First publ. in: Learning and Individual Differences 17 (2007), pp. 3–16

Emotional experiences during test taking: Does cognitive ability make a difference?

Thomas Goetz [a,*], Franzis Preckel [a], Reinhard Pekrun [a], Nathan C. Hall [b]

[a] *University of Munich, Germany*
[b] *University of California, Irvine*

Abstract

This study examined test-related experiences of enjoyment, anger, anxiety, and boredom in a sample of 2059 German school students (50% female) from grade 6, and how they relate to students' abstract reasoning ability (ARA). Emotions were assessed immediately before, during, and after a mathematics achievement test. Analysis of variance showed that emotions experienced during the test situation differed based on students' ARA level, with correspondence analysis revealing substantial differences between the emotional profiles of different ability groups. Enjoyment proved to be most prominent in students with high ARA, whereas anger and anxiety were predominant for students with low ARA. Boredom was found to be highest among students in the intermediate ARA group. Implications for research and practice are discussed.

Keywords: Cognitive ability; State emotions; Mathematics; Test; Enjoyment; Anxiety; Anger; Boredom

Despite burgeoning research interest in the role of affect in psychological development, emotions experienced in the academic domain has until recently remained a largely unexplored field of psychological research. With the exceptions of research on emotions in achievement settings based on attribution theory (see Weiner, 1985, 2001) and an extensive body of research on test anxiety which has been studied since the 1950s (Sarason & Mandler, 1952; Zeidner, 1998), there is a notable lack of empirical research on students' emotions (Pekrun, Goetz, Titz, & Perry, 2002a). Little is known about students' state emotions experienced in academic settings, that is, their emotions during actual academic situations including class lessons, taking tests and exams, and completing homework assignments. Considering situations of testing as emotionally salient events, numerous studies have concentrated on state emotions experienced before and after taking a test, particularly in the context of test anxiety. However, less is known about emotions

☆ This study is supported by grants from the German Research Foundation to the third author (DFG; PE 320/11-1, PE 320/11-2, PE 320/11-3, PE 320/11-4) and by a doctoral fellowship from the Social Sciences and Humanities Research Council of Canada (SSHRC) to the fourth author.
Correspondence concerning this article should be addressed to Thomas Goetz, Department of Psychology, University of Munich, Leopoldstr. 13, D - 80802 Munich, Germany. Electronic mail may be send via Internet to goetz@edupsy.uni-muenchen.de.
* Corresponding author. Fax: +49 89 2180 5250.
E-mail address: goetz@edupsy.uni-muenchen.de (T. Goetz).

experienced *while* actually working on an achievement test (Schutz & Davis, 2000). The present study aims to contribute to reducing this research gap by investigating students' emotional experiences not only before and after working on an achievement test, but also during the performance phase.

Much research has been conducted on the relation between individual difference variables and achievement outcomes (see Guthrie, Wigfield, Metsala, & Cox, 1999 for motivational orientations and achievement in the area of literacy). However, we lack knowledge on how individual difference variables such as cognitive abilities, coping styles, or extraversion account for differences in the intensity and quality of the emotions experienced by students. The present study aimed to investigate one variable of particular relevance for differences in emotional experiences during testing situations, namely cognitive ability (see Zeidner, 1995a). As such, we examined whether state emotional experiences before, during, and after working on a mathematics achievement test differed according to the level of students' abstract reasoning ability[1].

We consider emotions experienced before, during, and after testing situations to be worthy of investigation for two main reasons (for a general discussion on the importance of emotions in educational settings, see Goetz, Zirngibl, Pekrun, & Hall, 2003). First, students' emotional experiences throughout testing situations are an important component of their subjective well-being (Diener, 2000; Diener & Larsen, 1993; Ekman & Davidson, 1994) and are consequently an important topic of research in their own right (cf., subjective well-being in the context of positive psychology, Seligman & Csikszentmihalyi, 2000). Second, emotions also have an impact on motivation, activation of learning resources, choice of cognitive and metacognitive learning strategies, and consequently on achievement outcomes (Goetz, 2004; Pekrun, Goetz, Perry, et al., 2004; Pekrun et al., 2002a; for positive affect, see Aspinwall, 1998; Pekrun, Goetz, Titz, & Perry, 2002b; for test anxiety, see Sarason & Mandler, 1952; Zeidner, 1998). Emotions *during* test taking are assumed to be of particular relevance in terms of the quality of students' work during the testing situation. Due to their impact on achievement outcomes, emotions experienced in testing situations are a particularly critical topic of investigation in modern, achievement-oriented societies.

1. Theoretical background

1.1. State emotions during test performance

In order to both describe and measure individuals' emotions, it is important to differentiate present emotional experiences (state-emotions; e.g., "I am anxious at this moment") and "typical" emotional experiences that occur consistently in specific situations (trait-emotions; e.g., "I am generally anxious while taking math exams"; see Cattell & Scheier, 1961; Spielberger, 1972). When categorizing and describing state emotions during an achievement test, it is important to highlight the specific phase of test completion during which the emotions were measured. Schutz and Davis (2000) suggest that, consistent with research by Zimmerman (1998, 2000), these phases of test completion can be categorized sequentially as follows: (1) the *forethought* phase in which students prepare for the test, (2) the *performance* phase during which students actually take the test, and (3) the *self-reflection* phase in which students reflect on the test (evaluative processes), wait for, receive, and make sense of test results. Although there has been a tremendous amount of research on the forethought and self-reflection phases, particularly in the context of test anxiety (e.g., Folkman & Lazarus, 1985; Smith & Ellsworth, 1987), less is known about anxiety and other emotions during the performance phase (Schutz & Davis, 2000; for an assessment of state anxiety during an examination period, see Gross, 1990; for an assessment of appraisals of curricular tasks in real classroom situations, see Crombach, Boekaerts, & Voeten, 2003).

One possible reason for this lack of research on emotions experienced during test performance involves ethical considerations, such that the process of examining students' emotions at this time could negatively influence their test results by interrupting their problem-solving efforts (Zeidner, 1995b). As a consequence of this ethical dilemma, researchers have mainly investigated emotions experienced before and after exams, as opposed to during exam

[1] It is important to note that we did not use the results of the mathematics achievement test to account for differences in emotional experiences related to this test. From the perspective of predicting students' emotional experiences when completing a test, results of a single achievement test can be assumed to be less stable than students' cognitive abilities, which are to be regarded as relatively stable personality traits. Consequently, the prediction of students' emotional experiences when working on a test might be more robust when using nonverbal ability as a predictor rather than using results derived from one single mathematics test.

situations. Nonetheless, some studies have investigated students' emotions during test completion by asking them to think back to the testing situation and report their feelings in a retrospective manner (e.g., Davis, Schutz, & DeCuir, 1999; Pekrun et al., 2004).

