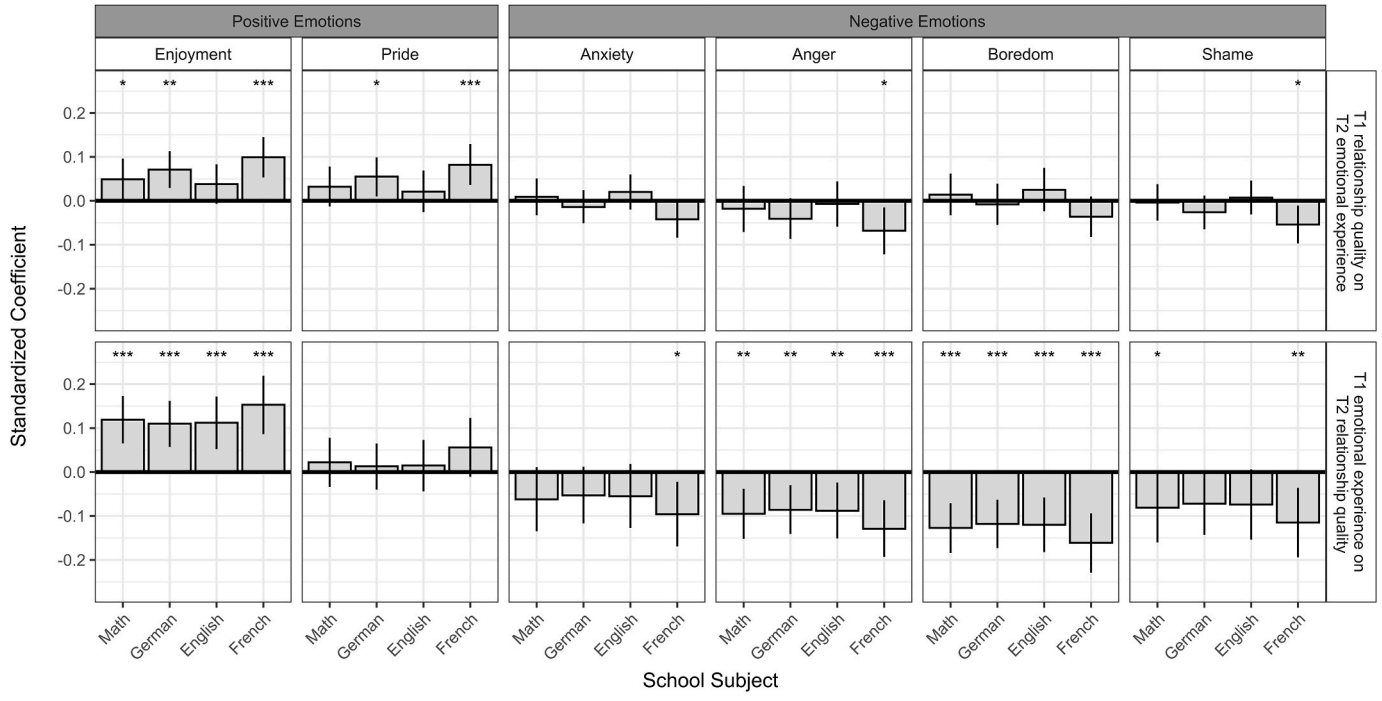

Fig. 3. The estimated standardized coefficients of regressing relationship quality on emotional experiences (upper panels) and emotional experiences on relationship quality (lower panels) based on Model 9, separately for each school domain and discrete emotion. The inversion of negative emotions was undone for this graph to ease the interpretation of the figure. The reciprocal associations between relationship quality and emotional experience varied primarily across discrete emotions but were rather equivalent across school domains. Error bars represent 95% confidence intervals and asterisks indicate the significance level (*$p < .05$; **$p < .01$; ***$p < .001$).

4.3. Robustness checks

In our main analysis, we used dummy variables to account for possible differences between the six distinct emotions regarding the assumed reciprocal association of relationship quality and emotional experience. To check the robustness of our findings, we also estimated the reciprocal associations in six separate models, one for each emotion. These models fitted the data well (see appendix Tables A4 and A5 for details), RMSEA ≤ 0.012, SRMR ≤ 0.007, CFI ≥ 0.998, TLI ≥ 0.995, $\chi^2(18) < 22.3$, $p > .215$. Importantly, they also corroborated our main findings (see Fig. 3): T1 relationship quality was associated with T2 emotional experience in the models for enjoyment (β = 0.054, *SE* = 0.027, *p* = .046) and anger (inverted; β = 0.056, *SE* = 0.027, *p* = .039), and T1 emotional experience was associated with T2 relationship quality in models for enjoyment (β = *0.132, SE = 0.027, p* < .001), anger, (inverted; β = *0.077, SE = 0.024, p* = .002), boredom (inverted; β = *0.100, SE = 0.023, p* < .001), and shame (inverted; β = *0.058, SE = 0.024, p* = .013).

