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Who learns from errors on a class test? Antecedents and profiles of adaptive reactions to errors in a failure situation

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1. Introduction

In learning and performance contexts, errors provide informative feedback on knowledge gaps or misconceptions, and thus exhibit a high potential to be engaged as a learning tool (Cannon & Edmondson, 2001; Steuer, Rosentritt-Brunn, & Dresel, 2013). Particularly when students make errors on a class test, a suitable opportunity may be generated to help them learn from the errors that were made. However, it is well documented that many students are demotivated by errors and make little out of the immanent learning opportunities (Weinert, 1999). Previous studies on the antecedents of the adaptivity of affective, motivational, cognitive, and behavioral reactions to errors demonstrated that this particularly is the case when students have a negative ability self-concept, pursue mastery goals only to a small degree, and are more inclined to pursue performance-avoidance goals (Dresel, Schober, Ziegler, Grassinger, & Steuer, 2013; Heimbeck, Frese, Sonnentag, & Keith, 2003).

However, the specific situation, in which errors get salient, is frequently disregarded in these studies (e.g., failure experiences, obtainment of negative feedback in a class test)—instead, reactions to errors were assessed in a more generalized manner in terms of habitualized reaction styles. Less is known about different patterns of more or less adaptive reactions to errors in specific situations. Moreover, it is unclear whether the above-mentioned characteristics also function as determinants of adaptive reactions to errors in the critical situation. Beyond their hypothesized impact, one may additionally assume that adaptive reactions to errors depend on attributional processes in the specific situation (Graham & Williams, 2009; Stiensmeier-Pelster, 1994; Weiner, 1986, 2005).

The current paper focusses on the specific situation when secondary school students receive the results of a class test in the subject of Mathematics and experience failure. It analyzes (1) the extent to which there are different profiles of adaptive responses to errors made on this class test and (2) the individual antecedents under which students can learn from these errors.

1.1. Definitions of errors and failure

An error can be defined as an individuals' decision or behavior that unintentionally deviates from a certain norm, prevents the attainment of a specific goal, and is judged to be incorrect (cf. Zhao & Olivera, 2006). In the process of self-regulated learning an error occurs in the actional phase and is then salient in this phase, or in the post-actional phase, through a comparison of the target with the actual result attained, whereby the target state is established through existing standards or objectives (see Kreutzmann, Zander, & Hannover, 2014; Perels, Otto, Landmann, Hertel, & Schmitz, 2007; Winne & Hadwin, 1998; Zhao & Olivera, 2006; Zimmerman, 1986, 1989). Existing differences in the target-actual comparison can be determined by the individual him/herself or by a third party (e.g., a teacher). The former option

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refers to the process of monitoring that is prevalent in self-regulated learning and can be conceptualized as observation of the learning process and its outcomes and as evaluations whether the learning activities correspond with the learning strategies planned, and whether their outcomes correspond with the learning goals (Winne & Hadwin, 1998; Wirth & Leutner, 2008).

In contrast, failure is defined as a more global non-attainment of self-set goals, which is exclusively post-actional and subjectively perceived, dependent on the individual's level of aspirations (cf. Zhao & Olivera, 2006). The evaluation of performance on a class test by awarding it with a grade provides a pupil with feedback over the quality of his/her performance on the test. Should this grade lie beneath a specific aspiration level, the student experiences failure.

1.2. Receiving the results of a class test as a situation in which errors become salient

The situation of receiving the results of a class test seems to be particularly significant for two reasons: (1) The assessment of an impending performance becomes salient and initiates potential performance comparisons among classmates; thus, it becomes a situation which is particularly emotionally charged (Weiner, 1985, 1986). Especially for students who experience failure, this situation may pose a threat to self-worth. (2) In no other scholastic situation do pupils receive such a compact form of feedback with regard to their state of knowledge. Unless all of the exercises on the test were answered correctly, students in this situation will become aware of the errors they made. In particular for those students who do experience failure, this situation actually embodies a high potential to function as a learning opportunity.

1.3. Adaptive reactions to errors

Errors can induce the regulation of one's own behavior. Boekaerts (1996) and Boekaerts and Niemivirta (2000), in their model of adaptive learning, differentiate between the regulation of one's self with the over-riding goal of reducing threats to self-esteem, and the regulation of knowledge and competences with the over-riding goal of expanding on these two qualities. By analogy, one can distinguish affective-motivational and action-related reactions to errors, which are considered to be more or less adaptive (Dresel et al., 2013; Steuer et al., 2013; for an overview see also Tulis, Steuer, & Dresel, 2016). The affective-motivational adaptivity of error reactions is defined as the degree to which a learner maintains positive affect and motivation to learn in the face of errors. This is crucial because errors can induce outcome achievement emotions like shame or anger due to attributional processes (Pekrun, 2006; Reisenzein, 2014). The regulation of these outcome emotions seems to be important for forthcoming learning motivation and learning behavior (Baker & Berenbaum, 2007; Krohne, Pieper, Knoll, & Breimer, 2002). On the other hand, action adaptivity of error reactions is defined as the degree to which a learner initiates cognitive processes and behaviors aimed to specifically overcome a possible misconception underlying the present error. These cognitive processes are reflexive ones, so that the experience of an error leads to changed conceptions (Boyd & Fales, 1983; Moon, 1999, 2004).

1.4. Interindividual differences in adaptive reactions

Schoolchildren show different reactions to errors and failure. For example, Tulis and Ainley (2011) found four profiles of emotional experience following failure: One group of students primarily experienced anger and boredom, another group expressed inward-looking emotions such as shame or sadness, a third group reported increased positive emotion, and a fourth group showed themselves to be predominantly unemotional. Also early investigations on learned helplessness have reported large inter-individual differences in the patterns following failure (Abramson, Seligman, & Teasdale, 1978; Stiensmeier-Pelster & Schürmann, 1990; Ziegler, Schober, & Dresel, 2005).

Specifically pertaining to affective-motivational adaptive and action adaptive reactions to errors, Steuer et al. (2013) found large differences between secondary school students in the subject of Mathematics (aside from mild differences between classrooms).