Although very few studies have undertaken an investigation of emotional experiences during all three performance phases, namely before, during, and after test completion, the results of these studies are intriguing. For example, some studies indicate that negative emotions are highest at the beginning of the test (for anxiety, see Galassi, Frierson, & Sharer, 1981a; Galassi, Frierson, & Sharer, 1981b; Klinger, 1984; for anxiety and hopelessness, see Spangler, Pekrun, Kramer, & Hofmann, 2002). Similarly, Pekrun et al. (2004) also found that students reported greater anxiety, hopelessness, sadness, and envy before the test than during or after the test. However, these authors also found that anger, shame, and disappointment were more often reported during and after the test than before the test began. The findings of Pekrun et al. (2004) also showed that positive emotions such as joy, pride, relief, gratitude, admiration, and feeling of security were least reported at the beginning of the exam and most often reported after students had finished the exam. The results of Spangler et al. (2002) also showed an increase in positive emotions (i.e., hope, enjoyment) during the process of completing an exam, with the highest levels of positive affect observed after the test was completed.

In examining the antecedents of high vs. low anxiety during test performance, Galassi et al. (1981a) found that high test-anxious students reported the most negative thoughts (assessed by checklists), low perceptions of control, and low expectancies. Concerning cognitive appraisals during the performance phase, Schutz and Davis (2000) also concluded that according to their findings and general model of affective self-regulation, "the ideal cognitive appraisal for this situation is seeing the test as important (but not overly important) and judging the test as challenging but also seeing ourselves as being in control and having confidence in our ability to get out of any potential problems that may occur" (p. 251).

1.2. Cognitive ability and state emotional experiences

Pekrun's (2000, 2006) control-value theory of emotions relating to learning and achievement depicts a causal model outlining key antecedents of emotional experiences, using the terms "achievement emotions" and "academic emotions" to describe emotions experienced in achievement and academic contexts (Pekrun et al., 2002a). As such, achievement and academic emotions are emotional experiences that are directly related to academic settings, such as classroom instruction and completing tests and exams. According to this model, students' emotional experiences may differ due to individual differences (e.g., abilities, genotype, control- and value-related cognitions), aspects of the proximal social environment (e.g., expectations and goal structures of teachers, parents, and peers), and aspects of the distal social environment (e.g., cultural values), all of which are assumed to interact to influence students' emotional development (for empirical findings, see Goetz, 2004; Goetz, Pekrun, Hall, & Haag, 2006; Pekrun et al., 2004, 2002a). In this paper, we focus on one central student difference variable, namely students' cognitive ability, which is assumed to have a strong impact on achievement-related emotional experiences through its effect on academic achievement outcomes and perceived control.

Cognitive ability should correspond with more positive academic emotional experiences because high cognitive abilities typically coincide with good academic achievement outcomes (Holling, Preckel, & Vock, 2004; Jensen, 1998; Ones, Viswesvaran, & Dilchert, 2004; on the problem of underachievement, see Carr, Borkowski, & Maxwell, 1991; McCoach & Siegle, 2003; Preckel, Holling, & Vock, 2006; Reis & McCoach, 2000). Positive performance outcomes may also lead students to anticipate positive results in future testing situations as well as a sense of achievement both during and after test completion. Furthermore, because previous positive achievement outcomes positively influence the anticipated quality and intensity of reward by teachers, parents, and peers, these positive expectations might also influence students' emotional experiences while working on a test. Altogether, high academic achievement outcomes due to high cognitive abilities can be assumed to foster overall positive emotional experiences and low levels of negative emotions during the completion of an achievement test.

Furthermore, students with high cognitive abilities might experience a more positive pattern of emotional experiences than students with low cognitive abilities due to their discrepant perceptions of personal control. Favorable perceptions of control concerning academic tasks could lead students to perceive achievement situations as challenging rather than threatening, which should induce positive emotions. Control-related cognitions involve perceptions of cause–effect relationships (e.g., action-outcome expectancies; see Heckhausen & Schulz, 1995) including appraisals of

conditional relationships between personal characteristics and achievement outcomes (for an overview of research on perceived academic control, see Perry, Hall, & Ruthig, 2005). Moreover, a meta-analytic review of empirical research suggests that cognitive abilities are positively correlated with control-related cognitions (Ackerman & Heggestad, 1997), such as self-appraisals of one's own competencies (i.e., perceived competence). Numerous studies have also demonstrated that self-efficacy expectancies positively correspond with cognitive ability levels (Bandura, 1986; Roznowski, Reith, & Hong, 2000; Zeidner & Matthews, 2000). Thus, to the extent that high levels of cognitive ability fosters control-related cognitions through perceptions of competence, they may also indirectly encourage an adaptive emotional profile which typically accompanies perceived academic control, that is, high levels of positive emotions (e.g., hope, enjoyment) and low levels of negative emotions (e.g., hopelessness, anger, anxiety; see Perry et al., 2005). Nonetheless, it is also important to note that high control cognitions might also coincide with greater boredom because these students no longer find course material challenging.

2. Research questions and hypotheses

The present study examines predictors of students' state emotional experiences while working on a mathematics achievement test. Based on Pekrun's (2000) control-value model of achievement emotions, we hypothesized that students with high levels of abstract reasoning ability would show a more positive state emotional profile than students with lower abstract reasoning abilities. That is, we hypothesized that students with high level of abstract reasoning ability should experience more enjoyment and less anger and anxiety than other students. As for boredom, the relationships are assumed to be more complicated. On the one hand, high cognitive abilities should coincide with positive emotional experiences and, consequently, less boredom due to feelings of success while working on the task. On the other hand, high levels of control might lead some students to perceive academic tasks as less challenging, resulting in more frequent experiences of boredom. Thus, concerning the level of boredom that high ability students experience while working on a mathematics achievement test, our study is exploratory in nature.

In our study, state emotions were selected based on two selection criteria. *First*, we wanted to include discrete emotions that were not too similar in their underlying phenomenology. Emotions have long been classified based on underlying dimensions such as activation, valence, intensity, and duration. We decided to base our selection of emotions on Watson and Tellegen's (1985) circumplex model which categorizes emotions according to activation and valence (cf., Russel, 1980). This model was adapted for the domain of achievement related emotions by Pekrun et al. (2002a). *Second*, we searched the literature for emotions that are particularly salient in academic settings (see Goetz, 2004; Pekrun et al., 2002a). As a result of these two strategies, we decided to include the emotions of enjoyment (positive and activating), anxiety and anger (negative and activating), as well as boredom (negative and deactivating) in the present study. We did not integrate positive deactivating emotions (e.g. relief, relaxation) because these emotions typically do not occur during but following an academic achievement setting (see Pekrun et al., 2002a).

3. Method

3.1. Participants

The present analyses are based on data from the "Project for the Analysis of Learning and Achievement in Mathematics" (PALMA; Pekrun, Goetz, vom Hofe, et al., 2004). The data consisted of a representative sample of students with respect to socio-economical status and gender, and was obtained from students at the end of the 6th grade. The entire sample included 2,059 students (50% female) from 81 classes of 42 schools from all tiers of the German three-track education system. In the German school system, students are separated after grade 4 into three tracks (upper, middle, and top track) according to their level of achievement. The mean age of the participants was 12.77 years (SD = .52; range = 11.17–15.42 years).

