Positive Error Climate Promotes Learning Outcomes through Students' Adaptive Reactions towards Errors

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Abstract

Errors are an integral part of the learning process and an opportunity to increase skills and knowledge, but they are often discouraged, sanctioned and derided in the classroom. This study tests whether students' perceptions of being part of an error-friendly classroom context (i.e., a positive classroom error climate) is positively related to students' learning outcomes via students' adaptive reactions towards errors. A total of 563 Italian middle school students from 32 mathematics classes completed a questionnaire on their perceptions of classroom error climate and their reactions towards errors. Students' math grades were used as indicators of their level of learning outcomes. A multilevel model showed that perceived classroom error climate was positively related to math grades via increased adaptive reactions towards errors. Our findings revealed that an error-friendly classroom context is associated with students' adaptive adjustment to errors and to better learning outcomes in mathematics.

Keywords: Error climate, Students' reactions, Middle school, Learning Outcomes, Multilevel.

Positive Error Climate Promotes Learning Outcomes through Students' Adaptive Reactions towards Errors.

1. Introduction

Students make errors every day at school. The learning process itself occurs while learners engage in tasks that refer to knowledge beyond their mastery level (Vygotsky, 1978). Therefore, making errors should be considered as an integral part of the learning process and an opportunity to increase skills and knowledge (Bray & Santagata, 2014). However, the link between errors and evaluation and competition in school (Butera et al., 2021) may increase the students' fear of erring (Grassinger & Dresel, 2017), and ultimately prevent learning.

The learning from errors model (Tulis et al., 2016) is an integrative theoretical framework encompassing the individual processes, personal and environmental features that may promote learning from errors. According to this model, error detection leads to a series of self-regulation processes (i.e., students' emotional arousal, motivational regulation, metacognitive activities), which may, in turn, promote (or not) learning. These processes are influenced by students' personal features (e.g., their error beliefs, Tulis et al., 2018) and their perceptions of the classroom environment (e.g., the perceived error climate, Steuer et al., 2013).

To date, scant empirical research has examined whether the perceived error climate is associated with students' learning outcomes (i.e., grades), via their self-regulated processes (i.e., adaptive reactions towards errors, Grassinger et al., 2018), and no study has tested this association in a comprehensive model, considering other personal features and perceptions of classroom environment facets, as theorised by the learning from errors model (Tulis et al., 2016). In addition, most studies based on the learning from errors model (Tulis et al., 2016) focused on German secondary schools only (e.g., Dresel et al., 2013; Steuer et al., 2013).

Therefore, we aimed to expand the literature in two ways. First, we empirically tested the association of perceived error climate with students' learning outcomes (i.e., grades) via adaptive reactions towards errors, analysed only once so far (Grassinger et al., 2018). In particular, the unique contribution of the present research is that we tested this association in a comprehensive model, controlling for other personal (i.e., students' errors beliefs) and perceived classroom features (i.e., classroom goal structure). Second, we generalized the learning from errors model (Tulis et al., 2016) in another context than the German one by validating the Italian version of the scales related to the theoretical model (e.g., Dresel et al., 2013; Steuer et al., 2013; Tulis et al., 2018), and providing relevant results obtained in the Italian middle school context (i.e., grade 6-8).

1.1. Perceived Error Climate in the Classroom

Using errors as a steppingstone for learning may depend on how they are perceived within the teacher-student relationship during classroom activities. Several studies have shown that students' perceptions of their teachers' behavioural and emotional error-related responses impact their fear of failure and the use of errors as a learning opportunity (e.g., Heinze et al., 2012; Käfer et al., 2019; Spychiger et al., 1999; Spychiger et al., 2006). In the same line, other studies explored the role of teachers' error-handling strategies in conveying errors' meanings (e.g., Santagata, 2004), influencing students' errors (e.g., Rach et al., 2013; Tulis, 2013) and classroom climate perceptions (Soncini et al., 2020).

Teachers have a pivotal role in establishing what Steuer and colleagues (2013) defined as the perceived error climate, namely the error-related classroom climate that depends on how teachers frame, handle, and evaluate students' errors. Starting from the concept of error culture developed and studied in both organisational (Rybowiack et al., 1999) and educational contexts (e.g., Spychiger et al., 2006), Steuer and colleagues (2013) developed a new instrument to assess error climate. Differently from other scales (e.g., Spychiger et al., 2006), the perceived error climate questionnaire assesses only students' perceptions of classroom climate instead of mixing students' perceptions and students personal handling of errors.

The perception of error climate depends on how students interpret its subdimensions, which determine if they feel to be part either of an error-friendly environment (namely, positive error climate) or an environment in which errors are not tolerated (namely, negative error climate). The subdimensions refer to: Teachers' attitudes and behaviours towards errors (i.e., Error tolerance by the teacher, Irrelevance of errors for assessment, Teacher support following errors, Absence of negative teachers' reactions); classmates' reactions (i.e., Absence of negative classmate reactions and Taking the error risk); practical use of errors during learning activities (i.e., Analysis of errors and Functionality of errors for learning).

These eight subdimensions constitute a superordinate and uniform construct, namely the overall error climate (Steuer et al., 2013). Feeling part of an error-friendly environment has been shown to be related to students' higher achievement (Grassinger et al., 2018) and students' adaptive reactions towards errors (Steuer et al., 2013).

1.2. Adaptive Reactions Towards Errors

Students' reactions towards errors refer to the self-regulation processes triggered by error detection, and, in turn, determine if the learner enacts functional and proactive emotional responses and behaviours after making errors. Dresel and colleagues (2013) conceptualized two different reactions towards errors, namely affective-motivational and action reactions. The former refers to the students' positive emotions and high motivation maintained in facing errors, while the latter refers to the behaviours and actions carried out to overcome errors (Grassinger & Dresel, 2017). Several studies analysed the two reactions towards errors, showing that they represent two distinct constructs (Dresel et al., 2013; Grassinger et al., 2015; Grassinger & Dresel, 2017; Steuer et al., 2013, Tulis et al., 2018). Also, consistent with the predictions of the learning from error model (Tulis et al., 2016), one study (Grassinger et al., 2018) pointed out that adaptive affective-motivational reactions predict action reactions towards errors, but not the reverse.

However, little is known about the effect of both adaptive reactions towards errors on students' learning. To the best of our knowledge, only Steuer and colleagues (2013) found a relationship between the reactions towards errors and students' sustained effort in learning. In addition, only one study (Grassinger et al., 2018) tested the effect of adaptive reactions on learning outcomes, such as students' grades.