Second, in our main analysis we mean-centered all continuous variables to remove variance on the class level. An alternative approach is to explicitly account for differences between classes in a multilevel analysis. Specifically, such an analysis can be used to incorporate between-class differences in the levels of relationship quality and emotional experience as well as in the strength of their association. We conducted a "type = random twolevel complex" analysis and specified models with random class intercepts of the dependent variables and random slopes for the cross-lagged associations. In line with our main analysis, the (average) association between T1 emotional experience and T2 relationship quality was β = 0.085, *SE* = 0.013, *p* < .001, in the random intercept model and β = 0.077, *SE* = 0.012, *p* < .001, in the random slope model. This was about twice as large as the (average) association between T1 relationship quality and T2 emotional experience, which was β = 0.036, *SE* = 0.013, *p* = .005, in the random intercept model and, β = 0.038, *SE* = 0.013, *p* = .005, in the random slope model. These findings correspond well with our main analysis in showing that initial emotional experiences are more strongly associated with subsequent relationship quality than initial relationship quality is associated with subsequent emotional experiences. Thus, removing potential differences between classes prior to the analysis and accounting explicitly for these differences in the analysis yields analogous findings, speaking for the robustness of our findings in terms of their generalizability across classes and teachers.

5. Discussion

In this longitudinal study, we tested the assumption that there are reciprocal associations between student-teacher relationship quality, operationalized through interpersonal closeness, and students' emotions in the classroom. Our results provide first evidence that such reciprocal associations indeed exist, even when controlling for core variables like gender, age, and academic achievement assessed via student records.

5.1. Reciprocal associations between student-teacher relationship and students' emotions

Although the autoregressive associations were strong for both relationship quality and emotional experience, indicating that both constructs are relatively stable, we found significant reciprocal associations as well. Better student-teacher relationship quality was associated with students' positive emotional experience (i.e., positive emotions and inverted negative emotions) and vice versa. Thus, our results were in line with the tenets of Pekrun's (2006) CVT that suggests reciprocal associations between emotions and the learning environment, of which relationship quality is an important facet. This finding could be consequential particularly when considering cumulative effects of established associations: Having the same teacher for a year or longer with numerous interactions happening on a daily basis may have long-term effects on students' meaningful outcomes. In the case of continuing negative relationships and negative emotions, downward spirals over extended periods of time may lead to even more negative relationships and emotional experiences, resulting in poor achievement outcomes, low well-being, and reduced motivation to pursue a career in the corresponding domain (e.g., Krannich et al., 2019). Conversely, upward spirals may have the potential of contributing to positive academic achievement outcomes, high well-being, and enhanced career aspirations for a specific domain of study.

5.2. Relative strength of reciprocal associations between relationship and emotions

Our analysis showed that the association of initial positive emotional experiences with perceived relationship quality one year later was significantly stronger than the reversed association (i.e., the association between initial relationship quality and later emotional experience). Although these associations are not necessarily causal, they might be taken to suggest that emotions contribute to perceived relationships more strongly than relationships shape emotions. This finding is particularly important in light of previous studies, all of which almost exclusively focused on the unidirectional effects of relationship quality on emotions (e.g., Stuhlman & Pianta, 2001). Together with the finding demonstrating that emotional experiences at T1 (but not relationship quality) were associated with academic achievement at T2, our study underlines the high relevance of student's achievement emotions in the classroom. The direct application of these results might be in the design and implementation of programs intended to foster students' positive emotions and to reduce their negative emotions, which could also serve as a test of the causality of the observed associations.

Our findings raise the question of why the strength of the reciprocal associations differs and what significance this has for teaching practices. This question can be addressed with reference to the CVT. In terms of CVT, relationship quality is one of several aspects of the learning environment, and its effects on emotions, learning, and achievement are mediated by cognitive appraisals. For relationship quality to have an effect on emotions, it therefore must change these appraisals in the first place. It is, for example, conceivable that students' judgment of high interpersonal closeness to the teacher enhances their perceived control over the situation (e.g., due to trust) and their intrinsic value of the content (e.g., due to sharing teachers' values). These effects on appraisals could, however, still be diluted by other aspects of the environment like teacher behavior and instructional quality, explaining its weak associations with later emotional experiences.