1.5. Motivational tendencies and beliefs as antecedents of adaptive reactions to errors

In previous work on antecedents of adaptive reactions to errors self-related motivational tendencies and beliefs (notably ability self-concept and performance-avoidance goals) proved to be significant for affective-motivational adaptive reactions to errors. Motivational tendencies and beliefs, which predominantly allude to the task or activity at hand (notably mastery goals), were associated with action adaptive reactions to errors (Dresel et al., 2013; Grassinger et al., 2015).

Students with a positive ability self-concept—defined as the individual perception of one's own abilities (Spinath & Stiensmeier-Pelster, 2003)—perceive errors as less threatening to their self-worth and are more likely to demonstrate affective-motivational adaptive reactions to errors (Steuer et al., 2013). Students who pursue performance-avoidance goals are motivated to avoid demonstrating what they consider to be low skills or lack of knowledge (Ames, 1992; Dweck, 1986; Maehr & Zusho, 2009). Characteristic here is the avoidance of negative effects on one's self in social learning and achievement situations (Elliot, 1999; Hulleman, Schrager, Bodmann, & Harackiewicz, 2010). For these students, errors entail a threat to these goals, which is associated with an affective-motivational maladaptive reaction to errors (Dresel et al., 2013; Heimbeck et al., 2003; Tulis & Ainley, 2011).

Students with mastery goals pursue the goal of expanding their competences (Elliot & Dweck, 1988). This type of achievement goals enables them to perceive errors as an indication of what exactly still needs to be learned in order for subsequent learning steps to be attained, or which learning strategies need to be improved (see Elliot & Dweck, 1988, cf. Maehr & Zusho, 2009). Accordingly, mastery goals are related with action adaptive reactions to errors (Dresel et al., 2013; Dickhäuser & Buch, 2009; Grassinger et al., 2015; Heimbeck et al., 2003; Steuer et al., 2013).

1.6. Failure attributions as antecedents to adaptive reactions to errors

Errors, by definition, are unintentional and have a negative valence for many students. They likely trigger explicit attributional processes (Köller & Möller, 1996; Möller & Köller, 1997) and as a consequence have impact on outcome emotions, further motivation, and learning behavior. To explain the consequences of specific causal factors to which errors or failure are attributed, it is decisive to consider individuals' perceptions of the degree to which these causal factors are variable, internal, and controllable (Weiner, 1985, 1986). Variable attributions of negative achievement outcomes are usually associated with small or no decrease of self-efficacy (Meyer, 1973) and ability self-concept (Skaalvik, 1994). Controllable attributions are related with less anger (Försterling, 1984), and internal and stable failure attributions are seen as precursors of learned helplessness (Abramson et al., 1978; Seligman, 1986; Stiensmeier-Pelster, 1994).

1.7. Research questions and hypotheses

The present study aims to understand who demonstrates adaptive reactions to errors in a class test and why. Specifically, dimensions, profiles, and antecedents of adaptive reactions in this concrete error situation were investigated.

When receiving the results of a class test students are, in effect, being given feedback on their performance on the test. In particular, when students experience failure under these circumstances, errors made on the test become salient. In order to better understand when students will take advantage of this learning opportunity, we are first of all interested

in the dimensionality of adaptive error behavior in the concrete error situation. As argued in the sections above, affective-motivational adaptive reactions and action adaptive reactions have to be separated from each other in the situation in which errors made on the test become salient. Consequently, our first hypothesis refers to this differentiation.

Hypothesis H1. Affective-motivational adaptive reactions to errors on a class test can be differentiated from action adaptive reactions to errors on a class test.

With focus on different profiles, basically four combinations of affective-motivational adaptive and action adaptive error reactions seem to be possible (2×2) when it is assumed that both types of adaptive reactions can be either strong or weak. However, from a theoretical point of view it seems reasonable that strong action adaptive reactions are only possible in connection with strong affective-motivational adaptive reactions. As mentioned, it can be assumed that ego-protective goals are overriding and cognitive processes to overcome possible misconceptions underlying errors can only be initiated after the regulation of a potential threat of ones' self-esteem (Boekaerts & Niemivirta, 2000). We assume that affective-motivational adaptive reactions are necessary, but not sufficient for action adaptive reactions. Therefore, we expected two (strong adaptivity on both dimensions, weak adaptivity on both dimensions) or three (strong adaptivity on both dimensions, weak adaptivity on both dimensions, strong affective-motivational and weak action adaptivity) profiles on adaptive reactions to errors.

Hypothesis H2. Two or three profiles of (mal)adaptive reaction patterns to errors on a class test can be identified.

Regarding the antecedents of adaptive error reactions it is expected that the theoretical arguments and previous findings reported above can be transferred to the situation of receiving the results of a class test. More specifically, justified on the basis of the differentiation between the regulation of one's self and the regulation of one's knowledge and competences (Boekaerts & Niemivirta, 2000), we assume that motivational tendencies and beliefs that are primarily related to ones' self (ability self-concept, performance-avoidance goals) are differently associated with adaptive reactions on errors as motivational tendencies and beliefs that are primarily related to the task (mastery goals). In detail, in a failure situation a negative ability self-concept and strong performance avoidance goals may lead to a stronger threat of self-esteem due to holding one's self in mind. As a consequence, we expect a stronger relationship of these two antecedents with affective-motivational adaptive error reactions. In analogy, mastery goals are supposed to be stronger associated with action adaptive reactions since learners with strong mastery goals are able to hold the task in mind.

Hypothesis H3a. Students with a more positive ability self-concept, weaker performance-avoidance goals, and stronger mastery goals show more adaptive reactions to errors on a class test.

Hypothesis H3b. Ability self-concept and performance-avoidance goals are stronger associated with affective-motivational adaptive reactions to errors on class tests than with action adaptive reactions; mastery goals are stronger associated with action adaptive reactions than with affective-motivational adaptive reactions.

