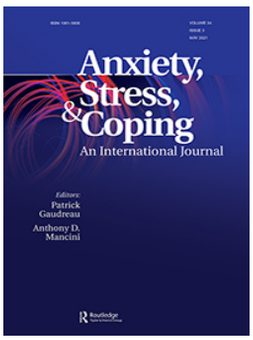

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Test anxiety components: an intra-individual approach testing their control antecedents and effects on performance

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ABSTRACT

Background and Objectives: Although anxiety consists of multiple components, including cognitive, affective, motivational, and physiological, and some findings suggest that there might be differences regarding their control antecedents and effects on performance, previous studies have largely neglected to examine these components separately and for reasons of convenience often assessed test anxiety as a unified construct using a single-item. Therefore, this study investigated the different test anxiety components with the goal to: (1) examine the relative impact of the anxiety components in the mediating mechanism that connects control and performance – as proposed by Pekrun's control-value theory, and (2) determine which specific anxiety component is underlying common single-item anxiety measures.

Methods: The research questions were investigated using an intra-individual approach in a sample of $N = 137$ German 8th graders during a mathematics exam.

Results: As expected, control was negatively related to all anxiety components, but associations varied in strength. Additionally, the components differed in their relative impact on performance, with the cognitive component being central for this outcome. Furthermore, common single-item measures seem to specifically assess the affective component, and thus not the component most relevant for test performance.

Conclusion: Consequently, our study strongly recommends to distinguish between the anxiety components depending on the research question at hand.

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Test anxiety; components; performance; antecedents; control-value theory; intra-individual

Anxiety, and especially test anxiety, is a prevalent emotion in school (prevalence 25% to 40%; Zeidner, 2014) and one of the most powerful obstacles to learning (Enright et al., 2000). Therefore, a deeper understanding of test anxiety's nature is important, especially in educational psychology, to develop effective anxiety interventions or instructional techniques that can help students deal with this detrimental emotion (Astleitner, 2000; Zeidner, 2007, 2014). The control-value theory (CVT) refers to control (appraisals) as a central antecedent to anxiety and lower performance as a major

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consequence of anxiety (Goetz et al., 2006). Although in the research literature anxiety is typically conceptualized as consisting of multiple components (i.e., cognitive, affective, motivational, and physiological components), empirical knowledge about the antecedents and effects of individual anxiety components is relatively scarce (Scherer, 2009; Zeidner, 2007). This may result from anxiety being usually assessed and examined relatively undifferentiated as an overall construct (i.e., by building a sum score, or by using a single-item measure) or by only roughly differentiating between worry and emotionality components (Zeidner, 2007). Thus, it remains unclear whether all anxiety components are equally important in the mediating mechanism proposed by the CVT that connects control, anxiety (components) and test performance. A more detailed understanding about the relative importance of the different components in this model may prove helpful to identify which anxiety components should be addressed to increase students' performance – a very important outcome at school (Putwain, 2008; von der Embse & Witmer, 2014) and to gain a better understanding about how strongly the different components depend on control appraisal antecedents.

The goal of the present study was twofold. First, we investigated the individual anxiety components based on assumptions of the CVT to examine the relative impact that antecedent appraisals of control have on the individual anxiety components and which of the anxiety components has the strongest impact on student's performance (i.e., mediation). As the CVT describes intra-individual processes (i.e., processes within a person), we applied an intra-individual real-time approach (Murayama et al., 2017). Particularly, we examined the within-person association of control appraisal, anxiety components (cognitive, affective physiological, and motivational) and performance during a real-life math exam.

Because anxiety is, despite its componential nature, usually examined as a relatively undifferentiated construct (i.e., no differentiation between subscales by using or building sum scores) and given a recent line of recent research that, assesses it with single-item measures – often for reasons of practicability and economy (Ashcraft, 2002; Csikszentmihalyi & Larson, 2014; Goetz et al., 2013; Tong et al., 2007), the second goal of the current study was to investigate which anxiety component is hidden behind such relatively undifferentiated measures of test anxiety. In other words, we wanted to explore which anxiety component affects student reports when we ask them about their anxiety in the context of a test with a single-item. In combination with our first research questions, this may help future research in deciding whether and how differentiated anxiety should be assessed depending on the conclusions the researchers want to draw.

Anxiety and its components

Anxiety is an emotion that is familiar to all of us and a prevalent form occurs in the context of a test or exam, also referred to as test anxiety, test-related anxiety or exam anxiety (von der Embse et al., 2018; Zeidner, 2014). Therefore, this is the type of anxiety this manuscript is centered around. However, in cases in which we do not refer explicitly only to "test anxiety" but to more general concepts of anxiety, in the following, we still use the term "anxiety".

Early research conceptualized test anxiety as a single, unidimensional construct (Mandler & Sarason, 1952). However, in the current literature it is usually conceived as consisting of multiple components (Lowe et al., 2008; Pekrun et al., 2004; Zeidner, 2014). Liebert and Morris (1967) introduced the distinction between the "worry" and "emotionality" components of test anxiety. The worry component has been defined as a cognitive concern about one's performance (e.g., thinking about the potential consequences of failure during examinations and tests), as well as doubts about one's ability to perform adequately. Emotionality refers to negative experiences, such as negative arousal and unease (e.g., feeling nervous, sweaty palms, or generally upset feelings) that may occur during a stressful academic event (Morris & Liebert, 1970). More recently, an even finer distinction between the components has been made (e.g., Hodapp & Benson, 1997; Lowe et al., 2008; Sarason, 1984; Segool et al., 2014). A common distinction, which is also reflected in emotion questionnaires such as the Achievement Emotions Questionnaire (AEQ; Pekrun et al., 2011), is the

differentiation between four components that are theoretically distinct, yet related (Scherer, 2009; Zeidner, 2014). Regarding test anxiety, they can be described by intrusive thoughts and worries (i.e., cognitive component), a feeling of nervousness (i.e., affective component – often also referred to as the component that describes the core feeling of an emotion), increased physiological arousal such as higher heart rate or sweating (i.e., physiological component), and an urge to withdraw from the situation (i.e., motivational component; Pekrun et al., 2004; 2011; Zeidner & Matthews, 2005).