In contrast, achievement emotions constitute a core facet of CVT with direct influences on learning, motivation, and cognitive resources and consequently on academic achievement. There may be several pathways how students' emotions can influence teachers' behavior and shape student-teacher relationships. For example, it is reasonable to assume that teachers' relationship with their students is influenced by students' achievement, given that student performance is a central goal of teachers' instructional behavior (Hagger & Malmberg, 2011; Lenos, 1996). To the extent that students' achievement is influenced by their emotions, these emotions can therefore impact relationship quality, with achievement being the mediating mechanism. A more direct link is that students' emotions might be interpreted by teachers as feedback regarding their classroom instruction, with displayed positive emotions

serving as positive feedback about supportive behavior, thus further increasing teachers' support. Overall, our findings suggest that fostering students' positive emotions might pay off both in terms of better student achievement and by facilitating subsequent relationship quality.

5.3. Equivalence of results across emotions

In line with our hypotheses, the associations between relationship quality and emotional experience differed significantly across emotions. With respect to the association of initial student-teacher relationship quality with later emotional experience, only negative emotions showed significant links. The pattern was different for the reversed direction: We found significant associations for both positive (mainly enjoyment) and negative emotions (mainly boredom and anger). Thus, our results are not consistent with Diaz et al.'s (2017) assumption that negative emotions may be more noticeable and draining for teachers, as compared to positive emotions, and should therefore have a more direct impact on the quality of student-teacher relationship. Enjoyment in particular, which may be noticeable and easily observable by teachers, showed clear associations with relationship quality across academic domains.

Strong reciprocal associations between student-teacher relationship and emotions were found for boredom and anger. This might suggest that bored or angry students have a lower chance of developing good relationships with their teachers. In the past decade there has been a noticeable increase in the number of studies on boredom (Goetz et al., 2019). However, to our knowledge, the importance of boredom with respect to shaping social relationships at school has been generally neglected.

Another key finding concerns anxiety, the achievement emotion that has received most attention in the field (Pekrun et al., 2002). We found hardly any associations of this emotion with relationship quality, namely, no significant associations of this emotion at T1 with relationship quality at T2. The reverse association (i.e., of relationship quality at T1 with anxiety at T2) was significant in one domain only (French) and weak. Student anxiety seems to have no link to subsequent relationship quality – maybe due to differences in how teachers deal with students' emotions. Some teachers may try to actively cultivate positive relationship with anxious students with the goal to support them, whereas for other teachers students' anxiety may make it rather difficult to build a strong, close relationship. More research is needed to fully understand links between student-teacher relationships and student anxiety in the classroom.

5.4. Equivalence of results across academic domains

In line with our hypotheses, the associations between relationship quality and emotional experiences were virtually equivalent across academic domains. This finding is in line with results of previous investigations that used the CVT (Pekrun, 2006) as their conceptual framework. These studies supported the functional equivalence assumption of the CVT across academic domains (e.g., Goetz et al., 2010, for academic self-concept and emotions). This finding is important with respect to future studies in this field. It suggests that the associations between student-teacher relationships and students' emotions as well can be investigated in any academic domain with conclusions generalizable to other domains. Thinking one step further, this result might also justify to develop intervention programs in one domain under the assumption that it may also work in other academic domains.

5.5. Limitations

In our study we collected data at two time points with a time interval of one year. Future studies may increase the number of assessments to make it possible to tease apart stability in relationship quality and emotional experience that results from within-person effects versus stable traits (e.g., using a random-intercepts cross-lagged panel model; Hamaker, Kuiper, & Grasman, 2015), which would in turn facilitate causal inferences regarding the reciprocal associations we observed. Alternatively, the time interval among individual assessments might be shortened to increase temporal granularity and thereby permit an observation of potential changes in links among student-teacher relationship quality and emotions throughout an academic year.

There are several variables that could be collected in future research to better understand the connection between relationship quality and emotions. For example, we used CVT to generate hypotheses but we did not assess the cognitive appraisals of control and value that are specified therein as mediators between the learning environment and emotions (Pekrun, 2006). Including these mediating variables might shed light, for instance, on the question of why initial relationship quality had only weak links with emotions and performance one year later. From this perspective, it would also be interesting to assess how much students like a certain school subject, which is an important aspect of their perception of the learning environment that might affect value appraisals (e.g., students might like the topics taught in German classes even though they do not like their German teacher). Moreover, how much students like a school subject might also bias their perception of the relationship with the teacher. For example, the variation we observed in the average relationship quality across subjects might at least partly reflect that some subjects are generally more liked than others irrespective of who teaches them.