1.3. Error Beliefs

Maintaining high motivation and using efficient metacognitive processes after making errors also depends on personal characteristics, such as error beliefs, namely students' belief that it is possible to learn from errors (Tulis et al.,2018). The authors showed that error beliefs are related to more adaptive affective-motivational and action reactions towards errors. In the same study, the authors highlighted that error beliefs affect students' reactions towards errors beyond other personal characteristics (e.g., achievement motivation).

Differently from students' error climate perception that may change according to teachers' error-handling strategies (Soncini et al., 2020), error beliefs tend to be a more stable personal characteristic (Tulis et al., 2018). For this reason, in the present study, errors beliefs are considered as a stable personal variable, used as control.

1.4. Classroom Goal Structure

In addition to perceived error climate, which relies on how errors are framed during learning activities, other classroom characteristics may impact students' likelihood to learn from their errors, such as their classroom goal structure (Bardach et al., 2020; Meece et al., 2006). Classroom goal structure refers to students' perceptions of teachers' goal-related messages shared with students during the learning activities (Bardach et al., 2020). Three main goal structures have been studied, namely mastery (the main goal is to properly master the task and the subject), performance-avoidance (the main purpose is avoiding showing one's own incompetence), and performance-approach (the main purpose is to obtain good grades and outperform others; see Midgley et al., 2000).

Classroom goal structure is related to classroom error climate in three ways. First, they both concern students' perceptions of classroom characteristics. Second, classroom goal structure refers to achievement and learning, which depend on errors. Third, both constructs are related to teachers' attitudes and behaviours while teaching and managing the class. Although perceived error climate overlaps to some extent with classroom goal structure, it has been shown to have a distinct effect on students' learning (Steuer et al., 2013).

1.5. The Present Study

The present study aimed to expand the literature about the learning from errors model (Tulis et al., 2016). More precisely, to date, no research has tested the interplay between perceived error climate, the adaptive reactions towards errors and students' learning outcomes in a comprehensive model in which the contribution of personal variables (i.e., error beliefs) and other classroom variables (i.e., classroom goal structure) were controlled for. Indeed, although Tulis and colleagues' (2016) theoretical model includes all these constructs, no empirical research has so far included them in the same analysis: Grassinger and colleagues (2018) did test the association between perceived error climate, adaptive reactions towards errors and students' achievement, but their research neither included error beliefs—studied by Tulis and colleagues (2018) in conjunction with reactions towards errors—nor classroom goal structure—studied by Steuer and colleagues (2013) in conjunction with perceived error climate and adaptive reactions towards errors. Therefore, in the present study we analysed how perceived error climate is associated with students' mathematics grades via adaptive reactions towards errors, controlling for perceived classroom goal structure and error beliefs. In addition, since most of the studies that implemented this model have been carried out in the

German context, we provided further data on the generalizability of the model and on the validity and reliability of the related measures in another national educational context.

Accordingly, the present study had two main aims: (1) to test a comprehensive model that hypothesises that perceiving a positive error climate is related to students' learning outcomes in mathematics (i.e., mathematics grades), via adaptive reactions towards errors, while controlling for both error beliefs and classroom goal structure; and (2) to test for the first time the factorial structure and reliability of the error-related measures (i.e., error climate questionnaire, adaptive reactions towards errors and error beliefs scales) in a different context than Germany (i.e., Italy).

The following main hypothesis was formulated (Figure 1). We expected that perceived error climate would indirectly affect students' learning outcomes (i.e., grades in mathematics) via the two adaptive reactions towards errors (H1). More precisely, perception of a more positive error climate should be directly related to more adaptive affective-motivational reactions towards errors (H1a), which in turn, should be directly associated with more adaptive action reactions towards errors (H1b), which should result in higher students' learning outcomes (H1c), while the students' error beliefs and their classroom goal structure are controlled for.

Figure 1.

Overview of the Hypotheses

(Figure 1 here)

Note. The black arrows refer to the hypothesized indirect effect of perceived classroom error climate on students' learning outcomes via affective-motivational reactions and action reactions towards errors (H1). This effect is the result of the three direct effects (i.e., H1a, H1b, H1c). Control variables are not represented in this Figure.

To test our hypotheses, we carried out a correlational study in Italian middle schools, and administered a questionnaire to students during mathematics classes, which have some interesting characteristics. First, errors in mathematics are generally more easily detectable than in other subjects because the answers expected in tests and exercises tend to be more univocal. Second, a peculiar feature of mathematics lessons in Italy is that students are often engaged in exercises in front of the class (i.e., exercises solved at the blackboard), and their errors are discussed publicly (Santagata, 2004). During this teaching practice, teachers' error handling strategies are implemented in front of all the students, thereby making their strategy highly salient. Third, according to the Italian middle school curricula (i.e., grade 6-8; Law 89/2009), mathematics is the subject with the second-highest number of teaching hours per week, after Italian. Students spend several hours in mathematics classes (between 6 to 9 hours), and mathematics is a core subject in the Italian school curriculum.

2. Method

2.1. Sample and Procedure

As simulation studies demonstrated that it is possible to obtain unbiased estimates in multilevel models even with samples including between 10 and 30 between-level units (i.e., classrooms; Huang, 2018; McNeish & Stapleton, 2016), we aimed at recruiting approximately 30 classrooms. A total of 563 students (M_{age} = 11.98, SD = 0.79, 54.2% girls, 4.7% with Specific Learning Disabilities certification) from 32 classes ($M_{\text{Students per class}}$ = 17.59) from three middle schools of one Italian region completed the questionnaire. Among these students, 4.1% were born in another country than Italy, and 15.8% spoke another language in addition to Italian. Nevertheless, all the students were able to understand the questionnaire and to complete it adequately, and thus, we did not exclude participants from the total sample.

The questionnaire comprised several self-report scales that referred to the mathematics class. As for the three error-related scales (i.e., perceived error climate, adaptive reactions toward errors and error beliefs questionnaires, see Measures section), a forward-backward translation procedure had been performed. More precisely, a bilingual expert carried out the first translation from German to Italian. Then, another bilingual expert translated the Italian version back into German. Finally, the researchers and the two bilingual experts created the final translation, adjusting words and expressions to the Italian context.

Before data collection, we obtained the University Ethical Board's approval, the school headmasters' and teachers' agreement, and the parents' signed consent for each student. Data collection took place between December 2019 and February 2020 during mathematics classes. A trained researcher administered the questionnaire to the students who had from 30 to 45 minutes to complete it. After the first term of the school year (January 2020), mathematics teachers provided the summative mathematics grades obtained by the students, which were used as our dependent variable.