Finally, the argumentation above leads to the assumption that situated failure attributions are additional antecedents of adaptive error reactions. Students who attribute a failure to variable causes (e.g. they misunderstood the task) and/or controllable causes (e.g., they gave too little effort), should not suffer much from performance anxiety or should not perceive failure as a threat to self-worth and, thus, demonstrate beneficial affective-motivational reactions. It is also expected that the more variable or controllable students perceive the causes for a failure-afflicted performance to be, the more they are likely to initiate cognitive processes and behaviors aimed to overcome possible misconceptions underlying errors made on the class test.

Hypothesis H4a. Variable and controllable failure attributions are positive antecedents of adaptive reactions to errors on a class test.

Although directional hypotheses for the dimensions stability and controllability are reasonable, the location dimension also appears to be significant, even though the direction of the hypothesis is not particularly evident. Students who more strongly perceive the causes of failure to be located externally should thus perceive self-worth as less threatened or feel less ashamed or angry; responses which are associated with affective-motivational adaptive reactions. On the other hand, one may expect that students who predominantly perceive the causes for a failure to be rooted in internal characteristics would also more intensely localize attributions on the self and, consequently, make modifications to controllability of the experience and behavior, and as such react more adaptively.

Hypothesis H4b. Internal failure attributions are associated with adaptive reactions to errors on a class test.

2. Method

2.1. Procedure

In the context of a class test in the subject of Mathematics, ninth grade students were surveyed two times under the supervision of trained research assistants during their regular class periods. The class test was a teacher made collection of mathematical tasks. It was a critical component of the regular class examination and as such mandatory for all students. The content of the class tests focussed on the mathematical topics addressed in the previous six to eight weeks of instruction and, thus, varied between classrooms.

The first survey was conducted approximately two weeks prior to this class test. Assessments were made of ability self-concept as well as mastery goals and performance-avoidance goals for the subject of Mathematics. The second measuring point occurred on the day the results of the test were made known to the participants. The students evaluated the grades they got on this test to be either a success or a failure (Item: “For me, the grade I got on the last math test was a … good grade/rather good grade/rather poor grade/poor grade”). The students who experienced failure (i.e. those who responded with either “rather poor grade” or "poor grade") responded to questions concerning how they attribute the failure on the class tests, and on affective-motivational adaptive and action adaptive reactions to errors on the class test. Only this subgroup of the sample was included in the analyses. This approach ensured analyzing students for whom errors were salient when receiving the results of the test.[1]

2.2. Participants

The sample consisted of 479 students with an average age of 15.45 years ($SD = 0.49$) who reported that they received a poor or rather poor grade in the class test. The proportion of female students came to 56.2%. The students were enrolled in grade 9 of upper secondary track programs and were members of one of 41 different classes, distributed over a total of 18 different schools (located in both urban and rural areas of southern Germany). Participation in the study was voluntary; parental permission was obtained.

[1] That does not mean that students who performed (rather) well in the class test made no errors. Nevertheless, by questioning students with poor results we ensured that we analyze students who actually made a significant number of errors (otherwise they would have had no poor achievement).

2.3. Measures

All measurements were operationalized with respect to the subject of Mathematics using previously validated scales.

Ability self-concept for Mathematics was assessed with a subscale of the Scales to Assess Scholastic Self-concept (Schöne, Dickhäuser, Spinath, & Stiensmeier-Pelster, 2002) which comprised of five items with 5-point bipolar answer scales. For example, the item stem "In math, I'm …" was presented with the two answer anchors "not talented" (1) and "very talented" (5). The internal consistency of the scale was Cronbach's $\alpha = 0.93$.

Achievement goals in the subject of Mathematics were assessed with subscales from the Scales on the Assessment of Learning and Achievement Motivation (Spinath, Stiensmeier-Pelster, Schöne, & Dickhäuser, 2002). Items were presented alongside Likert-type scales ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). *Performance-avoidance goals* were operationalized with eight items (e.g., "My main goal in Math is that the other students don't think that I'm stupid"). $\alpha = 0.84$. *Mastery goals* were also measured with eight items (e.g., "My main goal in Math is to learn something interesting"). $\alpha = 0.83$.

Attributional dimensions of failure were assessed directly after the results of the class test were made known with subscales of the Revised Causal Dimension Scale (McAuley, Duncan, & Russell, 1992). The students were asked to rate the dimensionality of the main reason of their failure in the class test using items with 6-point bipolar answer scales. Each attributional dimension was assessed with three items, the *stability* of the individual failure attribution ($\alpha = 0.73$) with answer anchors such as "temporary" (1) and "permanent" (6), the *controllability* of this attribution ($\alpha = 0.87$) with answer anchors such as "something that you cannot influence" (1) and "something that you can influence" (5), and the *internality* dimension ($\alpha = 0.90$) was assessed with answer anchors such as "something that has nothing to do with yourself" (1) and "something that has to do with yourself" (6).

Adaptive reactions to errors were assessed, specific to subject and future-oriented, with a scale on the management of errors developed by Dresel et al. (2013). Following an introductory item-root, *action adaptive reactions to errors* were operationalized with items like "… I try to make up for exactly those things that tripped me up on the class test" or "… I practice the material that I did not get right on the class test". The scale consisted of seven items. $\alpha = 0.87$. *Affective-motivational adaptive reactions to errors* were operationalized with items such as "… math is still just as much fun for me" or "… I like math less than I did before". The scale consisted of six items. $\alpha = 0.72$.

2.4. Missing values

On the item level, missing rates were no more than 3.1%. Missing values were imputed using the expectation-maximization algorithm (see Peugh & Enders, 2004).

2.5. Analyses

In the first step, a pure measurement model was estimated. To this end, for all eight constructs, two parcels each were created according to the item-to-construct-balance method (Little, Cunningham, & Shahar, 2002).

To test the assumption that there are two dimensions of adaptive reactions to errors (Hypothesis H1) this measurement model was compared to a model with seven factors for which only one factor was specified for error reactions.