In the literature on student-teacher relationship, a distinction is commonly made between interpersonal closeness and conflict, especially in research focusing on pre- and primary school children (Birch & Ladd, 1997; Pianta, 1999). In line with research on older students (e.g., Wentzel, 1997), however, in the present research we operationalized student-teacher relationship quality as a single dimension with closeness and conflict as the two ends of the continuum. Future research might complement our findings with more fine-grained assessments of relationship quality that distinguish between qualitatively different dimensions (e.g., agency, Wubbels et al., 2015; conflict, dependency, Pianta, 1999) and relate them to achievement emotions, especially in samples with younger children for which such instruments have been devised (Pianta, 2001). For instance, it might be that closeness is more strongly associated with positive emotions, whereas conflict is more strongly associated with negative emotions. A similar reasoning applies to the assessment of emotions: Administering a more extensive instrument like the Achievement Emotions Questionnaire (Pekrun et al., 2011) might shed light on how relationship quality is associated with the different facets of an emotion (e.g., affective versus motivational).

Our analysis of relationship quality and emotions was based on students' perceptions and self-reports, which might be problematic (e.g., due to recall biases) and should therefore be complemented by additional sources of data like teacher self-report, observations, or physiological assessments (Roos et al., 2017) in future research. It seems worthwhile that future studies also consider teachers' perspectives. Teachers often perceive relationships with their students differently than the students themselves (Hughes, 2011; Murray, Murray, & Waas, 2008; Rey, Smith, Yoon, Somers, & Barnett, 2007) and it would be interesting, for instance, to relate discrepancies between students' and teachers' perceptions to emotional experiences. A further route would be to gauge teacher emotions in addition to student emotions. This might be critical for understanding associations between relationship quality and emotional experiences due to possible emotional transmission processes taking place in the classroom (see Frenzel, Becker-Kurz, Pekrun, Goetz, & Lüdtke, 2018; Frenzel et al., 2009).

Further, our sample consisted of students who were 16–17 years old. To make our results more generalizable, subsequent studies may downward and upward extend the results (e.g., elementary and primary school students, university students, and adults) and also attempt at replicating them in other contexts (e.g., work context). Researchers could also focus on potential changes in levels of relationship quality and emotional experiences in transitional phases, for instance, when students get a different teacher. Such studies will help to identify consequences of up- and downward spirals of relationship-emotion associations over several school years.

Finally, it should be noted that our study is longitudinal but correlational in nature. One might thus argue that the observed association between relationship quality and emotional experience could be driven by unmeasured variables. For instance, how teachers behave in the classroom in terms of involvement, structure, and autonomy support might have similar effects on how students perceive their relationship to this teacher as well as their emotional experience in class (e.g., Reeve, Jang, Carrell, Jeon, & Barch, 2004; Skinner & Belmont, 1993), which, in turn, could affect their emotional experience. We cannot discard alternative explanations like this based on the data we collected for our study. However, research on social-functional theories of emotions (Frijda, 1986; Keltner & Haidt, 1999; Parkinson, 1996) has generally established direct and strong connections between relationship quality (interpersonal closeness) and emotions, making it unlikely that the revealed association is spurious in educational settings. Still, we consider it to be important that future research either takes an experimental approach to investigate the association between relationship quality and emotional experience or controls for other plausible variables like teacher behavior.

6. Conclusion and outlook

We observed reciprocal associations between student-teacher relationship quality and students' emotions in the classroom. A major strength of our study was the coverage of four different school domains (mathematics, German, English, and French), which revealed that the association between relationship and emotions is largely equivalent across them. This provides solid grounds for researchers to focus on a single subject domain and measure additional variables, such as control and value, without jeopardizing the validity of the measurement due to administering a large number of repetitive items. Such research would help to closely examine how and for whom relationship quality and emotional experience are associated.

One of the main findings in our study was that initial emotional experience is more strongly associated with relationship quality one year later than vice versa. In a next step, it should be investigated whether this difference holds causally and, if so, whether there might be up- and downward spirals of developments based on cumulative effects occurring over extended periods of time. It is plausible that such cumulative effects could be either beneficial or detrimental in nature and our data might be taken to suggest that they might be fueled more strongly by emotional experiences than by student-teacher relationship quality. Should emotions indeed exert stronger causal effects on relationships than the other way around, teachers would be well advised to keep a particular focus on their students' emotions in the classroom and should try to foster their positive and reduce their negative emotions. This seems also important in light of our additional finding that students' initial emotions, but not their initial relationship quality, were associated with objective academic achievement in the subsequent year.

Our observation of differences in the reciprocal associations between relationship quality and emotional experiences also have practical implications. The rather weak associations between relationship quality and subsequent emotional experience suggest that, in terms of CVT, there should be other aspects of the learning environment that ultimately affect cognitive appraisals and thereby influence achievement emotions. Instructors might address these aspects in order to partially compensate for poor relationship quality. For instance, offering interesting materials and tasks, providing encouraging feedback, or allowing for autonomous group work probably fosters students' valuation of a subject and thereby facilitates positive emotional experiences even though relationship quality might be poor. Our data suggest that these efforts might pay off as we observed that positive emotional experiences are in turn strongly associated with a better relationship quality over time. It is an important insight that emotions are a powerful starting point for leveraging the quality of relationships between students and teachers as part of the learning environment. Although proposed in CVT, for instance, such feedback effects of emotions on the environment have rarely been investigated within the framework of the theory. Yet, they seem important especially in educational contexts, which are characterized by myriads of interactions between students and their teachers that might affect well-being and achievement over a prolonged period of time.