2.2. Measures

Perceived Error Climate. We used the Perceived error climate questionnaire developed and validated by Steuer and colleagues (2013). The scale comprises 31 items, divided into eight dimensions: Error tolerance by the teacher (e.g., "*In our math class errors are nothing bad for our teacher*", 4 items); Irrelevance of errors for assessment (e.g., "*If someone in our math class makes an error, he/she will get a bad grade*."-reverse coded, 4 items); Teacher support following errors (e.g., "*If someone in our math class can't solve an exercise correctly, the teacher will help him/her*", 4 items); Absence of negative teacher reactions to errors (e.g., "*If someone in our math class makes errors, the teacher often looks annoyed*"-reverse coded, 4 items); Absence of negative classmate reactions to errors (e.g., "*If someone in our math class solves an assignment incorrectly, his/her classmates will mock him/her*"-reverse coded, 4 items); Taking the error risk (e.g., *"In our math class a lot of students would rather say nothing at all than something that is wrong*."-reverse coded, 3 items); Analysis of errors (e.g., "*In our math class errors are investigated in detail.*", 4 items); Functionality of errors for learning (e.g., "*In our math class wrong answers on assignments are used to learn something*", 4 items). According to Steuer and colleagues (2013), the perceived error climate questionnaire is reliable as an eight-factor structure and a superordinate and uniform factor structure scale.

Adaptive reactions towards errors. Students' reactions following errors were measured with the two subscales of adaptive reactions towards errors developed and validated by Dresel and colleagues (2013). The scale consisted of 13 items divided into two dimensions: adaptive affective-motivational reactions (e.g., "*During a math class, if I say something incorrect, I still enjoy the class*", 6 items); and adaptive action reactions towards errors (e.g., "*When I can't do something in mathematics, then I try even harder the next time around*", 7 items).

Error beliefs. We used the 5-item scale developed by Tulis and colleagues (2018). The items focus on the importance of making errors for learning something new (e.g., "*I can learn something from my errors"*).

Classroom goal structure. The classroom goal structure was measured using the Pattern of Adaptive Learning Survey (Midgley et al., 2000). It comprised 14 items divided into three subdimensions: Mastery (e.g., "*In our math class, it is important to understand the subject well*", 6 items), performance-approach (e.g., "*In our math class, it is important to get good grades in tests*", 3 items), and performance-avoidance classroom goal structure (e.g., "*In our math class, it is important not to do worse than others*", 5 items).

Math grades. In the Italian education system, grades vary from 1 to 10, and 6 is the pass-fail cut-off grade. During the school year, students undergo two summative evaluations for each subject: the first, at the end of the first school semester (mid-September/end of January), and the second, at the end of the school year (June). These grades result from the average of all the grades obtained by the students in various tests during the two semesters. In the present study, students' mathematics grades were provided by their teachers and refer to students' first semester summative grades (obtained in January 2020).

All the items were presented alongside a 5-point Likert scale, ranging from 1 ("*Not at all true*") to 5 ("*Totally true*"). The questionnaire also included demographic variables (i.e., sex and age), which were added as controls[1]. All items of the scales are reported in Table S1, both in the Italian and English versions.

2.3. Data Analysis

Although missing data were very few (1.15% in total, highest percentage in a single variable 2.66%), a significant Little's MCAR test suggested data were not missing completely at random, $\chi^2(928) = 11075.315$, $p < .001$. Therefore, since imputation is preferred to listwise deletion (Graham, 2009), missing data were imputed with the Expectation Maximization algorithm in SPSS Version.

Then, since the error-related scales (namely, perceived error climate, adaptive reactions towards errors and error beliefs) have not previously been translated and validated in Italian, we ran a series of confirmatory factor analyses (CFA) to test their factor structures. We also ran a CFA for the classroom goal structure to test if the two performance dimensions (i.e., performance-approach and performance-avoidance) are empirically distinguishable. CFAs were run with Mplus (version 6, Muthén & Muthén, 2007) using the TYPE = COMPLEX command to account for the nested structure of the data (i.e., students nested within classrooms). We set all the models using the Maximum Likelihood Robust chi-square estimator (MLR). We followed the cut-off criteria suggested by Bentler (1990) and Hu and Bentler (2009) to assess the models' fit. More precisely, Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) close to .95, Root Mean Square Error of Approximation (RMSEA) lower than .06 and Standardised Root-Mean Residual (SRMR) lower than .08 were taken into

[1] In the questionnaire we also measured the personal achievement goals (Elliot & McGregor, 2008). However, in the current article we did not consider this variable because we focused on students' perceptions of classroom features (i.e., goal structure and error climate) related to teachers' attitudes, messages, and behaviours. Results including these variables are available upon request from the corresponding author.

consideration. To compare models, we used the Satorra-Bentler scaled chi-square formula (Satorra & Bentler, 2010) and the conventional rule of thumb that the smaller the RMSEA and the larger the CFI, the better the fit.

Finally, we tested the hypothesized indirect effects (Figure 1) by running a two-level model, to adequately account for the variance components in the nested data (students in classrooms). Running a two-level model is recommended when the observations are not independent (i.e., students in the same classroom are likely to be more similar than students in different classrooms; see Hox et al., 2017). In this study, students represent the within-classroom level and classrooms represent the between-classroom level. At the within-classroom level, we estimated direct and indirect effects of perceived error climate (predictor) on students' learning outcomes (dependent variable) via the two affective-motivational and action reactions (mediators). We added to the model the two theoretically relevant control variables (error beliefs and classroom goal structure) and two demographic control variables (age and gender). At the between-classroom level, we regressed students' learning outcomes (dependent variable) and the adaptive reactions towards errors (mediators) on perceived error climate and classroom goal structure (contextual predictor and control). Therefore, perceived error climate and classroom goal structure, considered as students' perceptions of classroom characteristics, have been controlled at the within- and between-classroom levels as suggested by Lam and colleagues (2015) and Morin and colleagues (2014).

3. Results

3.1. Confirmatory Factor Analyses

Regarding the perceived classroom error climate, we tested three different models: the one-factor model (Model 1), the eight-factor model (Model 2), and the superordinate factor model (Model 3). Model 1 presented a poor fit with the data, whereas Model 3 and Model 2 have acceptable fit indexes (Table 1).