3.2. Measures

3.2.1. Cognitive ability

Abstract reasoning ability (ARA) was assessed using nonverbal reasoning scale of the KFT 4-12+R ($\alpha = .92$; Heller & Perleth, 2000). The KFT 4-12+R is a German adaptation of the Cognitive Abilities Test developed by Thorndike and

Hagen (1971). Norm data collection was carried out in 1996 by a German representative sample. The nonverbal scale contained 25 figural analogy items in a multiple-choice, paper-and-pencil format. The mean score (IQ scale) of the abstract reasoning ability (ARA) scale was $M=105.54$ (SD = 13.62). We constructed quartiles according to subjects' nonverbal abilities in order to test our expectation that students belonging to different ARA groups differed in their state-emotional profile while working on a mathematics achievement test. Means, standard deviations of the nonverbal reasoning scale, and number of students for each of the four ARA groups are as follows: $M=87.49$, SD = 9.14, $N=532$ for quartile I; $M=103.27$, SD = 2.03, $N=492$ for quartile II; $M=112.19$, SD = 3.57, $N=686$ for quartile III; and $M=123.85$, SD = 3.95, $N=336$ for quartile IV. There were no gender differences on the abstract reasoning ability measure ($t(2012) = .13$, $p=.90$; effect size $d=.005$).

3.2.2. Mathematics achievement

To assess students' performance in mathematics, a test instrument (63 items; $M=100$, SD = 10) based on the concept of "mathematical literacy" was developed as part of the PALMA project (OECD, 2003; vom Hofe, Pekrun, Kleine & Goetz, et al., 2002). According to this literacy concept, the test measures the ability of students to recognise and interpret mathematical problems encountered in their world, to translate these problems into a mathematical context, to use mathematical knowledge and procedures to solve the problems within their mathematical context, to interpret the results in terms of the original problem, to reflect upon the methods applied, and to formulate and communicate the outcomes. The test was scaled according to the Rasch model (Likelihood Ratio Test: $\lambda = 2.14 * 10^{-21}$, n.s.; cf., Anderson, 1973; Embretson & Reise, 2000) and was also presented in paper-and-pencil format.

In line with our assumptions, the four ARA groups (see above) differed significantly in their results on the math achievement test, with the high-ability group achieving the best test scores ($F(3,2045)=267.83$, $p<.001$). Post hoc tests revealed that the scores of all four groups differed significantly from each other ($p<.001$). However, the correlation between cognitive ability and mathematics achievement showed sufficient independence between the two measures ($r=.53$, $p<.001$). As such, we constructed quartiles based on students' mathematics achievement and used Kappa with linear weighting (Agresti, 1996) to calculate the degree of correspondence between students' location within the ARA quartiles and the mathematics achievement quartiles. The Kappa with linear weighting was only .38. Both the correlation between the nonverbal ability scores and the scores on the mathematics achievement test, as well as the size of Kappa, indicate that our cognitive ability measure and the achievement test scores should not be regarded as indicators of a single underlying construct.

3.2.3. State emotions

State emotions were assessed by self-report items four times during the completion of the mathematics achievement test: Immediately before the test (Time 1 = T1), twice during the test after one-third (Time 2 = T2) and two-thirds (Time 2 = T3) of the test items had been completed, and after the completion of the entire test (Time 4 = T4). Students' responses to the self-report emotion measures were recorded on a Likert-type scale (1 = strongly disagree to 5 = strongly agree). Single items were used to assess each of the four emotions at each of the four completion times; items which differed in their wording only with respect to the point in time during the mathematics achievement test at which the item was administered. Students' experiences of enjoyment were assessed using the following wordings: "I am looking forward to the test" (T1), "I am enjoying the tasks" (T2, T3), and "I have enjoyed the tasks" (T4). The other emotions were each measured using two different item wordings: "I am anxious" (T1, T2, T3), and "I was anxious" (T4) for anxiety; "I am angry" (T1, T2, T3), and "I was angry" (T4) for anger; and finally, "I am bored" (T1, T2, T3) and "I was bored" (T4) for boredom. All items were preceded by the following instructions: "How do you feel at the moment?" (T1, T2, T3), and "How did you feel while working on the test?" (T4).

Concerning the reliability and validity of single-item measures of emotional experiences, a related study by Goetz (2004; $N=699$; 55% female; grades 7 and 9) found single-item measures of achievement emotions in mathematics to show acceptable reliability and validity. For the emotions of enjoyment and anxiety (trait emotional experiences), both single items and multi-item scales had been assessed in this study. Whereas single items referred to the global emotion under investigation (e.g., "I enjoy mathematics classes" for assessing class-related enjoyment), the multi-item scales assessed affective, cognitive, motivational, and physiological components of each emotion (enjoyment: $n=30$ items, $\alpha=.94$; anxiety: $n=35$ items, $\alpha=.94$; see Scherer, 1984, for multi-component conceptions of emotions). The single-item measures correlated $r=.73/.69$ (enjoyment/anxiety) with the corresponding multi-item scales, indicating acceptable validity of the single-item measures.

Although multi-item measures can be used to assess multi-faceted structures of emotions, such measures take longer to complete than single-item measures, which is particularly important to consider when assessing emotions during the completion of an achievement test. More specifically, longer measures could negatively influence students' engagement with test completion, and consequently, their state emotions. Further, when students are asked about the state emotions they experience immediately after having worked on the test, longer self-report measures could comprise students' responses during this phase by allowing for more reflection time and greater response bias (e.g., hindsight). In addition, by taking more time to respond, multi-item scales might be in danger of assessing students' emotions experienced while completing the questionnaire, rather than emotions referring to completing the achievement test. For these reasons, single-item measures were assumed to be more appropriate than multi-item measures for the purposes of the present study. The assumption that single-item measures are appropriate for this study is also supported by results of a meta-analysis in which single-item measures of overall job satisfaction are correlated with scales measuring overall job satisfaction (Wanous, Reichers, & Hudy, 1997). The authors argue that single-item measures are acceptable when, as in our study, the research situation suggests using them.

3.3. Procedure

Participants were recruited and data was collected by the German Data Processing Center (DPC) of the IEA (International Association for the Evaluation of Educational Achievement). Participants were tested in class and took part on voluntary basis. An experimenter was present throughout the entire testing session which lasted approximately 180 min with short breaks included. Instructions were given verbally by the experimenters and were also written on the test material. Students first completed the cognitive ability test, and then the mathematics achievement test which also included emotion measures (self-report state items), and finally a questionnaire assessing psychosocial constructs.

3.4. Rationale for analysis

3.4.1. Preliminary analyses

First, we present the means and standard deviations for the state emotion items (relating to enjoyment, anger, anxiety, and boredom) for the entire sample. Correlations between all state emotion items are then presented in order to highlight how students' state emotional experiences interrelate.

3.4.2. Analysis of variance

In order to examine differences between ability groups, the sample was grouped by ARA quartiles. For testing our hypothesis of different emotional experiences during a math achievement test based on students' level of ARA, we conducted a 4×4 repeated measures analysis of variance for each of the four emotions (between subject variable: ARA quartile; within subject variable: intensity of emotion at each of the four points of assessment during the mathematics test).