One of the ways to enhance positive and reduce negative emotions could be by addressing their causal antecedents, such as control and value appraisals (reappraisal; Pekrun, 2006). The literature additionally provides strategies to help students deal effectively with specific positive and negative emotions at school (Gross, 2014; Harley, Pekrun, Taxer, & Gross, 2019). For instance, according to Goetz and Bieg's (2016) "Promotion of Emotional Intelligence in Learning and Achievement Situations" (PEILAS) model students' emotional intelligence may be fostered to help them manage their emotions. More generally, the literature on self-regulation describes strategies (e.g., mental contrasting with implementation intentions; Oettingen & Gollwitzer, 2010) that are effective not only in fostering emotion regulation (Schweiger Gallo, Bieleke, Alonso, Gollwitzer, & Oettingen, 2018) but also in facilitating positive relationships (Bieleke, Gollwitzer, Oettingen, & Fischbacher, 2017) and therefore would allow targeting both components of the relationship-emotion association.

While we found a general association between relationship quality and emotional experience, the strength of this association clearly differed across emotions. As a consequence, specific effects of emotions on relationship quality and vice versa should be considered in future research. In other words, it is important to focus on specific emotions and not just on pleasant versus unpleasant feelings of students. Further, the reciprocal associations we found for specific emotions mostly emerged across school domains, that is, they seem to be important across different domains.

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CRediT authorship contribution statement

Thomas Goetz: Conceptualization, Funding acquisition, Project administration, Writing - original draft, Writing - review & editing. **Maik Bieleke:** Formal analysis, Methodology, Writing - original draft, Writing - review & editing. **Katarzyna Gogol:** Formal analysis, Methodology. **Jan van Tartwijk:** Conceptualization, Methodology, Writing - original draft, Writing - review & editing. **Tim Mainhard:** Conceptualization, Methodology, Writing - original draft, Writing - review & editing. **Anastasiya A. Lipnevich:** Writing - original draft, Writing - review & editing. **Reinhard Pekrun:** Conceptualization, Funding acquisition, Writing - original draft, Writing - review & editing.

Appendix

The following shows the Mplus input file for estimating Model 1.

```
VARIABLE:
 USEVARIABLES =
       ! aREL1 = class-mean centered relationship quality at T1
       ! aEMO1 = class-mean centered positive emotional experience at T1
       ! aREL2 = class-mean centered relationship quality at T2
       ! aEMO2 = class-mean centered positive emotional experience at T2
       ! aGRA1 = class-mean centered grades at T1 (academic achievement)
       ! aGRA2 = class-mean centered grades at T2 (academic achievement)
       ! aAge1, aSex1 = class-mean centered age and gender at T1
       aEMO1 aREL1 EMO2 REL2 aGRA1 GRA2 aAge1 aSex1

       ! dummies for achievement emotions and school domains
       d_joy d_pri d_ang d_bor d_sha d_ger d_eng d_fre

! interactions between T1 predictors and dummies
R1xDJOY R1xDPRI R1xDANG R1xDBOR R1xDSHA R1xDGER R1xDENG R1xDFRE
       E1xDJOY E1xDPRI E1xDANG E1xDBOR E1xDSHA E1xDGER E1xDENG E1xDFRE;

CLUSTER = ID; !clustered at the student level

DEFINE: ! interaction variables
       E1xDJOY = aEMO1 * d_joy; E1xDPRI = aEMO1 * d_pri;
       E1xDANG = aEMO1 * d_ang; E1xDBOR = aEMO1 * d_bor;
       E1xDSHA = aEMO1 * d_sha; E1xDGER = aEMO1 * d_ger;
       E1xDENG = aEMO1 * d_eng; E1xDFRE = aEMO1 * d_fre;
       R1xDJOY = aREL1 * d_joy; R1xDPRI = aREL1 * d_pri;
       R1xDANG = aREL1 * d_ang; R1xDBOR = aREL1 * d_bor;
       R1xDSHA = aREL1 * d_sha; R1xDGER = aREL1 * d_ger;
       R1xDENG = aREL1 * d_eng; R1xDFRE = aREL1 * d_fre;

ANALYSIS:
       ESTIMATOR = mlr; TYPE = complex;

MODEL:
       aREL1 aEMO1 aGRA1 aAge1 aSex1 !FIML
             d_joy d_pri d_ang d_bor d_sha d_ger d_eng d_fre
             R1xDJOY R1xDPRI R1xDANG R1xDBOR R1xDSHA R1xDGER R1xDENG R1xDFRE
             E1xDJOY E1xDPRI E1xDANG E1xDBOR E1xDSHA E1xDGER E1xDENG E1xDFRE;

       aREL2 on aREL1 aEMO1 aGRA1 aAge1 aSex1 !Predict T2 relationship quality
             d_joy d_pri d_ang d_bor d_sha d_ger d_eng d_fre
             E1xDGER@0 E1xDENG@0 E1xDFRE@0
             E1xDJOY@0 E1xDPRI@0 E1xDANG@0 E1xDBOR@0 E1xDSHA@0;

       aEMO2 on aEMO1 aREL1 aGRA1 aAge1 aSex1 !Predict T2 emotional experience
             d_joy d_pri d_ang d_bor d_sha d_ger d_eng d_fre
             R1xDGER@0 R1xDENG@0 R1xDFRE@0
             R1xDPRI@0 R1xDSHA@0 R1xDANX@0 R1xDBOR@0 R1xDJOY@0;

       aGRA2 on aGRA1 aEMO1 aREL1 aAge1 aSex1 !Predict T2 academic achievement
             d_joy d_pri d_ang d_bor d_sha d_ger d_eng d_fre;
```