Different profiles of reactions to errors on a class test (Hypothesis H2) were identified by means of a latent profile analyses. To determine the number of profiles, each of the resulting fit indices were subjected to Bayesian Information Criteria (BIC) and Lo-Mendel Rubin Tests (LMRT; Nylund, Asparouhov, & Muthén, 2007). The LMRT checks whether a solution with k classes leads to a significant improvement of the model fit in comparison to a solution with k − 1 classes. Moreover, entropy values were calculated—the closer they are to 1, the clearer it is that one can differentiate between different classes (Celeux & Soromenho, 1996).

To test the relationships between motivational tendencies and beliefs (Hypothesis H3a) and failure attributions (Hypotheses H4a and H4b) with adaptive reactions to errors, a structural equation model was estimated. Twelve paths were specified from motivational tendencies and beliefs, as well as from the attributional dimensions, to adaptive reactions to errors. Furthermore, nine paths were modelled from motivational tendencies and beliefs to the attributional dimensions. Moreover, the motivational tendencies and beliefs were correlated with one another and the attributional dimensions were correlated with one another. To test the assumption that certain paths are more substantial than others (Hypothesis H3b) we constrained the relevant paths to be equal and compared the model fits with those of the unrestricted model.

3. Results

3.1. Preliminary analyses

The measurement model showed a very good fit to the data ($\chi^2 = 120.4$, $df = 76$, $p < 0.001$, CFI = 0.989, TLI = 0.983, RMSEA = 0.035). Table 1 holds all of the descriptive statistics and the latent bivariate correlations for the individual scales.

3.2. Dimensions of adaptive reactions to errors on a class test

The seven factor model ($\chi^2 = 772.6$, $df = 83$, $p < 0.001$, CFI = 0.835, TLI = 0.761, RMSEA = 0.135), in which adaptive error reactions were modelled as one common factor, proved to be an unacceptable and a significantly poorer representation of the data in comparison to the measurement model with eight factors ($\Delta\chi^2 = 652.2$, $df = 7$, $p < 0.001$). Thus, adaptive reactions to errors can be differentiated in two factors, affective-motivational adaptive and action adaptive reactions to errors.

3.3. Profiles of reactions to errors on a class test

Results of the latent profile analyses which were performed to identify relevant profiles of reactions to errors are presented in Table 2. LMRT values show that the model with two profiles was significantly better than the model with one profile. Moreover, the model with three profiles did not show any further improvements regarding model fit. However, a decrease in the BIC statistic and a higher entropy calculation did provide support for the model with three profiles, so the model with three profiles was given preference (Hypothesis H2). Fig. 1 provides an illustration of these three profiles, which correspond well with the expected profiles. One profile can be characterized by both, strong affective-motivational and strong action adaptive reactions—it comprises 47% of the students. A second profile covering 44% of the students can be characterized by weak affective-motivational adaptive and weak action adaptive reactions. Finally, a third profile (9% of the students) can be characterized by strong affective-motivational adaptive, but weak action adaptive reactions to errors. Remarkably, no profile was evident that combines weak affective-motivational and strong action-adaptive reactions to errors in the class test.

3.4. Antecedents of adaptive reactions on errors on a class test

Estimates of the structural equation model are presented in Fig. 2.[2] They revealed that students with a positive ability self-concept, weak

[2] Since this model is a saturated model and unaltered in the measurement part it demonstrated exactly the same fit to the data as the measurement model.

Table 1
Descriptive statistics, latent bivariate correlations.

			Range								
	M	*SD*	Potential	Actual	2.	3.	4.	5.	6.	7.	8.
Motivational tendencies and beliefs											
1. Ability self-concept	3.09	0.89	1–5	1.0–3.1	−0.15	0.58	−0.44	0.05	−0.03	0.57	0.12
2. Performance avoidance goals	2.38	0.78	1–5	1.0–4.9		0.01	0.07	−0.04	−0.03	−0.24	0.03
3. Mastery goals	3.48	0.72	1–5	1.0–4.9			−0.27	0.01	−0.02	0.38	0.26
Dimensionality of the attribution of a failure in a class test											
4. Stability	3.05	1.28	1–6	1.0–6.0				−0.05	0.12	−0.35	−0.17
5. Controllability	3.90	1.54	1–6	1.0–6.0					0.75	0.11	0.22
6. Internality	4.20	1.40	1–6	1.0–4.2						0.10	0.20
Adaptivity of reactions to errors on a class test											
7. Affective-motivational adaptivity	3.66	1.09	1–6	1.0–6.0							0.12
8. Action adaptivity	4.05	0.89	1–6	1.0–6.0							

Note: $N = 479$. $|r| > 0.09$: $p < 0.05$.

performance-avoidance goals, and strong mastery goals reacted, as expected, with more affective-motivational adaptive reactions to errors on a class test. Further, students with strong mastery goals showed more action adaptive reactions to errors (Hypothesis H3a). Restricting the coefficients of the two paths from an endogenous variable to the two types of error reactions to be equal (Hypothesis H3b), resulted in significant deteriorations in the model fit in two out of three cases—indicating that the path coefficients differed significantly. Specifically, the path from ability self-concept to affective-motivational adaptive reactions was larger than its (non-significant) path to action adaptive reactions ($\Delta\chi^2 = 34.3$, $\Delta df = 1$, $p < 0.001$). The same was true for the path coefficients from performance-avoidance goals ($\Delta\chi^2 = 10.0$, $\Delta df = 1$, $p < 0.01$). However, the coefficients of the two path coefficients leading from mastery goals to the two types of error reactions differed not significantly ($\Delta\chi^2 = 3.2$, $\Delta df = 1$, $p = 0.07$). In other words, ability self-concept and performance-avoidance goals were stronger associated with affective-motivational adaptive reactions to errors on class tests than with action adaptive reactions. However, mastery goals were not stronger associated with action adaptive reactions than with affective-motivational adaptive reactions (Hypothesis H3b).