As for the Adaptive reaction towards errors scale, we tested the two-factor structure of the 13-item scales, and the results showed a poor fit with the data, $\chi^2(64) = 359.052$, $p < .001$, RMSEA = 0.090, 90% C.I. RMSEA = 0.081- 0.100, CFI = 0.869, TLI = 0.840, SRMR = 0.076). Modification indices highlighted that one item of the affective-motivational subscale resulted in higher loadings on the action reactions subscale, and by deleting it, the χ^2 decreased. One possible explanation is that the wording of the item may have been ambiguous (i.e., "*In mathematics when I don't know how to do something, I still want to work*"), and thus, students may have referred to an action (working) made after erring (i.e., action reactions) rather than to the motivation or affect regulation (i.e., affective-motivational reactions). Therefore, we removed this item from subsequent analyses, and we compared the two-factor structure with 12 items (Model 2) with the one-factor structure with 12 items (Model 1). Results revealed that Model 2 had a better fit than Model 1.

Finally, we tested the unifactorial structure of the error beliefs scale, which fitted the data well, and we compared two models for the classroom goal structure: A two-factor model in which one factor represented the merged performance classroom structures (approach and avoidance) and the other factor represented the mastery structure (Model 1), and a three-factor model in which the items loaded on the three subscales (Model 2). Model 2 fitted the data better than Model 1.

(Table 1 here)

3.2. Descriptive statistics

We created composite scores for each variable, by averaging answers to the respective items. As reported in Table 2, Cronbach's alphas showed satisfactory reliability for all measures and all the variables are associated in the expected direction at the bivariate level. For an easier comparison, descriptive statistics and reliability of the German and Italian scales are provided in the Supplementary Online Materials (Table S2).

(Table 2 here)

3.3. Two-Level Path Analysis

The analysis of the intraclass correlations (ICC, Table 2) showed that mathematics grades significantly varied across the classrooms, as did the affective-motivational reactions towards errors. The action reactions towards errors had a nearly significant between-classroom level variance (p = .06) and the ICC was higher than .05. Therefore, data analysis was run with a two-level approach, including classroom-level predictors of adaptive reactions towards errors and mathematics grades[2].

In the path analysis we tested the hypothesized indirect effect of perceived classroom error climate on students' mathematics grades via the two adaptive reactions towards errors (i.e., affective-motivational and actions reactions towards errors), controlling for students' error beliefs and classroom goal structure. To reduce the complexity of the model, we used only the single composite score of perceived error climate as within-level and between-classroom level predictor[3], since the superordinate factor structures fitted well the data. We used Maximum Likelihood Robust (MLR) as estimation method. We controlled for error beliefs, age, and gender only at the within-classroom level and for classroom goal structures both at the within and at the between-classroom level.

The findings of the two-level path model are presented in Figure 2 and in Table 3. Supporting our main hypothesis (H1), the sequential indirect effect of the perceived classroom error climate on students' learning outcomes via both adaptive reactions towards errors was significant, b = 0.05, $S.E.$ = 0.02, p = .002. Thus, perceiving positive classroom error climate

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[2] To explore if our model's random slopes variances were significant, we tested the random slopes for each of the main relations. Findings suggested that associations between perceived error climate, adaptive reactions towards errors, and students' grades did not significantly vary across classrooms (ps > .91; see Table S3 in the Supplementary Online Materials).

[3] We also ran the path analysis with the eight error climate dimensions as within-level predictors and the single composite score as between-level predictor, but the program could not compute the analysis (because of the complexity of the model). Nevertheless, we provided in the Supplementary Online Materials (Table S4) the results of a within-subject path analysis, in which we entered the eight subdimensions as predictors.

was related to more adaptive affective-motivational reactions towards errors (H1a), which, in turn, was related to more adaptive action reaction towards errors (H1b), which was related to high students' learning outcome (H1c). Differently from our expectation, we also found a significant direct path between affective-motivational reactions and students' learning outcomes, and a significant indirect effect of perceived error climate on students' learning outcomes via affective-motivational reactions (b = 0.17, *S.E.* = 0.06, p = .002, Figure 2). At the between-level, we found a positive relationship between perceived classroom error climate and affective-motivational reactions, and between perceived classroom error climate and learning outcomes (Table 3).

Figure 2
Two-Level Path Model Results. Significant Unstandardized Results at the Within-Level Are Shown. Standard Errors are Presented in Brackets.

(Figure 2 here)

Note. The indirect effect at the bottom of the figure represents the indirect effect of perceived error climate on students' learning outcomes (H1). The dashed arrows represent the estimated paths not part of the hypothesized model. Only significant estimates of these paths are shown. Results of control variables are reported in Table 3. ** p < .01, *** p < .001.

As for the classroom goal structure, at the within-classroom level mastery classroom goal structure was associated with higher adaptive action reactions towards errors, whereas performance-avoidance classroom goal structure was negatively associated with affective-motivational reactions and students' learning outcomes (Table 3). On the contrary, no significant relation was found at the between-classroom level. Further, we found a positive association between error beliefs and adaptive action reactions to errors, and a negative relation between gender and affective-motivational reactions, indicating that boys reacted more adaptively to errors than girls.

(Table 3 here)

4. Discussion

This study was set out to advance the existing knowledge on the learning from errors model (Tulis et al., 2016) in different ways. We tested the indirect relations between perceived error climate and students' learning outcomes via adaptive reactions towards errors in a comprehensive multi-level model which included other variables, namely students' error beliefs and classroom goal structure. Moreover, we generalised existing evidence (e.g., Dresel et al., 2013; Steuer et al., 2013; Tulis et al., 2018) to another context than the German one, by administering error-related scales to Italian middle school students for the first time.

The first contribution pertains to our main hypothesis that perceived error climate is indirectly associated with students' learning outcomes via two adaptive reactions towards errors (i.e., affective-motivational and action reactions), while controlling for error beliefs and classroom goal structure. Differently from previous research (i.e., Grassinger et al., 2018; Steuer et al., 2013; Tulis et al., 2018) that tested the associations between parts of the model, we provided empirical evidence for a comprehensive model that allows understanding the psychological and classroom dynamics related to the learning from errors process.

In addition to the hypothesized indirect effect, the affective-motivational reactions towards errors were also directly related to students' learning outcomes, underling the central role of emotional and motivational regulations in determining the learning-from-errors process (Tulis et al., 2016) and the actual learning. Broadening the focus, these results are in line with other findings based on self-regulated learning theories (Heemsoth & Heinze, 2016; Ramdass & Zimmerman, 2008), which pointed out the role of emotional, motivational, and cognitive strategies in supporting learning from errors.