Fig. A1. Mplus input file for estimating Model 1.

Table A1
Overview of the Predictors of T2 Relationship Quality Across Models 1 to 9.

Predictor	Model								
	1	2	3	4	5	6	7	8	9
Relationship Quality	0.500*** (0.022)	0.520*** (0.022)	0.495*** (0.022)	0.514*** (0.021)	0.500*** (0.022)	0.500*** (0.022)	0.500*** (0.022)	0.500*** (0.022)	0.499*** (0.022)
Pos. Emotional Experience	0.088*** (0.017)	–	0.091*** (0.017)	–	0.086*** (0.022)	0.068* (0.032)	0.088*** (0.017)	0.088*** (0.017)	0.062 (0.037)
Academic Achievement	0.099*** (0.021)	0.105*** (0.021)	0.101*** (0.021)	0.107*** (0.021)	0.099*** (0.021)	0.100*** (0.021)	0.099*** (0.021)	0.099*** (0.021)	0.099*** (0.021)
Age	−0.022 (0.022)	−0.022 (0.022)	−0.021 (0.022)	−0.022 (0.023)	−0.021 (0.022)	−0.021 (0.022)	−0.022 (0.022)	−0.022 (0.022)	−0.021 (0.022)
Gender	0.014 (0.021)	0.014 (0.021)	0.013 (0.021)	0.014 (0.021)	0.014 (0.021)	0.013 (0.021)	0.014 (0.021)	0.014 (0.021)	0.013 (0.021)
German	0.085*** (0.021)	0.086*** (0.021)	0.086*** (0.021)	0.087*** (0.021)	0.085*** (0.021)	0.085*** (0.021)	0.085*** (0.021)	0.085*** (0.021)	0.085*** (0.021)

(*continued on next page*)

Table A1 (*continued*)

Predictor	Model								
	1	2	3	4	5	6	7	8	9
English	0.027	0.031	0.028	0.031	0.028	0.027	0.027	0.027	0.027
	(0.023)	(0.024)	(0.023)	(0.024)	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)
French	−0.030	−0.030	−0.030	−0.030	−0.029	−0.030	−0.030	−0.030	−0.029
	(0.022)	(0.023)	(0.023)	(0.023)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)
Enjoyment	0.041***	0.000	0.042***	0.000	0.041***	0.041***	0.041***	0.041***	0.042***
	(0.008)	(0.000)	(0.008)	(0.000)	(0.008)	(0.011)	(0.008)	(0.008)	(0.010)
Pride	0.055***	0.000	0.057***	0.000	0.055***	0.027*	0.055***	0.055***	0.026*
	(0.011)	(0.000)	(0.011)	(0.000)	(0.011)	(0.012)	(0.011)	(0.011)	(0.012)
Anger	0.014***	0.000	0.015***	0.000	0.015***	0.008	0.014***	0.014***	0.007
	(0.003	(0.000)	(0.003)	(0.000)	(0.003)	(0.008)	(0.003)	(0.003)	(0.008)
Boredom	0.031***	0.000	0.032***	0.000	0.031***	0.030**	0.031***	0.031***	0.029**
	(0.006)	(0.000)	(0.006)	(0.000)	(0.006)	(0.009)	(0.006)	(0.006)	(0.009)
Shame	−0.001	0.000	−0.001	0.000	−0.001	−0.005	−0.001	−0.001	−0.006
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.007)	(0.000)	(0.000)	(0.007)
EMO_1 × German	–	–	–	–	−0.006	–	–	–	−0.005
					(0.012)				(0.012)
EMO_1 × English	–	–	–	–	−0.004	–	–	–	−0.003
					(0.012)				(0.013)
EMO_1 × French	–	–	–	–	0.014	–	–	–	0.016
					(0.012)				(0.013)
EMO_1 × Enjoyment	–	–	–	–	–	0.018	–	–	0.022
						(0.014)			(0.015)
EMO_1 × Pride	–	–	–	–	–	−0.023	–	–	−0.020
						(0.021)			(0.021)
EMO_1 × Anger	–	–	–	–	–	0.011	–	–	0.012
						(0.012)			(0.012)
EMO_1 × Boredom	–	–	–	–	–	0.023	–	–	0.023
						(0.014)			(0.014)
EMO_1 × Shame	–	–	–	–	–	0.007	–	–	0.007
						(0.010)			(0.010)