The unrestricted structural equation model additionally revealed that the more students attributed their failure in the class test to variable and internal causes, the more likely they showed affective-motivational adaptive reactions to their errors on the class test (Hypothesis H4a). Furthermore, the more they attributed the failure to internal and variable causes, the more action adaptive reactions they demonstrated (Hypothesis H4b). Controllable attributions, which were highly correlated with internal attributions, proved not to be, contrary to our expectations, a significant predictor of adaptive reactions to errors.

4. Discussion

In models of self-regulated learning the regulation of one's self and the regulation of one's knowledge and competencies are differentiated (Boekaerts, 1996; Boekaerts & Niemivirta, 2000). Accordingly, the results of the study indicate that in situations in which errors become salient to students (here, failure experiences on a class test), one has to differentiate between affective-motivational adaptive and action adaptive reactions to errors. The first type of reactions can be characterized by, for example, a successful maintenance of positive emotions and valuing of the task (Baker & Berenbaum, 2007; Krohne et al., 2002). The second type of reactions comprises an analysis of errors with regard to own knowledge gaps or the formation of action plans with the intention to close up exposed knowledge gaps.

We argued that affective-motivational adaptive reactions may be necessary but not sufficient for action adaptive reactions to errors. Consistent to this, three profiles of error regulators were identified: Nearly one half of the students showed both strong affective-motivational and strong action adaptive reactions to errors (generally adaptive). A little less of the students showed both, weak affective-motivational and weak action adaptive reactions to errors (moderately generally maladaptive). Finally, about 9% of the students showed strong affective-motivational and weak action adaptive reactions to errors (purely affective-motivationally adaptive). Despite the rather low frequency of the third profile, it is fully in line with our theoretical argumentation. However, we did not find a profile combining weak affective-motivational and strong action adaptive reactions to errors. Obviously, affective-motivational adaptivity is essential for action adaptivity: Reactions on errors that are directed to specific learning activities to overcome misunderstandings or knowledge gaps that came alight in an error seem to be not possible without reactions that help to overcome the affective-motivational and self-related threats that are potentially inherent in every error. This fits to findings reported by Boekaerts (1996) that the goal of regulation of the self takes precedence over the goal of augmenting knowledge or expanding one's competences (see also Witkowski & Stiensmeier-Pelster, 1998). However, the causal impact of affective-motivational on adaptive reactions to errors needs to be subjected to further investigations.

As expected, and in accordance to the literature on adaptive reactions to errors (Dresel et al., 2013; Steuer et al., 2013), it was shown that when students receive the results of a class test, there is a higher probability that they will demonstrate an affective-motivational adaptive response to the errors they made when they have a positive ability self-concept, strongly pursue mastery goals and rarely pursue performance avoidance goals. Mastery goals further were associated with action adaptive reactions when these students made errors—that includes, for instance, building up the intention to plug up exposed knowledge gaps through increased learning efforts. More generally speaking, self-related motivational tendencies and beliefs were associated with affective-motivational adaptive reactions to errors, whereas action adaptive reactions to errors were associated with task-related a motivational tendency. This further underpins the theoretical distinction between self-related and action-related processes in dealing with errors (Keith & Frese, 2005).

Building on the results for trans-situational motivational tendencies and beliefs, situational failure attributions were associated with reactions to errors as expected. The more students attributed their failure

Table 2
Criteria for assessing fit for different numbers of classes.

# K	# P	BIC	Entr	p_{LMRT}
1	26	19829	–	–
2	40	19076	0.797	0.001
3	54	18672	0.844	0.521

Note: # K = Number of latent profiles, # P = Number of free parameters, BIC = Bayesian criterion, Entr = Entropy, p_{LMRT} = *p*-Value of Lo-Mendel-Rubin-Test for k versus k − 1 classes.

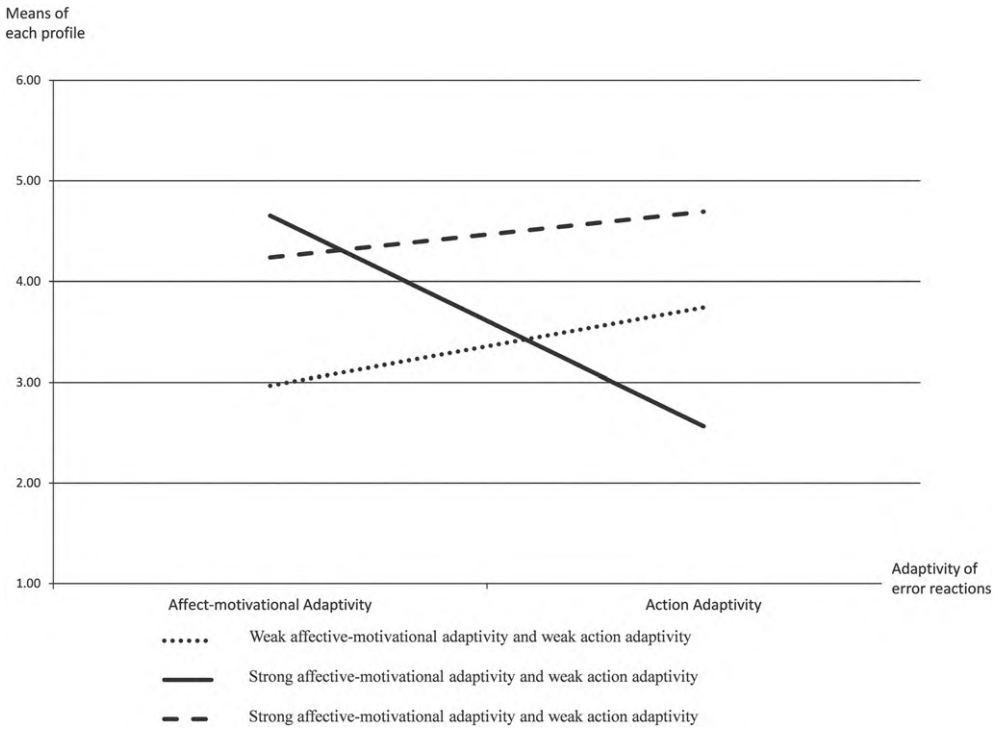

Fig. 1. Latent profiles of adaptivity of error reactions.