The association between error beliefs and action reactions is partially in line with Tulis and colleagues (2018) who found a small association also with affective-motivational reactions. As explained by the authors, it is plausible that believing that errors are useful for learning may push students to activate cognitive responses (such as deeply analysing the error).

As for classroom goal structures, students' perception of mastery structure was positively associated with action reactions towards errors, whereas students' perception of performance-avoidance classroom structure was negatively related to affective-motivational reactions towards errors and students' mathematics grades. These results are in line with previous literature (see Meece et al., 2006; Givens Rolland, 2012), supporting that mastery teaching orientations promote students' motivation and learning outcomes.

An additional methodological conclusion of this study stems from the two-level structure of the analyses. At the between-classroom level, we found a positive relationship between perceived classroom error climate and affective-motivational reactions towards errors and learning outcomes. Therefore, in addition to individual differences in the perception of error climate, students in classrooms with a higher perception of a positive error climate had more adaptive affective-motivational reactions towards errors and better math grades. The first result corroborated the findings of Steuer and colleagues (2013), supporting the idea that shared perception of the error climate (i.e., perception of error climate at the classroom-level) is related to the personal affective-motivational reactions. The second result adds to Steuer and colleagues' results, which showed that perceived error climate at the classroom-level was related to students' efforts' regulation.

The second contribution of the present research relies on the analysis of the factor structure and the internal consistency of the error-related scales. We confirmed that the perceived error climate questionnaire, the adaptive reactions towards errors scale, and the error belief scale are reliable and valid instruments to measure error-related perception, reactions, and beliefs in Italian middle school context. In line with previous results (Steuer et al., 2013; Dresel et al., 2013; Tulis et al., 2018) our findings confirmed both the eight-factor and the superordinate factor structures of the perceived error climate questionnaire, the two-factor structure with 12 items of the adaptive reactions towards errors scale, and the one-factor structure of the error beliefs scale. Furthermore, correlations between the error-related variables were in the expected direction (i.e., positive) and medium-high, suggesting convergent validity. The fact that these results replicated in two different countries (Germany and Italy, see Table S2) supports for the first time the external validity of both the model and the instruments, as far as generalization to different national contexts is concerned.

In addition, we provided insights on Italian middle school students' error beliefs, perceptions of error climate and reactions towards errors for the first time. Our results corroborated previous findings (Steuer et al., 2013; Tulis et al., 2018), showing that participants on average perceived an overall positive error climate, held positive beliefs about errors and reacted adaptively after erring. Although a systematic intercultural comparison is beyond the scope of the present study, it should be noted that other research carried out in different countries with different measures reported similar findings. Pan and colleagues (2020) found that Canadian and US students believed that making errors is part of the learning process and something positive for learning. They endorsed the value of error correction, but only a minority among them expressed motivation to try harder after erring. Kyaruzi and colleagues (2020) reported that Tanzanian students tended to use errors fruitfully for their learning and perceived their teachers as supportive after erring.

Furthermore, our results support prior findings on teachers' error-related practices. Indeed, the perceived error climate dimensions are largely related to teachers' attitudes (the first four dimensions) and management of classmates' reactions and errors (the other four dimensions). Students' high rating of teachers' positive affective responses, supportive behaviours, and error-based teaching methods (e.g., analysis of errors dimension) are related to students' better achievement, lower fear of making errors and more positive perceptions of the classroom climate (see, Heinze et al., 2012; Kyaruzi et al., 2020; Rach et al., 2013; Tulis, 2013). Overall, although cultural differences in teachers' error handling practices may exist (Santagata, 2005; Stigler & Hiebert, 1999), these findings corroborated the idea that teachers have a pivotal role in determining how students react to errors and use them effectively for learning.

4.1. Limitations and Further Research

The present study has some limitations. First, although the hypothesized and found sequential indirect effect is theoretically grounded in relevant literature, data were correlational, and thus causality could not be firmly established. Future research should aim at extending and replicating our findings with longitudinal and experimental designs.

Second, the use of self-report measurements, through which we measured the predictor and the mediators, may lead to common method bias. Although our dependent variable derived from a different source (students' grades obtained from teachers) than the independent ones (Podsakoff et al., 2003), future research could include observational techniques to assess students' perceptions or teachers' behaviours (see Santagata, 2005; Tulis, 2013). Furthermore, given our use of self-reported questionnaires to assess students' perceptions of errors, we could not know the error situation students were thinking about (e.g., making errors at the blackboard, or during homework correction). Future research could limit this ambiguity by using realistic vignettes (see Bauer, 2008) or interviewing students (as in Santagata, 2004).

Another limitation of this study concerns the focus on specific variables (e.g., classroom goal structure), a specific domain (i.e., mathematics) and school level (i.e., middle school). Indeed, we did not consider other aspects of the classroom—such as the assessment method (i.e., formative vs normative)—or the characteristics of the students—such as their previous mathematics knowledge—that may affect the perceptions of error climate and their adaptive reactions towards errors. Furthermore, students' perceptions of error climate, error beliefs and reactions may change in different domains, as highlighted by Tulis and colleagues (2018), or throughout the school levels, as happens for other students' features (e.g., mastery goal, interest and academic self-concept, Yeung et al., 2011; Liu & Wang, 2005). Future research could therefore explore which other variables (e.g., the relevance of formative assessment in class, previous knowledge) may affect students' perceptions of error climate and their reactions towards errors, and if these variables differ among school domains and levels.

Finally, our dependent variable, namely students' mathematics grades, cannot be considered a full indicator of students' learning, but only one parameter to assess students' learning process. Grades result from a complex interplay between several factors (e.g., Matteucci et al., 2008), which includes students-related variables (e.g., their motivation, commitment, and cognitive resources) and teachers-related variables (e.g., their knowledge about students' characteristics, Dompnier et al., 2006). Therefore, the definition of grades as learning outcomes may reduce the complexity of both the processes involved in scholastic judgments and learning. Further research should assess other variables related to the learning process, such as acquisition of new knowledge, besides learning outcomes expressed in grades.

4.2. Practical Implications

Our findings suggest that students' perceptions of a positive error climate help them to positively adjust to errors and improve their learning outcomes. Establishing a positive error climate depends on how teachers' handle student' errors during the lessons (Soncini, 2020). Therefore, in line with previous research on teacher training (e.g., Heemsoth & Heinze, 2016; Kyaruzi et al., 2020), our findings might be used to develop training to make teachers aware of the importance of establishing a positive error climate to improve students' self-regulated processes (i.e., adaptive reactions towards errors) and learning.