3.4.3. Dimension analytical method

In addition to the analysis of variance, we performed a correspondence analysis to compare the emotional profiles of the four ability groups. With this analysis, potential differences in the emotional profiles of the different groups can be detected that go beyond mere level differences in the intensities of emotional experiences. Although the groups may differ in the intensities of their emotional experiences, the profiles might be the same across groups. Thus, we investigated the structural proximity of the emotional profiles of the four ability groups using correspondence analysis which can graphically illustrate these differences in emotion profiles. This method is primarily intended to assist in the interpretation of multidimensional data by transforming numeric information into a graphical format (cf., Greenacre & Blasius, 1994). Correspondence analysis will locate not only the four emotions assessed (for each assessment period) on a graph based on their underlying emotional dimensions, but will also plot the locations of the four ability groups in relation to these emotional experiences. As such, the emotions which are closest to a specific ability group on this two-dimensional grid are those which correspond most closely with that ability level (cf., Benzécri, 1992; Greenacre, 1993).

In the present study, each achievement emotion was examined four times during the completion of the mathematics achievement test. Thus, each ability group had a specific profile of academic enjoyment, anger, anxiety, and boredom, with each emotion assessed at four points in time (i.e., a profile consisting for each of the four groups of 16 variables).

Table 1
Descriptive statistics for emotion items

	State emotions							
	Enjoyment		Anger		Anxiety		Boredom	
	M	SD	*M*	SD	*M*	SD	*M*	SD
T1 — before test	3.66	1.11	1.39	0.93	1.42	0.89	2.04	1.27
T2 — during test	3.32	1.19	1.44	0.97	1.32	0.82	1.98	1.25
T3 — during test	3.21	1.31	1.57	1.12	1.31	0.84	2.11	1.36
T4 — after test	3.13	1.29	1.66	1.17	1.32	0.86	2.23	1.27

Note. $N = 2059$. State emotions: single-item self-ratings. For all emotion items a Likert scale (1 to 5) was used.

Correspondence analysis was used to compare and visually plot the emotional profiles of each ability group by reducing the dimensionality of these profiles to a two-dimensional plane by calculating the Euclidian distances between them.

4. Results

4.1. Preliminary analyses

Means and standard deviations for the state emotion items for the entire sample are presented in Table 1. Table 2 shows the correlations between all state emotion items.

Concerning the *within-emotion relations*, the correlations between the state emotions assessed at different points in time were similar for each of the four emotions assessed, ranging from $r = .34$ (anxiety, T1–T4) to $r = .75$ (enjoyment, T3–T4; median: .57). Within-emotion relations were highest for adjacent time points (e.g., for anxiety: $r = .53$ for T1–

Table 2
Correlations between the emotion items

	Enjoyment				Anger				Anxiety				Boredom			
	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4
Enjoyment																
T1	–															
T2	.57	–														
T3	.54	.71	–													
T4	.52	.65	.75	–												
Anger																
T1	−.37	−.30	−.27	−.25	–											
T2	−.30	−.30	−.26	−.24	.58	–										
T3	−.25	−.29	−.35	−.30	.44	.56	–									
T4	−.26	−.26	−.32	−.35	.43	.50	.64	–								
Anxiety																
T1	−.12	−.07	−.05	−.04	.22	.18	.15	.12	–							
T2	−.08	−.09	−.05	−.06	.18	.27	.19	.19	.53	–						
T3	−.07	−.11	−.09	−.08	.17	.27	.35	.23	.41	.57	–					
T4	−.09	−.10	−.10	−.10	.16	.26	.24	.38	.34	.45	.58	–				
Boredom																
T1	−.31	−.31	−.35	−.33	.41	.31	.31	.29	.03	.03	.08	.12	–			
T2	−.30	−.36	−.37	−.31	.37	.40	.36	.34	.02	.08	.12	.13	.67	–		
T3	−.28	−.34	−.41	−.37	.34	.35	.45	.40	.02	.05	.16	.17	.61	.69	–	
T4	−.26	−.29	−.36	−.38	.26	.26	.31	.41	.01	.05	.11	.17	.54	.59	.69	–

Note. T1: Time 1 (before the test), T2, T3: Time 2, Time 3 (during the test), T4: Time 4 (after the test). $N = 2{,}059$. $|r| \geq .04$: $p < .05$; $|r| \geq .06$: $p < .01$; $|r| \geq .07$: $p < .001$.

T2, r=.41 for T1–T3, r=.34 for T1–T4) and ranged from r=.53 to r=.75. These high relations for adjacent assessments imply that students' emotions experienced before the test (T1) had the strongest impact on their emotions after the first part of the test (T2), and that emotional experiences assessed after two-thirds of the test (T3) were most correlated with the retrospective emotion ratings (T4). In other words, students' retrospective assessments of their emotional experiences during the test were most strongly influenced by the emotions they experienced during the last part of the test. Interpreting within-emotion relations between adjacent time points as indicators of test–retest reliability, these findings also indicate that the reliability of the single-item measures of emotions used in the present study was acceptable.

With respect to the *between-emotion relationships*, with few exceptions, state emotional experiences correlated most highly within each of the four points of assessment (e.g., anger and enjoyment: r=−.37 for T1–T1, r=−.25 for T1–T4, r=−.26 for T4–T1). However, the correlations within specific points in time were relatively weak, ranging from $|r|$=.03 to $|r|$=.45. For example, the correlations between anxiety and boredom ($|r|$=[.03; .17]) and between enjoyment and anxiety [$|r|$=[.05; .15]) were near zero.

4.2. Analysis of variance

Results of the 4×4 repeated measures ANOVA are presented in Table 3 (see also Fig. 1 and the Appendix). Most important for our research question, for three of four emotions under investigation, namely for enjoyment, anger, and anxiety, the between-subjects effect was significant such that these emotional experiences differed according to the ARA quartiles students belonged to.

For each of the four emotions, multivariate tests showed strong main effects of time. That is, each emotion showed significant differences in intensity as a function of the point of time at which it was assessed. The strongest main effect was found for enjoyment, which reflects the intense decrease of this emotion from Time 1 to Time 4 (see also Table 1).

For enjoyment, anger, and anxiety, the interaction between time and ARA quartiles did not reach statistical significance. This result indicates that the emotional experiences were not differentially influenced by time of assessment for the different ARA quartiles. For boredom, however, the interaction between time and ARA was significant, even though this effect was weak (F(9, 5637)=1.96, p=.04). That is, experiences of boredom were differentially influenced by time of assessment for the different ARA quartiles. Furthermore, the between-subject effect was not significant for boredom, indicating that experiences of boredom did not vary systematically for the ARA quartiles.

The results of the ANOVA analyses are presented in Fig. 1. For each of the four state emotions, the intensities of the emotion at each point of assessment and for each ARA quartile are depicted. For enjoyment, post hoc tests (Scheffé) revealed that the significant between-subject effect was due to ARA quartile IV (high-ability group). Quartile IV differed significantly from ARA quartiles I to III, while quartiles I to III did not differ significantly. Thus, students with high abilities experienced more enjoyment while working on the test than other students. In contrast, students' feelings of anger were found to increase for all four ability groups from Time 1 to Time 4. Post hoc tests showed that although ARA quartile I (low-ability group) differed substantially from quartiles II to IV, there was no substantial difference between quartiles II to IV. That is, low-ability students (quartile I) experienced a significantly higher level of anger than other students.