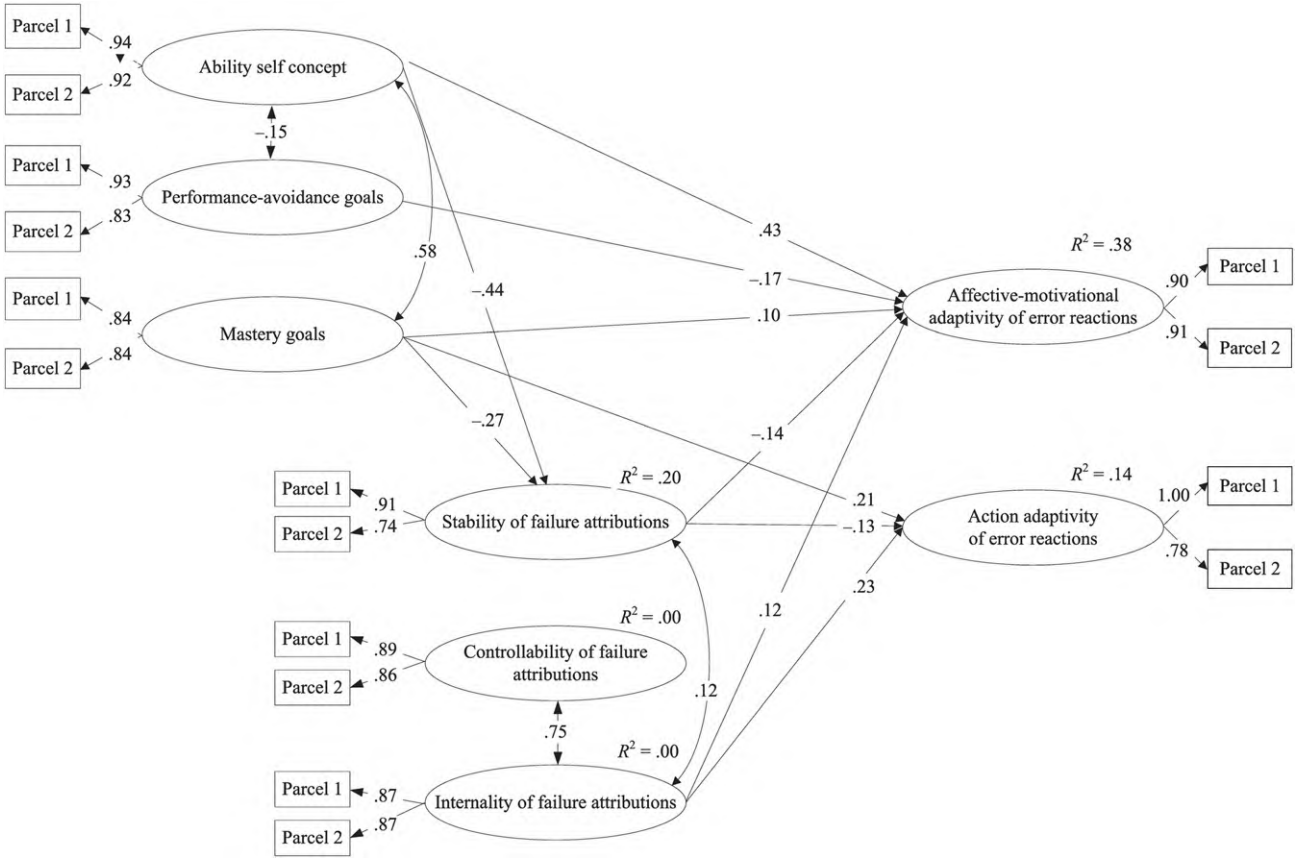

Fig. 2. Structure equation model to predict adaptive reactions to errors on a class test from motivational tendencies and beliefs and dimensions of failure attributions (only paths and correlations with $p < 0.05$ are visualized).

on a class test variably and internally, the more they respond with adaptive reactions to the errors they made on the class test. The fact that the attributional dimension of controllability had, contrary to expectations, no effect here, may be due to the high correlation it showed with internality.

With respect to the limitations of the present study, it should be noted that the sample was exclusively comprised of students enrolled at college preparatory high schools, attending the ninth grade. Furthermore, the study was only realized in the subject of Mathematics. Even though the findings are consistent with work published by Dresel et al. (2013) and Steuer et al. (2013), generalization is thus somewhat restricted. The present study realized a design in which error reactions were assessed from students with failure and many errors in the class test – thus, the level of analysis was the summative feedback on a group of errors and not feedback on a specific error (cf. Dickhäuser, Reinhard, Diener, & Bertrams, 2009). Future studies focusing on specific errors also taking different types of errors into account seem worthwhile.

5. Conclusions

When students experience failure while processing the results to a class test, the errors made on that test become salient. The present work supplements literature on adaptive reactions to errors in that adaptive reactions to errors were operationalized in a situation which necessitates that the errors become salient, potentially initiate performance comparisons, and demonstrate a high potential to be utilized as a learning opportunity (Tulis, Steuer, & Dresel, 2015; Tulis et al., 2016; Weinert, 1999; Zhao, 2011). It can be concluded that in the critical situation in which errors become salient, affective-motivational adaptive and action adaptive reactions to errors can be differentiated (Dresel et al., 2013; Tulis et al., 2015). Strong mastery goals, a positive self-concept, variable and internal failure attributions functioned as protective factors against maladaptive reactions to errors whereas strong performance avoidance goals functioned as a risk factor for them. The identified profiles of error reactions underpin the assumption that affective-motivational adaptive reactions to errors are necessary but not sufficient for the action adaptive reactions to errors which are, in the narrower sense, responsible for learning from errors.

References

Abramson, L. Y., Seligman, M. E. P., & Teasdale, J. D. (1978). Learned helplessness in humans: Critique and reformulation. *Journal of Abnormal Psychology*, *87*, 49–74.