4.3. Conclusion

The present study contributes to enrich the line of research on the learning from errors model (Tulis et al., 2016) by highlighting that students' perceptions of the error climate is a key variable strictly intertwined with their reactions towards errors and, in turn, with learning outcomes. Broadening the focus further, this study also echoes all the research findings that underline the importance of establishing an error friendly environment (e.g., Kafer et la., 2019; Steuer et al., 2013; Spychiger et al., 2006) and, more generally, a supportive classroom environment to promote students' emotions, motivations, and learning process (e.g., Gasser et al., 2018; Frenzel et al., 2007; Wang et al., 2020).

Declarations of interest

None.

References

Bardach, L., Oczlon, S., Pietschnig, J., & Lüftenegger, M. (2020). Has achievement goal theory been right? A meta-analysis of the relation between goal structures and personal achievement goals. *Journal of Educational Psychology*, *112*, 1197-1220. Retrieved from: https://psycnet.apa.org/buy/2019-60501-001

Bentler, P. M. (1990). Comparative fit indexes in structural models. *Psychological Bulletin, 107*, 238–246. https://doi.org/10.1037/0033-2909.107.2.238

Bray, W., & Santagata, R., (2014). Making mathematical errors "springboards for learning". In K. Karp, and A. R. McDuffie (Eds), *Annual Perspectives in Mathematics Education: Using Research to Improve Instruction* (pp. 239–248). National Council of Teachers of Mathematics.

Butera, F., Świątkowski, W., & Dompnier, B. (2022). Competition in education. In S. Garcia, A. Tor, & A. Elliot, (Eds.), *The Oxford Handbook on the Psychology of Competition*. New York, NY: Oxford University Press. Online first: https://doi.org/10.1093/oxfordhb/9780190060800.013.24

Dompnier, B., Pansu, P., & Bressoux, P. (2006). An integrative model of scholastic judgments: Pupils' characteristics, class context, halo effect and internal attributions. *European Journal of Psychology of Education*, *21*, 119-133. https://doi.org/10.1007/BF03173572

Dresel, M., Schober, B., Ziegler, A., Grassinger, R., & Steuer, G. (2013). Affektiv-motivational adaptive und handlungsadaptive Reaktionen auf Fehler im Lernprozess. *Zeitschrift für Padagogische Psychologie*. https://doi.org/10.1024/1010-0652/a000111.

Elliot, A. J., & McGregor, H. A. (2001). A 2x2 achievement goal framework. *Journal of Personality and Social Psychology*, *80*, 501-519. https://doi.org/10.1037//0022-3514.80.3.501.

Frenzel, A. C., Pekrun, R., Goetz, T. (2007). Perceived learning environment and students' emotional experiences: A multilevel analysis of mathematics classrooms, *Learning and Instruction*, 17, 478-493. https://doi.org/10.1016/j.learninstruc.2007.09.001

Gasser, L., Grütter, J., Buholzer, A., & Wettstein, A. (2018). Emotionally supportive classroom interactions and students' perceptions of their teachers as caring and just. *Learning and Instruction*, *54*, 82-92. https://doi.org/10.1016/j.learninstruc.2017.08.003

Givens Rolland, R. (2012). Synthesizing the evidence on classroom goal structures in middle and secondary schools: A meta-analysis and narrative review. *Review of Educational Research*, *82*, 396-435. http://doi.org/10.3102/0034654312464909

Grassinger, R., & Dresel,M. (2017).Who learns from errors on a class test? Antecedents and profiles of adaptive reactions to errors in a failure situation. *Learning and Individual Differences*, 53, 61–68. https://doi.org/10.1016/j.lindif.2016.11.009.

Grassinger, R., Scheunpflug, A., Zeinz, H., & Dresel, M. (2018). Smart is who makes lots of errors? The relevance of adaptive reactions to errors and a positive error climate for academic achievement. *High Ability Studies*, *29*, 37-49. https://doi.org/10.1080/13598139.2018.1459294

Graham, J. W. (2009). Missing data analysis: Making it work in the real world. *Annual Review of Ppsychology*, *60*, 549-576. https://doi.org/10.1146/annurev.psych.58.110405.085530

Heinze, A., Ufer, S., Rach, S., & Reiss, K. (2012). The student perspective on dealing with errors in mathematics class. In E. Wuttke and J. Seifried (Eds.). *Learning From Errors at School and at Work* (pp. 65-79). Verlach Barbara Budrich.

Heemsoth, T., & Heinze, A. (2016). Secondary school students learning from reflections on the rationale behind self-made errors: A field experiment. *The Journal of Experimental Education*, *84*, 98-118. https://doi.org/10.1080/00220973.2014.963215

Hox, J. J., Moerbeek, M., & Van de Schoot, R. (2017). *Multilevel Analysis: Techniques and Applications*. Routledge.

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*, 1-55. https://doi.org/10.1080/10705519909540118

Huang, F. L. (2018). Multilevel modeling myths. *School Psychology Quarterly*, *33*, 492-499. http://doi.org/10.1037/spq0000272

Käfer, J., Kuger, S., Klieme, E., & Kunter, M. (2019). The significance of dealing with mistakes for student achievement and motivation: results of doubly latent multilevel analyses. European *Journal of Psychology of Education*, 34, 731–753. https://doi.org/10.1007/s10212-018-0408-7.

Kyaruzi, F., Strijbos, J. W., & Ufer, S. (2020). Impact of a short-term professional development teacher training on students' perceptions and use of errors in mathematics learning, *Frontiers in Education*, *5,* 1-15. https://doi.org/10.3389/feduc.2020.559122

Lam, A. C., Ruzek, E. A., Schenke, K., Conley, A. M., & Karabenick, S. A. (2015). Student perceptions of classroom achievement goal structure: Is it appropriate to aggregate? *Journal of Educational Psychology, 107*, 1102-1115. http://dx.doi.org/10.1037/edu0000028

from: www.gazzettaufficiale.it/gunewsletter/dettaglio.jsp?service=1&datagu=2009-0715&task=dettaglio&numgu=162&redaz=009G0099&tmstp=1247730678254

Liu, W. C., & Wang, C. K. J. (2005). Academic self-concept: A cross-sectional study of grade and gender differences in a Singapore secondary school. *Asia Pacific Education*

Review, *6*, 20-27. Retrieved from: https://link.springer.com/content/pdf/10.1007/BF03024964.pdf

Matteucci, M.C., Carugati, F., Selleri, P., Mazzoni, E., & Tomasetto, C. (2008). Teachers' judgment from a European psychosocial perspective. In F. Columbus (Ed.), *Teachers and Teaching: Strategies, Innovations and Problem Solving (pp.31-55).* Nova Science Publishers.