The pattern of results for anxiety was similar to that for anger, with low-ability students (quartile I) experiencing the highest level of anxiety. Again, quartile I differed significantly from quartiles III and IV, with low-ability students

Table 3
Results of the 4×4 repeated measures ANOVAs conducted separately for each emotion

	State emotions							
	Enjoyment		Anger		Anxiety		Boredom	
	F	p	F	p	F	p	F	p
Multivariate tests								
Time	127.87	<.01	37.53	<.01	8.78	<.01	24.22	<.01
Time X ARA quartiles	1.81	.06	1.48	.15	.82	.60	1.96	.04
Between-subject effects								
ARA quartiles	4.19	<.01	7.35	<.01	5.60	<.01	.53	.66

Note. ARA: Abstract reasoning ability. N=2059.

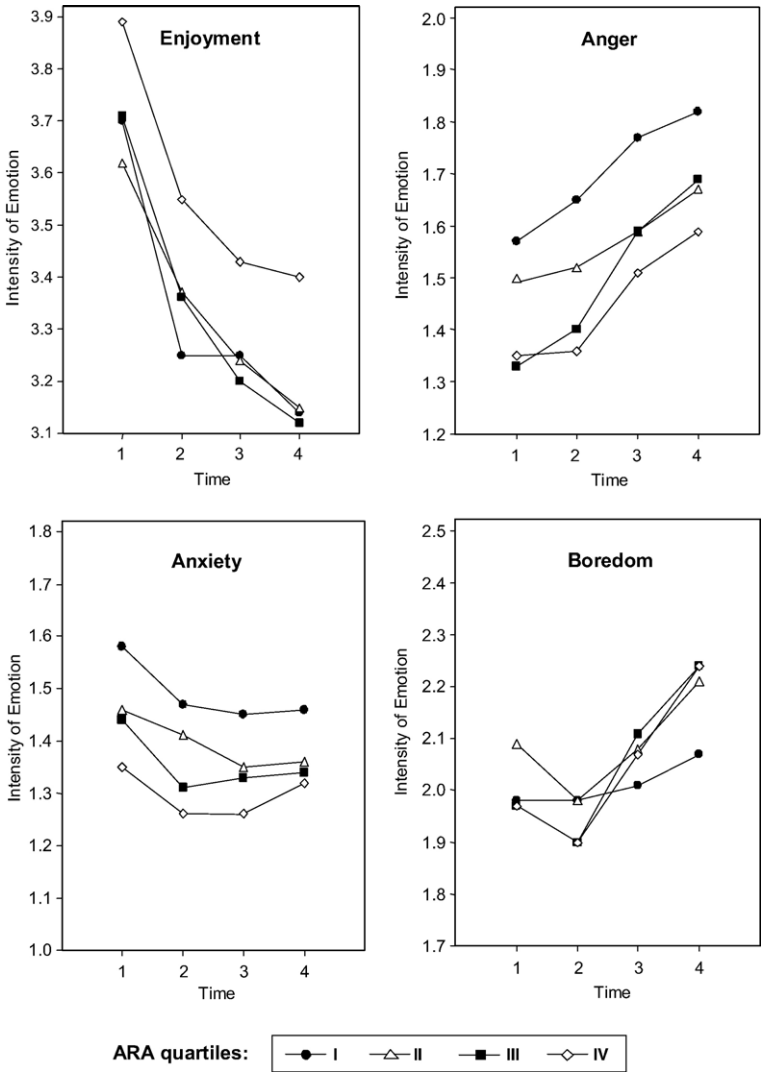

Fig. 1. Results of ANOVA Analysis. Time 1: Before the Test; Times 2 and 3 = During the Test; Time 4 = After the Test. ARA: Abstract Reasoning Ability. ARA Quartile1: Low ARA; ARA Quartile IV: High ARA.

(quartile I) experiencing the highest level of anxiety when working on the test. For all four ability groups, anxiety decreased from Time 1 to Time 2 and stayed relatively stable from Time 2 to Time 4. Reported intensities for boredom decreased from Time 1 to Time 2 yet increased from Time 2 to Time 4. Fig. 1 shows that the significant interaction between time and ARA was mainly due to students in ARA quartile I (low-ability students) who experienced less boredom at Times 3 and 4 than students in the other quartiles.

In sum, the ANOVA analyses showed that by assessing differences in emotional experiences based on students' abstract reasoning abilities, the four ability groups did not differ in their experiences of boredom. However, students with high abilities experienced high levels of enjoyment and low levels of anger and anxiety, while their low-ability counterparts experienced low levels of enjoyment and high levels of anxiety and anger when working on the mathematics achievement test.

4.2.1. Dimension analytical method

In assessing the state emotional profiles of the four ability groups (quartiles I to IV; see Fig. 2), we were able to identify specific clusters of emotional experiences. The four time-specific items for each of the four emotions tended to cluster together, indicating a considerable degree of dimensional similarity along the two dimensions identified by the

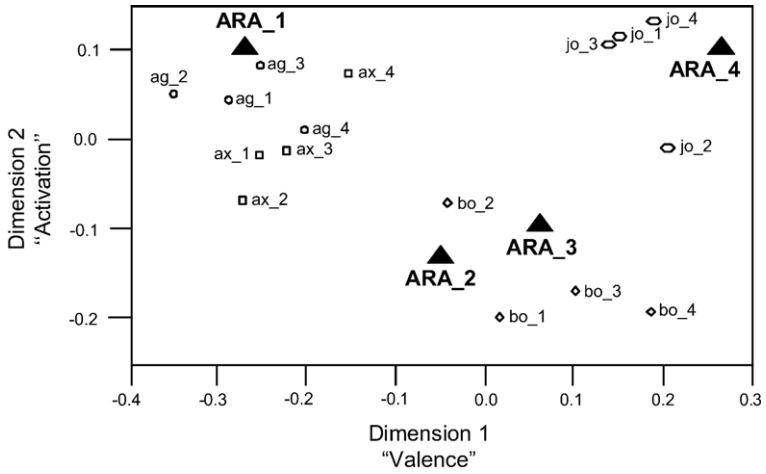

Fig. 2. Correspondence Analysis for Emotions Experienced During a Mathematics Test. Emotions: ⬭ = Enjoyment (jo), ○ = Anger (ag), □ = Anxiety (ax), ◇ = Boredom (bo). _1 = Before the Test; _2 and _3 = During the Test; _4 = After the Test. ▲ = Ability Group (ARA: Abstract Reasoning Ability; from ARA_1 [Low ARA] to ARA_4 [High ARA]).

correspondence analysis approach — dimensions which can be interpreted as representing valence and activation (see Fig. 2). With respect to the between-emotion relationships, students' experiences of enjoyment, boredom, and anxiety/anger could be represented as distinct clusters of emotions. Feelings of anxiety and anger, however, could not be differentiated empirically, suggesting that these two emotions share common characteristics which make them indistinguishable along the two emotional dimensions.