Ames, C. (1992). Classrooms: Goals, structures, and student motivation. *Journal of Educational Psychology*, *84*, 261–271.

Baker, J. P., & Berenbaum, H. (2007). Emotional approach and problem-focused coping: A comparison of potentially adaptive strategies. *Cognition & Emotion*, *21*, 95–118.

Boekaerts, M. (1996). Self-regulated learning at the junction of cognition and motivation. *European Psychologist*, *1*, 100–112.

Boekaerts, M., & Niemivirta, M. (2000). Self-regulated learning: Finding a balance between learning goals and ego-protective goals. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 417–451). San Diego, CA: Academic Press.

Boyd, E., & Fales, A. (1983). Reflective learning: Key to learning from experience. *Journal of Humanistic Psychology*, *23*, 94–117.

Cannon, M., & Edmondson, A. (2001). Confronting failure: Antecedents and consequences of shared beliefs about failure in organizational work groups. *Journal of Organizational Behavior*, *22*, 161–177.

Celeux, G., & Soromenho, G. (1996). An entropy criterion for assessing the number of clusters in a mixture model. *Journal of Classification*, *13*, 195–212.

Dickhäuser, C., & Buch, S. (2009). Leistung nach Misserfolg in Abhängigkeit von Zielorientierung und aufgabenspezifischem Fähigkeitsselbstkonzept [performance after failure depending on goal orientation and task-specific academic self-concept: An experimental study]. *Zeitschrift für Pädagogische Psychologie, S.*, 247–258.

Dickhäuser, O., Reinhard, M. -A., Diener, C., & Bertrams, A. (2009). How need for cognition affects the processing of achievement-related information. *Learning and Individual Differences*, *19*, 283–287.

Dresel, M., Schober, B., Ziegler, A., Grassinger, R., & Steuer, G. (2013). Affektiv-motivational adaptive und handlungsadaptive Reaktionen auf Fehler im Lernprozess [affective-motivational adaptive and action adaptive reactions to errors in learning processes]. *Zeitschrift für Pädagogische Psychologie*, *47*, 255–271.

Dweck, C. (1986). Motivational processes affecting learning. *American Psychologist*, *41*, 1040–1048.

Elliot, A. (1999). Approach and avoidance motivation and achievement. *Educational Psychologist*, *34*, 169–189.

Elliot, A., & Dweck, C. (1988). Goals: An approach to motivation and achievement. *Journal of Personality and Social Psychology*, *54*, 5–12.

Försterling, F. (1984). Bedeutsamkeit, kausale Attribuierung und empfundener Aerger (importance, causal attributions and the emotion of anger). *Zeitschrift für Psychologie*, *192*, 425–432.

Graham, S. & Williams, C. (2009). An attributional approach to motivation in school. In K. R. Wentzel & A. Wigfield (Eds.), Handbook of motivation at school (S. 11–33). New York, NY: Routledge.

Grassinger, R., Steuer, G., Berner, V. -D., Zeinz, H., Scheunpflug, A., & Dresel, M. (2015). Ausprägung und Entwicklung adaptiver Reaktionen auf Fehler in der Sekundarstuge (Magnitude and Changes in Adaptive Dealing with Errors in Secondary School). *Zeitschrift für Pädagogische Psychologie*, *29*, 215–225.

Heimbeck, D., Frese, M., Sonnentag, S., & Keith, N. (2003). Integrating errors into the training process: The function of error management instructions and the role of goal orientation. *Personnel Psychology*, *56*, 333–361.

Hulleman, C. S., Schrager, S. M., Bodmann, S. M., & Harackiewicz, J. M. (2010). A meta-analytic review of achievement goal measures: Different labels fort he same constucts of different constructs with similar labels? *Psychological Bulletin*, *136*, 422–449.

Keith, N., & Frese, M. (2005). Self-regulation in error management training: Emotion control and metacognition as mediators of performance effects. *Journal of Applied Psychology*, *90*, 677–691.

Köller, O., & Möller, J. (1996). Auslösende Bedingungen spontaner Attributionen: Die Rolle des experimentellen settings [antecedents of spontaneous attributions: The impact of different experimental settings]. *Zeitschrift für Sozialpsychologie*, *27*, 283–289.

Kreutzmann, M., Zander, L., & Hannover, B. (2014). Versuch macht klu(ch)g?! Der Umgang mit Fehlern auf Klassen– und Individualebene. Zusammenhänge mit Selbstwirksamkeit, Anstrengungsbereitschaft und Lernfreude von Schülerinnen und Schülern [Managing mistakes on the class and individual level: Interrelations with students' self-efficacy, effort investment, and joy of learning]. *Zeitschrift für Entwicklungspsychologie und Pädagogische Psychologie*, *46*, 101–113.

Krohne, H. W., Pieper, M., Knoll, N., & Breimer, N. (2002). The cognitive regulation of emotions: The role of success versus failure experience and coping dispositions. *Cognition and Emotion*, *16*, 217–243.

Little, T. D., Cunningham, W. A., & Shahar, G. (2002). To parcel or not to parcel: Exploring the question, weighing the merits. *Structural Equation Modeling*, *9*, 151–173.

Maehr, M. L., & Zusho, A. (2009). Achievement goal theory: The past, present, and future. In K. R. Wentzel, & A. Wigfield (Eds.), *Handbook of motivation at school* (pp. 77–104). New York, NY: Routledge.

McAuley, E., Duncan, T. E., & Russell, D. W. (1992). Measuring causal attributions: The revised causal dimension scale (CDSII). *Personality and Social Psychology Bulletin*, *18*, 566–573.

Meyer, W. -U. (1973). *Leistungsmotiv und Ursachenerklärung von Erfolg und Misserfolg [Achievement motive and attribution of success and failure].* Stuttgart: Klett.

Möller, J., & Köller, O. (1997). Spontane Kognitionen nach der Bekanntgabe von Klausurleistungen [Spontaneous cognitions after notification of examination results]. *Zeitschrift für Pädagogische Psychologie*, *11*, 195–201.