McNeish, D. M., & Stapleton, L. M. (2016). The effect of small sample size on two-level model estimates: A review and illustration. *Educational Psychology Review, 28,* 295–314. http://dx.doi.org/10.1007/s10648-014-9287-x

Meece, J. L., Anderman, E. M., & Anderman, L. H. (2006). Classroom goal structure, student motivation, and academic achievement. *Annual Review of Psychology*, 57, 487–503. https://doi.org/10.1146/annurev.psych.56.091103.070258.

Midgley, C., Maehr, M. L., Hruda, L. Z., Anderman, E., Anderman, L., Freeman, K. E., & Urdan, T. (2000). *Manual for the Patterns of Adaptive Learning Scales*. Ann Arbor: University of Michigan.

Morin, A. J. S., Marsh, H. W., Nagengast, B., & Scalas, L. F. (2014) Doubly latent multilevel analyses of classroom climate: an illustration, *The Journal of Experimental Education,* 82, 143-167. https://doi.org/10.1080/00220973.2013.769412

Muthén, L. K., & Muthén, B. O. (2007). *Mplus User's Guide* (6th ed.). Los Angeles, CA: Muthén & Muthén.

Pan, S. C., Sana, F., Samani, J., Cooke, J., & Kim, J. A. (2020). Learning from errors: students' and instructors' practices, attitudes, and beliefs. *Memory, 28*, 1105-1122. https://doi.org/10.1080/09658211.2020.1815790

Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology*, *88*, 879-903. https://doi.org/10.1037/0021-9010.88.5.879

Rach, S., Ufer, S., & Heinze, A. (2013). Learning from errors: effects of teachers training on students' attitudes towards and their individual use of errors. *PNA*, 8, 21–30.

Ramdass, D., & Zimmerman, B. J. (2008). Effects of self-correction strategy training on middle school students' self-efficacy, self-evaluation, and mathematics division learning. *Journal of Advanced Academics*, *20*, 18-41. https://doi.org/10.4219/jaa-2008-869

Revision of the structure, organisation and teaching of pre-school and first cycle of education Act, 2009/89 (Italy) [Revisione dell'assetto ordinamentale, organizzativo e didattico della scuola dell'infanzia e del primo ciclo di istruzione].

Retrieved Rybowiak, V., Garst, H., Frese, M., & Batinic, B. (1999). Error Orientation Questionnaire (EOQ): reliability, validity, and different language equivalence. *Journal of Organizational Behavior*, 20, 527-547. https://doi.org/10.1002/(SICI)1099-1379(199907)20:4<527::AID-JOB886>3.0.CO;2-G

Santagata, R. (2004). "Are you joking or are you sleeping?" Cultural beliefs and practices in Italian and US teachers' mistake-handling strategies. *Linguistics and Education*, *15*, 141-164. https://doi.org/10.1016/j.linged.2004.12.002

Santagata, R. (2005). Practices and beliefs in mistake-handling activities: a video study of Italian and US mathematics lessons. *Teaching and Teacher Education*, 21, 491–508. https://doi.org/10.1016/j.tate.2005.03.004

Satorra, A., & Bentler, P.M. (2010). Ensuring positiveness of the scaled difference chi-square test statistic. *Psychometrika*, 75, 243-248. https://doi.org/10.1007/s11336-009-9135-y

Soncini, A., Matteucci, M. C., & Butera, F. (2021). Error handling in the classroom: an experimental study of teachers’ strategies to foster positive error climate. *European*

Journal of Psychology of Education, *36*, 719-738. https://doi.org/10.1007/s10212-020-00494-1

Spychiger, M., Oser, F., Hascher, T., & Mahler, F. (1999). Entwicklung einer Fehlerkultur in der Schule [Development of an error culture at school]. In W. Althoff (Ed.), *Fehlerwelten: Vom Fehlermachen und Lernen aus Fehlern* (pp. 43–70). Opladen, Germany: Leske+Budrich

Spychiger, M., Kuster, R., & Oser, F. (2006). Dimensionen von fehlerkultur in der schule und deren messung [Dimensions of error culture at school and the measuring]. *Revue Suisse des Sciences de l'Education*, *28*, 87–110. Retrieved from: https://www.pedocs.de/frontdoor.php?source_opus=4140.

Steuer, G., & Dresel, M. (2015). A constructive error climate as an element of effective learning environments. *Psychological Test and Assessment Modeling*, 57, 262–275 Retrieved from: https://www.questia.com/library/journal/1P3-3728625781/a-constructive-error-climate-as-an-element-of-effective.

Steuer, G., Rosentritt-Brunn, G., & Dresel, M. (2013). Dealing with errors in mathematicss classrooms: structure and relevance of perceived error climate. *Contemporary Educational Psychology*, *38*, 196–210. https://doi.org/10.1016/j.cedpsych.2013.03.002.

Stigler, J. W., & Hiebert, J. (2009). *The teaching gap: Best ideas from the world's teachers for improving education in the classroom*. Simon and Schuster.

Tulis, M. (2013). Error management behavior in classrooms: teachers' responses to student mistakes. *Teaching and Teacher Education*, *33*, 56–68. https://doi.org/10.1016/j.tate.2013.02.003.

Tulis, M., Steuer, G., & Dresel, M. (2016). Learning from errors: a model of individual processes. *Frontline Learning Research*, *4*, 12–26. https://doi.org/10.14786/flr.v4i2.168.

Tulis, M., Steuer, G., & Dresel, M. (2018). Positive beliefs about errors as an important element of adaptive individual dealing with errors during academic learning. *Educational Psychology*, *38*, 139–158. https://doi.org/10.1080/01443410.2017.1384536.

Vygotsky, L. S. (1978). Mind in society: the development of higher psychological process. *Cambrigde, MA*.

Wang, M. T., Degol, J. L., Amemiya, J., Parr, A., & Guo, J. (2020). Classroom climate and children's academic and psychological wellbeing: A systematic review and meta-analysis. *Developmental Review*, *57*, 2-21. https://doi.org/10.1016/j.dr.2020.100912

Yeung, A. S., Lau, S., & Nie, Y. (2011). Primary and secondary students' motivation in learning English: Grade and gender differences. *Contemporary Educational Psychology*, *36*, 246-256. https://doi.org/10.1016/j.cedpsych.2011.03.001

Table 1
Results from Confirmatory Factor Analyses of Error-Related Scales and Classroom Goal Structure Scale. Models' Fit Indices and Model Comparisons are Shown.