Note. Reported are standardized coefficients along with their standard error in parentheses. EMO_1 = T1 Positive Emotional Experience. *$p < .05$; **$p < .01$; ***$p < .001$.

Table A2
Overview of the Predictors of T2 Positive Emotional Experience Across Models 1 to 9.

Predictor	Model								
	1	2	3	4	5	6	7	8	9
Pos. Emotional Experience	0.474***	0.460***	0.483***	0.470***	0.474***	0.474***	0.473***	0.470***	0.469***
	(0.016)	(0.017)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Relationship Quality	0.027*	0.030**	–	–	0.027*	0.027*	0.013	0.006	−0.009
	(0.011)	(0.011)			(0.011)	(0.011)	(0.019)	(0.015)	(0.022)
Academic Achievement	0.045***	0.046***	0.049***	0.051***	0.045***	0.045***	0.045***	0.045***	0.045***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Age	−0.003	−0.003	−0.001	−0.001	−0.003	−0.003	−0.002	−0.003	−0.003
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Gender	−0.005	−0.005	−0.006	−0.006	−0.005	−0.005	−0.005	−0.005	−0.005
	(0.010)	(0.010)	(0.009)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
German	0.007	0.007	0.009	0.009	0.007	0.007	0.007	0.007	0.007
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
English	0.006	0.007	0.008	0.009	0.006	0.006	0.008	0.006	0.008
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
French	−0.038***	−0.038***	−0.038***	−0.038***	−0.038***	−0.038***	−0.035***	−0.038***	−0.035*-** (0.009)
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	
Enjoyment	−0.274***	−0.282***	−0.269***	−0.277***	−0.274***	−0.274***	−0.274***	−0.276***	−0.276*-** (0.012)
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	
Pride	−0.339***	−0.350***	−0.333***	−0.343***	−0.339***	−0.339***	−0.339***	−0.341***	−0.342*-** (0.016)
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	
Anger	−0.121***	−0.124***	−0.120***	−0.123***	−0.121***	−0.121***	−0.121***	−0.122***	−0.122*-** (0.009)
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	
Boredom	−0.248***	−0.255***	−0.245***	−0.251***	−0.248***	−0.248***	−0.249***	−0.250***	−0.250*-** (0.011)
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	
Shame	−0.007	−0.007	−0.007	−0.007	−0.007	−0.007	−0.007	−0.007	−0.007
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
REL_1 × German	–	–	–	–	–	–	0.012	–	0.012
							(0.013)		(0.013)
REL_1 × English	–	–	–	–	–	–	−0.005	–	−0.005
							(0.012)		(0.012)

(*continued on next page*)

Table A2 (*continued*)

Predictor	Model								
	1	2	3	4	5	6	7	8	9
REL_1 × French	–	–	–	–	–	–	0.023* (0.011)	–	0.023* (0.011)
REL_1 × Enjoyment	–	–	–	–	–	–	–	0.022* (0.009)	0.023* (0.009)
REL_1 × Pride	–	–	–	–	–	–	–	0.018 (0.010)	0.017 (0.010)
REL_1 × Anger	–	–	–	–	–	–	–	0.011 (0.009)	0.011 (0.009)
REL_1 × Boredom	–	–	–	–	–	–	–	−0.003 (0.009)	−0.002 (0.009)
REL_1 × Shame	–	–	–	–	–	–	–	0.005 (0.005)	0.005 (0.005)

Note. Reported are standardized coefficients along with their standard error in parentheses. REL_1 = T1 Relationship Quality. *$p < .05$; **$p < .01$; ***$p < .001$.

Table A3
Overview of the Predictors of T2 Academic Achievement Across Models 1 to 9.