In Fig. 2, the *x*-axis can be interpreted as representing the dimension of *valence* from negative (left) to positive (right) and the y-axis as representing the dimension of *activation* from deactivating (bottom) to activating (top). Thus, consistent with our theoretical approach, anger and anxiety are represented as negative-activating emotions, enjoyment is represented as a positive-activating emotion, and boredom can be seen as a deactivating emotion with its valence located between that of enjoyment and anxiety/anger. The four ability groups were arranged as expected along the x-axis with the low-ability group (ARA_1) on the far left (negative valence), the intermediate ability groups (ARA_2, ARA_3) in the middle, and the high-ability group (ARA_4) on the far right (positive valence). Thus, although quartiles II and III (ARA_2, ARA_3) showed similar emotional profiles, the greatest distance on the grid was found between the low- and high-ability groups (ARA_1 and ARA_4), indicating that these two groups had the most different emotional profiles.

The correspondence analyses also provided information concerning the location for the four ability groups (ARA quartiles) with respect to the four state emotions assessed. Considering first students' feelings of enjoyment, this emotion was located near the highest ARA quartile (ARA_4). In contrast, the emotions of anxiety and anger were located near ARA quartile I (ARA_1), the lowest-ability group. Quartiles II and III were located near emotional experiences of boredom. That is, when comparing the relative intensities of emotional experiences of the four ability groups, boredom was found to be relatively high for students with average cognitive abilities. Altogether, by comparing the emotional profiles of the four ability groups, that is, the relative intensities of enjoyment, anger, anxiety, and boredom, the primary emotions for students with low cognitive abilities (ARA_1) were anxiety and anger, for students with average ability (ARA_2, ARA_3) was boredom, and for students with high cognitive abilities (ARA_4) was enjoyment.

5. Discussion

The present study investigated students' state emotional experiences throughout the entire process of test completion, in contrast to previous research that has typically examined test-related emotions either before or after an achievement test. In accordance with our hypothesis, analysis of variance showed that students of different ARA quartiles differed in their emotional experiences before, during, and after working on the test, with high-ability students experiencing a more positive pattern of emotions. Correspondence analysis revealed a state emotional structure that is also consistent with models in which emotions are organized along two dimensions, namely activation and valence (see Watson & Tellegen, 1985; Russel, 1980; Pekrun et al., 2002a). Along these two dimensions, anger and anxiety shared

common characteristics, namely high activation and negative valence. Enjoyment was located as an activating and positive emotion, and boredom was found to be a deactivating emotion with neutral valence.

Further, while analysis of variance showed how students' emotional experiences differed in terms of mean scores as a function of their abstract reasoning abilities, our correspondence analytic approach was used to explore the salience of specific emotions within the emotional patterns of students of the four ARA quartiles. In other words, even if the mean level of a specific emotion is, for example, lower in quartile one than in quartile two, this emotion might be more salient within the emotional pattern of quartile one than of quartile two. The dimension analytical method showed that students' emotional profiles while completing a math achievement test did indeed differ based on their nonverbal cognitive abilities (see Fig. 2).

In comparing the emotional profiles of the four ability groups, correspondence analysis revealed dimensional similarities between high abstract reasoning ability and enjoyment, low ability and anxiety/anger, as well as moderate ability and boredom. The emotional profiles of both low- and high-ability students (ARA_1 and ARA_4) showed boredom to not be as salient as for moderate-ability students (ARA_2 and ARA_3). This finding may be explained, in part, by the assumption that feelings of enjoyment and anger/anxiety vs. boredom are mutually exclusive emotional experiences. In other words, students are neither bored when they experience anger and anxiety (ARA_1) nor when they experience enjoyment (ARA_4). Another interesting finding was that the two groups of students with intermediate cognitive abilities (ARA_2 and ARA_3) had similar emotional profiles in that they were dimensionally located between enjoyment and anger/anxiety with boredom being the predominant emotion. Consistent with the explanation above, the reason for this finding might be that students with moderate cognitive abilities have a level of control and achievement which is too high to induce anger and anxiety, but also too low to make test completion enjoyable, resulting in an emotional profile in which boredom is more dominant than in either low- or high-ability students.

Analysis of variance as well as correspondence analysis revealed similar results for enjoyment, anger, and anxiety. With respect to both absolute emotional intensities and within-emotion profiles across the four points of assessment, enjoyment was found to be the predominant emotion among high-ability students while anxiety and anger were highest for students in the low-ability group. For boredom, no differences were found with analysis of variance between the four ability groups. However, correspondence analysis revealed that by controlling for different intensities between the ARA groups, boredom was the predominant emotion for students with intermediate cognitive abilities. In other words, boredom was more salient in the emotional profile of students with intermediate cognitive abilities, in spite of the fact that mean scores for these students' boredom did not differ from the mean scores for students of high and low ability.

6. Limitations and implications

One limitation of the present study involves our use of single-item state emotion measures which did not allow for reliability estimates at any given point of assessment. However, results of a study by Goetz (2004) indicate that single-item measures of academic emotional experiences can show sufficient reliability and validity. Further, the intercorrelations between the emotion measures across the four assessment phases were relatively high, indicating that our measures were indeed reliable. Further, correspondence analysis revealed a theoretically assumed state emotional structure which supports the validity of our single-item measures. In other words, invalid measures of emotional experiences would not have allowed us to differentiate between discrete emotions in such a coherent manner.

Future research assessing the development of state emotions over time using multi-item measures is warranted. However, since it would take students longer to answer multiple items, this change in experimental protocol could influence their engagement in the math test, and consequently, their state emotional experiences. Further, items related to emotions while working on a test can be assumed to be less valid if preceded by numerous other emotion-related items. In that case, emotion-related items like "*I am bored*" could assess state emotional experiences related to working on the emotion questionnaire rather than emotional experiences related to the test. As an alternative to multi-item scales, and in order to control for the reliability and validity of single-item assessments, future research could combine an assessment based on single items (subjective self-reports) with the assessment of physiological correlates of emotional experiences, or with behavioral observations (see Zeidner, 1998, concerning multiple methodologies for assessing test anxiety).

A second limitation of this study is that only four emotions were assessed in the present study. Future research in which a greater variety of emotions are examined, such as hope, hopelessness, shame, and pride, is

encouraged. In this way, we can further explore whether students with high cognitive abilities also experiences higher levels of hope and pride and lower levels of shame and hopelessness than students with lower cognitive ability levels.

Finally, we investigated students' test-related emotions in one specific domain, namely mathematics. Although our theoretical approach implies that students differing in cognitive abilities differ in their state emotional experiences during tests in other subject areas as well, the results of the present study can not be generalized beyond the domain of mathematics. Future research should also focus on other domains, for example, by investigating whether students with differing verbal cognitive abilities show different emotional patterns when working on an achievement test administered in language classes (i.e., English).

Based on our assumptions, we suggest four possible ways in which the negative effects of low abstract reasoning abilities on emotional experiences when working on a mathematics achievement test can be attenuated. First, by using both verbal and oral examinations involving adaptive tasks, that is, tasks which do not have only one correct answer but allow for responses with varying levels of complexity, educators can prevent students from feeling "out of control" and thereby minimize the accompanying negative emotional experiences. It is through the use of such adaptive tasks that even students with low abstract reasoning ability can attain a sense of achievement while completing the testing exercise.