Models	df or Δdf	χ^2 or $\Delta\chi^2$	RMSEA (C.I.)	CFI	TLI	SRMR	λ range
Perceived error climate							
Model 1 – one factor	434	2877.375	0.100 (0.097-0.103)	0.509	0.473	0.100	0.261-0.684
Model 2 – eight-factor	406	757.538	0.039 (0.035-0.044)	0.929	0.919	0.046	0.415-0.868
Model 3 – Superordinate	426	879.565	0.043 (0.039-0.048)	0.909	0.900	0.060	0.418-0.863
Model 1 vs. Model 2	28	2629.053***					
Model 2 vs. Model 3	20	-111.914					
Adaptive reactions towards errors							
Model 1 – one factor	54	511.298	0.123 (0.113-0.132)	0.759	0.705	0.097	0.258-0.762
Model 2 – two-factor	53	220.387	0.075 (0.065-0.085)	0.912	0.890	0.060	0.533-0.816
Model 1 vs. Model 2	1	607.059***					
Error belief							
Model 1 – one factor	5	28.190	0.091 (0.060- 0.125)	0.969	0.939	0.028	0.697-0.843
Classroom goal structure							
Model 1 – two-factor	76	305.024	0.073 (0.065- 0.082)	0.890	0.869	0.061	0.408-0.697
Model 2 – three-factor	74	206.956	0.056 (0.047- 0.066)	0.936	0.922	0.054	0.406-0.784
Model 1 vs Model 2	2	707.386***					

Note. *** $p < .001$

Table 2
Descriptive Statistics, Bivariate Correlations, Intraclass Correlation (ICCs) and Internal Consistency (Cronbach' α) of All Variables

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
1.Perceived classroom error climate Uniform factor	-	.584**	.657***	.759**	.747***	.530***	.398***	.652***	.543***	.557***	.443***	.450***	.435***	-.294**	-.183**	.206*
2.Error tolerance by the teacher		-	.345**	.370**	.376**	.144**	.064	.263**	.264**	.237**	.210**	.176**	.187**	-.161**	-.189**	.082
3.Irrelevance of errors for assessment			-	.457**	.498**	.286**	.167**	.294**	.200**	.383**	.224**	.190**	.229**	-.260**	-.183**	.115**
4.Teachers support following errors				-	.520**	.258**	.172**	.535**	.382**	.426**	.382**	.372**	.389**	-.169**	-0.91*	.144**
5.Absence of negative teachers' reactions					-	.398**	.303**	.341**	.246**	.477**	.246**	.256**	.263**	-.235**	-.148**	.168**
6.Absence of negative classmate reactions						-	.195**	.156**	.152**	.290**	.144**	.179**	.181**	-.284**	-.069	.161**
7.Taking the error risk							-	.139**	-.055	.321**	.078	.033	.011	-.041	.013	.066
8.Analysis of errors								-	.399**	.358**	.467**	.375**	.411**	-.137**	-.057	.115**
9.Functionality of errors for assessment									-	.234**	.382**	.578**	.423**	-.150**	-.165**	.150**
10.Affective-motivation reactions towards errors										-	.452**	.308**	.292**	-.238**	-.110**	.289**
11.Action reactions towards errors											-	.500**	.612**	-.072	-.011	.256**
12.Error beliefs												-	.511**	-.111**	-.131**	.122**
13.Mastery CGS													-	-.007	.073	.145**
14.Performance-avoidance CGS														-	.610**	-.207**
15.Performance-approach CGS															-	-.161**
16.Math grades																-
M	3.680	2.957	4.075	4.118	4.101	4.138	2.475	3.602	3.674	3.536	3.787	3.972	4.279	2.690	3.433	6.961
(*SD*)	(0.495)	(0.818)	(0.746)	(0.791)	(0.744)	(0.803)	(1.020)	(0.838)	(0.828)	(0.831)	(0.763)	(0.758)	(0.614)	(0.888)	(0.958)	(1.262)
α	.880	.591	.740	.781	.744	.862	.804	.783	.723	.788	.865	.859	.771	.759	.782	-
ICC[a]	0.234***	-	-	-	-	-	-	-	-	0.108***	0.068	0.046	0.074	0.052*	0.020	0.076**

Note. [a] We calculated ICC only for the variables added in the two-level model. * $p < .05$ ** $p < .01$. ***$p < .001$

Table 3
Two-Level Path Model Unstandardized Results at the Within and Between Level. Standard Errors are Shown in Brackets.

	Affective-motivational reactions towards errors	Adaptive action reactions towards errors	Students' learning outcomes (mathematics grades)
	b (SE)	b (SE)	b (SE)
Within-level predictors			
Perceived error climate	0.680 (0.097)***	0.057 (0.081)	- 0.134 (0.161)
Affective-motivational reactions towards errors	-	0.239 (0.052)***	0.243 (0.087)**
Action reactions towards errors	-	-	0.291 (0.082)***
Error beliefs	0.095 (0.056)	0.191 (0.061)**	- 0.019 (0.081)
Mastery CGS	0.083 (0.083)	0.499 (0.043)***	0.005 (0.132)
Performance-avoidance CGS	- 0.144 (0.038)***	0.025 (0.048)	- 0.194 (0.082)*
Performance-approach CGS	0.033 (0.041)	0.006 (0.038)	- 0.093 (0.070)
Age	0.006 (0.064)	- 0.049 (0.067)	0.030 (0.081)
Gender (1 = Male, 2 = Female)	- 0.231 (0.061)***	0.051 (0.074)	0.006 (0.109)
Between-level predictors			
Perceived error climate	1.326 (0.335)***	0.213 (0.240)	0.984 (0.388)*
Mastery CGS	0.218 (0.896)	1.054 (0.690)	3.215 (1.826)
Performance-avoidance CGS	0.363 (0.894)	0.046 (0.537)	3.256 (1.775)
Performance-approach CGS	0.100 (1.247)	0.011 (0.849)	- 3.343 (2.430)
R^2_{within}	0.283 (0.039)	0.462 (0.032)	0.111 (0.022)
R^2_{between}	0.969 (0.402)	0.975 (1.179)	0.890 (0.657)

Note: *$p < .05$; **$p < .01$; ***$p < .001$