Variable	Model								
	1	2	3	4	5	6	7	8	9
Academic Achievement	0.635*** (0.018)	0.636*** (0.018)	0.635*** (0.017)	0.637*** (0.017)	0.635*** (0.018)	0.635*** (0.018)	0.635*** (0.018)	0.635*** (0.018)	0.635*** (0.018)
Relationship Quality	0.033 (0.019)	0.035 (0.019)	0.029 (0.019)	0.031 (0.019)	0.033 (0.019)	0.033 (0.019)	0.033 (0.019)	0.033 (0.019)	0.033 (0.019)
Pos. Emotional Experience	0.060*** (0.014)	0.048*** (0.014)	0.061*** (0.014)	0.049*** (0.014)	0.060*** (0.014)	0.060*** (0.014)	0.060*** (0.014)	0.060*** (0.014)	0.060*** (0.014)
Age	−0.057** (0.020)	−0.057** (0.020)	−0.057** (0.020)	−0.057** (0.020)	−0.057** (0.020)	−0.057** (0.020)	−0.057** (0.020)	−0.057** (0.020)	−0.057** (0.020)
Gender	0.053* (0.020)	0.053* (0.020)	0.053* (0.020)	0.053* (0.020)	0.053* (0.020)	0.053* (0.020)	0.053* (0.020)	0.053* (0.020)	0.053* (0.020)
German	0.131*** (0.022)	0.131*** (0.022)	0.131*** (0.022)	0.131*** (0.022)	0.131*** (0.022)	0.131*** (0.022)	0.131*** (0.022)	0.131*** (0.022)	0.131*** (0.022)
English	0.069** (0.021)	0.069** (0.021)	0.069** (0.021)	0.069** (0.021)	0.069** (0.021)	0.069** (0.021)	0.069** (0.021)	0.069** (0.021)	0.069** (0.021)
French	0.035 (0.021)	0.035 (0.021)	0.035 (0.021)	0.035 (0.021)	0.035 (0.021)	0.035 (0.021)	0.035 (0.021)	0.035 (0.021)	0.035 (0.021)
Enjoyment	0.028*** (0.007)	0.022*** (0.007)	0.028*** (0.007)	0.023** (0.007)	0.028*** (0.007)	0.028*** (0.007)	0.028*** (0.007)	0.028*** (0.007)	0.028*** (0.007)
Pride	0.038*** (0.009)	0.030*** (0.009)	0.038*** (0.009)	0.031** (0.009)	0.038*** (0.009)	0.038*** (0.009)	0.038*** (0.009)	0.038*** (0.009)	0.038*** (0.009)
Anger	0.010*** (0.002)	0.008*** (0.002)	0.010*** (0.002)	0.008** (0.002)	0.010*** (0.002)	0.010*** (0.002)	0.010*** (0.002)	0.010*** (0.002)	0.010*** (0.002)
Boredom	0.021*** (0.005)	0.017*** (0.005)	0.022*** (0.005)	0.017** (0.005)	0.021*** (0.005)	0.021*** (0.005)	0.021*** (0.005)	0.021*** (0.005)	0.021*** (0.005)
Shame	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)

Note. Reported are standardized coefficients along with their standard error in parentheses.
*$p < .05$; **$p < .01$; ***$p < .001$.

Table A4
Model Fit Statistics and χ^2 Tests of Single-Emotion Models.

Emotion	RMSEA	SRMR	CFI	TLI	χ^2 (*df*)	*p*
Enjoyment	0.008	0.007	0.999	0.998	20.05 (18)	.330
Pride	0.011	0.005	0.998	0.996	21.78 (18)	.242
Anxiety	0.008	0.006	0.999	0.998	19.93 (18)	.337
Anger	0.000	0.004	1.000	1.000	10.01 (18)	.932
Boredom	0.000	0.006	1.000	1.000	16.43 (18)	.563
Shame	0.012	0.007	0.998	0.995	22.29 (18)	.219

Table A5
Estimated Cross-lagged Associations in Single-Emotion Models.

Emotion	Cross-lagged Association					
	$EMO_1 \rightarrow REL_2$			$REL_1 \rightarrow EMO_2$		
	β	*SE*	*p*	β	*SE*	*p*
Enjoyment	0.132	0.027	< .001	0.054	0.027	.046
Pride	0.028	0.024	.233	0.029	0.024	.226
Anxiety	0.040	0.023	.074	0.023	0.024	.985
Anger	0.077	0.024	.002	0.056	0.027	.039
Boredom	0.100	0.023	< .001	0.021	0.025	.404
Shame	0.058	0.024	.013	0.038	0.024	.115

Note. REL_1 = T1 relationship quality, EMO_1 = T1 positive emotional experience, REL_2 = T2 relationship quality, EMO_2 = T2 positive emotional experience.

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