Second, by administering achievement tests that are well-structured in nature and by clearly delineating the goals and expectations set for the students, teachers can foster a sense of control in their pupils which, in turn, should have a positive impact on their academic emotional experiences. Third, providing individual reference norms (e.g., tracking individual students' progress over time) may also aid in fostering a sense of achievement and positive emotions in students independent of the achievement levels of classmates. Finally, by incorporating achievement test formats which are cognitively stimulating for all students, such as authentic tasks involving age-specific exercises, educators can also help to foster positive emotional experiences in not only high-ability students but also their low-ability counterparts.

Appendix A. Means and standard deviations of the state emotion items

	ARA quartiles							
	I		II		III		IV	
	M	SD	*M*	SD	*M*	SD	*M*	SD
Enjoyment								
T1	3.65	1.16	3.57	1.15	3.66	1.06	3.84	1.06
T2	3.20	1.27	3.32	1.24	3.31	1.13	3.50	1.13
T3	3.20	1.37	3.19	1.35	3.15	1.25	3.38	1.23
T4	3.09	1.38	3.10	1.29	3.07	1.20	3.35	1.20
Anger								
T1	1.52	1.06	1.45	0.99	1.28	0.73	1.30	0.80
T2	1.60	1.10	1.47	1.00	1.35	0.82	1.31	0.82
T3	1.72	1.23	1.54	1.11	1.54	1.04	1.46	0.99
T4	1.77	1.31	1.62	1.16	1.64	1.11	1.54	1.03
Anxiety								
T1	1.53	0.97	1.41	0.91	1.39	0.84	1.30	0.65
T2	1.42	0.92	1.36	0.84	1.26	0.70	1.21	0.67
T3	1.40	0.93	1.30	0.82	1.28	0.77	1.21	0.73
T4	1.41	0.94	1.31	0.83	1.29	0.79	1.27	0.84
Boredom								
T1	2.02	1.34	2.13	1.33	2.01	1.20	2.01	1.14
T2	2.02	1.34	2.02	1.29	1.94	1.19	1.94	1.10
T3	2.05	1.38	2.12	1.40	2.15	1.33	2.11	1.28
T4	2.11	1.41	2.25	1.37	2.28	1.40	2.28	1.25

Note. ARA: Abstract reasoning ability; from I (low ARA) to IV (high ARA). T1: Time 1 (before the test), T2, T3: Time 2, Time 3 (during the test), T4: Time 4 (after the test). $N = 2{,}059$.

References

Ackerman, P. L., & Heggestad, E. D. (1997). Intelligence, personality, and interests: Evidence for overlapping traits. *Psychological Bulletin*, *121*, 219−245.

Agresti, A. (1996). *An introduction to categorical data analysis.* New York: Wiley.

Anderson, E. B. (1973). A goodness of fit test for the Rasch-model. *Psychometrika*, *38*, 123−140.

Aspinwall, L. G. (1998). Rethinking the role of positive affect in self-regulation. *Motivation and Emotion*, *22*, 1−32.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Englewood Cliff, NJ: Prentice Hall.

Benzécri, J. -P. (1992). *Correspondence analysis handbook.* New York: Marcel Dekker.

Carr, M., Borkowski, J. G., & Maxwell, S. E. (1991). Motivational components of underachievement. *Developmental Psychology*, *27*(1), 108118.

Cattell, R. B., & Scheier, I. H. (1961). *The meaning and measurement of neuroticism and anxiety.* New York: Ronald Press.

Crombach, M. J., Boekaerts, M., & Voeten, M. J. M. (2003). Online measurement of appraisals of students faced with curricular tasks. *Educational and Psychological Measurement*, *63*(1), 96−111.

Davis, H.A., Schutz, P.A., De Cuir, J.T. (1999, August). *They can't tell me I'm stupid: Undergraduate students coping with test anxiety.* Paper presented at the annual meeting of the American Psychological Association, Boston, MA.

Diener, E. (2000). Subjective well-being. The science of happiness and a proposal for a national index. *American Psychologist*, *55*(1), 34−43.

Diener, E., & Larsen, R. J. (1993). The experience of emotional well-being. In M. Lewis & J.M. Haviland (Eds.), *Handbook of emotions* (pp. 405−415). New York: Guilford Press.

Ekman, P., & Davidson, R. J. (1994). Affective science: A research agenda. In P. Ekman & R.J. Davidson (Eds.), *The nature of emotion: Fundamental questions* (pp. 411−434). New York: Oxford University Press.

Embretson, S. E., & Reise, S. P. (2000). *Item response theory for psychologists.* Mahwah, NJ: Erlbaum.

Folkman, S., & Lazarus, R. S. (1985). If it changes it must be a process: Study of emotion and coping during three stages of a college examination. *Journal of Personality and Social Psychology*, *48*(1), 150−170.

Galassi, J. P., Frierson, H. T., & Sharer, R. (1981a). Bahavior of high, moderate and low test anxious students during actual test situations. *Journal of Consulting and Clinical Psychology*, *49*, 51−62.

Galassi, J. R., Frierson, H. T., & Sharer, R. (1981b). Concurrent versus retrospective assessment in test anxiety research. *Journal of Consulting and Clinical Psychology*, *49*, 614−615.

Goetz, T. (2004). *Emotionales Erleben und selbstreguliertes Lernen bei Schülern im Fach Mathematik [Students' emotions and self-regulated learning in mathematics].* Muenchen: Utz.

Goetz, T., Pekrun, R., Hall, N. C., & Haag, L. (2006). Academic emotions from a social-cognitive perspective: Antecedents and domain specificity of students' affect in the context of Latin instruction. *British Journal of Educational Psychology*, *76*(2), 289−308.

Goetz, T., Zirngibl, A., Pekrun, R., & Hall, N. C. (2003). Emotions, learning and achievement from an educational–psychological perspective. In P. Mayring & C.v. Rhoeneck (Eds.), *Learning emotions. The influence of affective factors on classroom learning* (pp. 9−28). Frankfurt am Main: Peter Lang.

Greenacre, M. (1993). *Correspondence analysis in practice.* London: Academic Press.

Greenacre, M., & Blasius, J. (1994). *Correspondence analysis in the social sciences.* San Diego: Academic Press.

Gross, T. F. (1990). General test and state anxiety in real examinations: State is not test anxiety. *Educational Research Quarterly*, *14*(3), 11−20.

Guthrie, J. T., Wigfield, A., Metsala, J. L., & Cox, K. E. (1999). Motivational and cognitive predictors of text comprehension and reading amount. *Scientific Studies of Reading*, *3*(3), 231−257.

Heckhausen, J., & Schulz, R. (1995). A life-span theory of control. *Psychological Review*, *102*, 284−304.

Heller, K., & Perleth, C. (2000). *Kognitiver Fähigkeitstest für 4. bis 12. Klassen, Revision (KFT 4-12+R) [Cognitive ability test for class level 4 to 12, revised version].* Göttingen: Beltz Test GmbH.

Holling, H., Preckel, F., & Vock, M. (2004). *Intelligenzdiagnostik [Assessment of intelligence].* Göttingen: Hogrefe.

Jensen, A. R. (1998). *The g factor: The science of mental ability.* Westport: Praeger Publishers.