Moon, J. A. (1999). *Reflection in learning and professional development.* London: Kogan Page.

Moon, J. A. (2004). *Handbook of reflective and experiental learning: Theory and practice.* New York: RoutledgeFalmer.

Nylund, K. L., Asparouhov, T., & Muthén, B. O. (2007). Deciding on the number of classes in latent class analysis and growth mixture modeling: A Monte Carlo simulation study. *Structural Equation Modeling*, *14*, 535–569.

Pekrun, R. (2006). The control-value theory of achievement emotions: Assumptions, corollaries, and implications for educational research and practice. *Educational Psychology Review*, *18*, 315–341.

Perels, F., Otto, B., Landmann, M., Hertel, S., & Schmitz, B. (2007). Self-regulation from a process perspective. *Journal of Psychology*, *215*, 194–204.

Peugh, J. L., & Enders, C. K. (2004). Missing data in educational research: A review of reporting practices and suggestions for improvement. *Review of Educational Research*, *74*, 525–556. http://dx.doi.org/10.3102/00346543074004525.

Reisenzein, R. (2014). The attributional approach to emotion and motivation: Introduction to a special section of emotion review. *Emotion Review*, *6*, 332–335.

Schöne, C., Dickhäuser, O., Spinath, B., & Stiensmeier-Pelster, J. (2002). *Skalen zur Erfassung des schulischen Selbstkonzepts (SESSKO) [School-Related Self-Concept Scales].* Göttingen: Hogrefe.

Seligman, M. (1986). *Erlernte Hilflosigkeit [learned helplessness].* München: Psychologie Verlags Union.

Skaalvik, E. M. (1994). Attribution of perceived achievement in school in general and in maths and verbal areas: Relations with academic self-concept and self-esteem. *British Journal of Educational Psychology*, *64*, 133–143.

Spinath, B., & Stiensmeier-Pelster, J. (2003). Goal orientation and achievement: The role of ability self-concept and failure perception. *Learning and Instruction*, *13*, 403–422.

Spinath, B., Stiensmeier-Pelster, J., Schöne, C., & Dickhäuser, O. (2002). *Skalen zur Erfassung der Lern- und Leistungsmotivation (SELLMO) [Learning and Achievement Motivation Scales].* Göttingen: Hogrefe.

Steuer, G., Rosentritt-Brunn, G., & Dresel, M. (2013). Dealing with errors in mathematics classrooms: Structure and relevance of perceived error climate. *Contemporary Educational Psychology*, *38*, 196–210.

Stiensmeier-Pelster, J. (1994). Attribution und erlernte Hilflosigkeit [Attribution and learned helplessness]. In F. Försterling & J. Stiensmeier-Pelster (Hrsg.), Atributionstheorie (S. 185–211). Göttingen: Hogrefe.

Stiensmeier-Pelster, J., & Schürmann, M. (1990). Performance deficits following failure: Integrating motivational and functional aspects of learned helplessness. *Anxiety Research*, *2*, 211–222.

Tulis, M., & Ainley, M. (2011). Interest, enjoyment and pride after failure experiences? Predictors of students' state-emotions after success and failure during learning in mathematics. *Educational Psychology*, *31*, 779–807.

Tulis, M., Steuer, G. & Dresel, M. (2015). Learning from errors: Process and contextual conditions. Towards a model of individual processes within contexts. In M. Gartmeier, H. Gruber, T. Hascher & H. Heid (Eds.), Funktionen von Fehlern im Kontext individueller und gesellschaftlicher Entwicklung (S. 53–70). Münster, Germany: Waxmann. Opladen, Germany: Leske + Budrich.

Tulis, M., Steuer, G., & Dresel, M. (2016). Learning from errors: A model of individual processes. *Frontline Learning Research*, *4*, 12–26.

Weiner, B. (1985). An attributional theory of achievement motivation and emotion. *Psychological Review*, *92*, 548–573.

Weiner, B. (1986). *An attrubutional theory of motivation and emotion.* New York: Springer.

Weiner, B. (2005). Motivation from an attributional perspective and the social psychology of perceived competence. In A. J. Elliot, & C. S. Dweck (Eds.), *Handbook of competence and motivation* (pp. 73–84). New York, NY: Guilford.

Weinert, F. E. (1999). Aus Fehlern lernen und Fehler vermeiden lernen [Learning from errors and learning to avoid errors]. In W. Althof (Hrsg.), Fehlerwelten. Vom Fehlermachen und Lernen aus Fehlern (S. 101–110). Opladen: Leske + Budrich.

Winne, P. H., & Hadwin, A. F. (1998). Studying as self-regulated learning. In D. J. Hacker, J. Dunlosky, & A. Graesser (Eds.), *Metacognition in educational theory and practice* (pp. 277–304). Hillsdale, NJ: Lawrence Erlbaum.

Wirth, J., & Leutner, D. (2008). Self-regulated learning as a competence. Implications of theoretical models for assessment models. *Journal of Psychology*, *216*, 102–110.

Witkowski, T., & Stiensmeier-Pelster, J. (1998). Performance deficits following failure: Learned helplessness or self-esteem protection? *British Journal of Social Psychology*, *37*, 59–71.

Zhao, B. (2011). Learning from errors: The role of context, emotion, and personality. *Journal of Organizational Behavior*, *32*, 435–463.

Zhao, B., & Olivera, F. (2006). Error reporting in organizations. *Academy of Management Review*, *31*, 1012–1030.

Ziegler, A., Schober, B., & Dresel, M. (2005). Primary school sudents'implicit theories of intelligence and maladaptive behavioral patterns. *Education Sciences and Psychology*, *1*, 76–86.

Zimmerman, B. J. (1986). Development of self-regulated learning: Which are the key subprocesses? *Contemporary Educational Psychology*, *16*, 307–313.

Zimmerman, B. J. (1989). Models of self-regulated learning and academic achievement. In B. J. Zimmerman, & D. H. Schunk (Eds.), *Self-regulated learning and academic achievement: Theory,research, and practice* (pp. 1–25). New York: Springer.