Klinger, E. (1984). A consciousness-sampling analysis of test anxiety and performance. *Journal of Personality and Social Psychology*, *47*, 1376−1390.

McCoach, D. B., & Siegle, D. (2003). Factors that differentiate underachieving gifted students from high-achieving gifted students. *Gifted Child Quarterly*, *47*(2), 144−154.

Organisation for Economic Co-operation and Development (OECD) (2000). *PISA 2003 assessment framework — Mathematics, reading, science, and problem solving knowledge and skills.* Paris: OECD.

Ones, D. S., Viswesvaran, C., & Dilchert, S. (2004). Cognitive ability in selection decisions. In O. Wilhelm & R. Engle (Eds.), *Understanding and measuring intelligence* London: Sage.

Pekrun, R. (2000). A social-cognitive, control-value theory of achievement emotions. In J. Heckhausen (Ed.), *Motivational psychology of human development* (pp. 143−163). Oxford: Elsevier.

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.

Pekrun, R., Goetz, T., Perry, R. P., Kramer, K., Hochstadt, M., & Molfenter, S. (2004). Beyond test anxiety: Development and validation of the Test Emotions Questionnaire (TEQ). *Anxiety, Stress, and Coping*, *17*(3), 287−316.

Pekrun, R., Goetz, T., Titz, W., & Perry, R. P. (2002a). Academic emotions in students' self-regulated learning and achievement: A program of qualitative and quantitative research. *Educational Psychologist*, *37*(2), 91−105.

Pekrun, R., Goetz, T., Titz, W., & Perry, R. P. (2002b). Positive emotions in education. In E. Frydenberg (Ed.), *Beyond coping: Meeting goals, visions, and challenges* (pp. 149−173). Oxford: University Press.

Pekrun, R., Goetz, T., vom Hofe, R., Blum, W., Jullien, S., Zirngibl, A., et al. (2004). Emotionen und Leistung im Fach Mathematik: Ziele und erste Befunde aus dem, Projekt zur Analyse der Leistungsentwicklung in Mathematik“ (PALMA) [Emotional experiences and achievement in mathematics: Goals and preliminary findings of the Project for the Analysis of Learning and Achievement in Mathematics]. In J. Doll & M. Prenzel (Eds.), *Bildungsqualität von Schule: Lehrerprofessionalisierung, Unterrichtsentwicklung und Schülerförderung als Strategien der Qualitätsverbesserung* (pp. 345−363). Münster: Waxmann.

Perry, R. P., Hall, N. C., & Ruthig, J. C. (2005). Perceived (academic) control and scholastic attainment in higher education. In J. Smart (Ed.), *Higher education: Handbook of theory and research*, *Vol. 20*. (pp. 363−436)The Netherlands: Springer.

Preckel, F., Holling, H., & Vock, M. (2006). Scholastic underachievement: Relationship with cognitive motivation, achievement motivation, and conscientiousness. *Psychology in the Schools*, *43*, 401−411.

Reis, S. M., & McCoach, D. B. (2000). The underachievement of gifted students: What do we know and were do we go? *Gifted Child Quarterly*, *44* (3), 152−170.

Roznowski, M., Reith, M., & Hong, S. (2000). A further look at Youth intellectual giftedness and its correlates: Values, interests, performance, and behaviour. *Intelligence*, *28*(2), 87−113.

Russel, J. A. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology*, *39*, 1161−1178.

Sarason, S. B., & Mandler, G. (1952). Some correlates of test anxiety. *Journal of Abnormal and Social Psychology*, *47*(4), 810−817.

Scherer, K. R. (1984). On the nature and function of emotion: A component process approach. In K. R. Scherer & P. Ekman (Eds.), *Approaches to emotion* (pp. 293−317). Hillsdale, NY: Erlbaum.

Schutz, P. A., & Davis, H. A. (2000). Emotions and self-regulating during test taking. *Educational Psychologist*, *35*(4), 243−256.

Seligman, E. P., & Csikszentmihalyi (2000). Positive psychology: An introduction. *American Psychologist*, *55*(1), 5−14.

Smith, C. A., & Ellsworth, P. C. (1987). Patterns of appraisal and emotion related to taking an exam. *Journal of Personality and Social Psychology*, *52*(3), 475−488.

Spangler, G., Pekrun, R., Kramer, K., & Hofmann, H. (2002). Students’ emotions, physiological reactions, and coping in academic exams. *Anxiety, Stress, and Coping*, *15*(4), 413−432.

Spielberger, C. D. (1972). Anxiety as an emotional state. In C. D. Spielberger (Ed.), *Anxiety: Current trends in theory and research*, *Vol. I.* (pp. 23−49)New York: Academic Press.

Thorndike, R. L., & Hagen, E. (1971). *Cognitive abilities test.* Boston: Houghton-Mifflin.

vom Hofe, R., Pekrun, R., Kleine, M., & Goetz, T. (2002). Projekt zur Analyse der Leistungsentwicklung in Mathematik (PALMA). Konstruktion des Regensburger Mathematikleistungstests für 5.–10 Klassen. (Projekt for the analysis of learning and achievement in mathematics: Construction of the Regensburg mathematics achievement test for grades 5–10.). In M. Prenzel & J. Doll (Eds.), *Bildungsqualität von Schule: Schulische und außerschulische Bedingungen mathematischer, naturwissenschaftlicher und überfachlicher Kompetenzen (Zeitschrift für Pädagogik, 45. Beiheft, pp. 83.100)* Weinheim: Beltz.

Wanous, J. P., Reichers, A. E., & Hudy, M. J. (1997). Overall job satisfaction: How good are single-item measures? *Journal of Applied Psychology*, *82*(2), 247−252.

Watson, D., & Tellegen, A. (1985). Toward a consensual structure of mood. *Psychological Bulletin*, *98*, 219−235.

Weiner, B. (1985). An attributional theory of achievement motivation and emotion. *Psychological Review*, *92*(4), 548−573.

Weiner, B. (2001). Intrapersonal and interpersonal theories of motivation from an attribution perspective. In S. Farideh & C. Chi-yue (Eds.), *Student motivation: The culture and context of learning. Plenum series on human exceptionality* (pp. 17−30). Dordrecht, Netherlands: Kluwer Academic Publishers.

Zeidner, M. (1995a). Personality trait correlates of intelligence. In D. H. Saklofske & M. Zeidner (Eds.), *International handbook of personality and intelligence* New York: Plenum Press.

Zeidner, M. (1995b). Adaptive coping with test situations. A review of the literature. *Educational Psychologist*, *30*, 173−187.

Zeidner, M. (1998). *Test anxiety: The state of the art.* New York: Plenum Press.

Zeidner, M., & Matthews, G. (2000). Intelligence and personality. In R. J. Sternberg (Ed.), *Handbook of intelligence* (pp. 581−610). Cambridge: Cambridge University Press.

Zimmerman, B. J. (1998). Developing self-fulfilling cycles of academic regulation: An analysis of exemplary instructional models. In D. H. Schunk & B.J. Zimmerman (Eds.), *Self-regulation of learning and performances: Issues and educational applications* (pp. 3−21). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Zimmerman, B. J. (2000). Attaining self-regulation. A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 13−39). San Diego, CA: Academic.