Control antecedents and achievement effects of anxiety and its components

Pekrun's control-value theory (2006) is a prominent and well acknowledged appraisal theory in the educational context that deals with the antecedents and effects of emotions. It refers to control (appraisals) as a central antecedent and lower performance as a major effect of anxiety in achievement situations. Control reflects the cognitive appraisal of the possibility to personally influence activities and outcomes and may include perceptions such as competency beliefs and causal attributions (Goetz et al., 2006; Pekrun & Stephens, 2010). CVT suggests that an increase in anxiety occurs for achievement situations that a student perceives to be important, such as a test (i.e., high value) and when the student experiences a loss of control or insufficient control over the achievement activities or outcomes (i.e., negative control appraisals; Pekrun, 2006). This increased anxiety is in turn associated with decreased performance. Thus, this relationship can be described as a mediation: anxiety mediates the relationship between control and performance. In detail, increased anxiety resulting from perceived lack of control reduces cognitive resources and the use of flexible strategies and self-regulation, and subsequently has negative effects on performance (Pekrun et al., 2009). In accordance with Pekrun's assumptions, a large number of empirical findings consistently demonstrate that a lack of perceived control (i.e., low control appraisals such as low self-concept of ability, self-efficacy expectations, and academic control beliefs) is closely related to increased anxiety (e.g., Frenzel et al., 2007; Goetz et al., 2006; Perry et al., 2001) and that (test) anxiety is associated with lower performance (Hembree, 1988; Seipp, 1991; von der Embse et al., 2018).

So far, it remains unclear whether all the anxiety components are equally important in this proposed mediating mechanism that connects control and performance at school, as the multi-component view of anxiety is still largely neglected in many empirical studies. Regarding control antecedents, until now, to our knowledge there is no study that has examined control appraisals and their relation to the individual anxiety components. However, as control is a cognitive appraisal, it is reasonable to expect that it has the strongest effect on the cognitive anxiety component (Goetz et al., 2006).

Investigations of the effect of different anxiety components on performance, with the exception of findings from research that differentiated between worry and emotionality (e.g., Liebert & Morris, 1967), are also scarce because test anxiety researchers have typically relied on composite scores (Putwain, 2008; von der Embse & Hasson, 2012) or have not considered subscales or differentiated between the four components of anxiety. In the line of research on worry and emotionality, worry showed stronger negative correlations with performance than emotionality (Cassady & Johnson, 2002; Deffenbacher, 1977; meta-analysis: Seipp, 1991). In research by McIlroy (2000) that used a four-component model differentiating between worry, test-irrelevant thinking, tension and bodily symptoms it was found that in addition to worry, the test irrelevant thinking and tension components were also negatively related to performance. Keogh et al. (2004), however, reported that only the worry component was important. Putwain et al. (2010) found that bodily symptoms (i.e., the physiological component), in addition to worry, were significantly negatively related to achievement. In contrast to this finding, some evidence points to a positive relation between physiological arousal and performance in athletes, where increased physiological arousal can sometimes positively impact performance (e.g., Burton, 1988; Parfitt et al., 1995). Given these inconsistencies, the current study aimed to take a closer look at the anxiety components in two ways: by investigating their

relation with control appraisals – one of its most important antecedents, and by examining their effects on performance – a major outcome at school.

Assessing test anxiety

Single-items versus multiple items

An important aspect when examining anxiety and more specifically test anxiety is the differentiation between multiple item measures and general, single-item measures of anxiety. With the emergence of authentic studies that make use of repeated measurements of the same construct (i.e., experience sampling), single-item measures (e.g., "How much anxiety are you experiencing right now?") have become more popular (Ashcraft, 2002; Csikszentmihalyi & Larson, 2014; Goetz et al., 2013; Nett, Goetz, & Hall, 2011; Tong et al., 2007). Such measures have practical and economic advantages because they are less intrusive and easier to administer (especially in large scale assessments), and previous research suggested that they can be sufficient for adequately measuring subjective experiences such as anxiety (e.g., Ainley & Patrick, 2006; Gogol et al., 2014; Núñez-Peña et al., 2014). In the case of test anxiety, however, these single-item measures are only able to gauge anxiety in the context of a test situation as a global and undifferentiated construct (Diamantopoulos et al., 2012; Pekrun, 2016) and little is known about which anxiety components such measures actually tap into (i.e., what component of anxiety do students consider when we ask them about their anxiety) because they do not clearly indicate whether one, some, or all components of anxiety are perceived (Shuman et al., 2017). Since in most theoretical models on emotions the affective component is seen as the key emotional component (Scherer, 2005, 2009), it is possible that single-item anxiety measures are closely associated with the affective component. More knowledge about emerging single-item measures can be helpful when interpreting results and understanding the implications from studies that apply single-item anxiety measures. Moreover, we can determine which anxiety component is most prominently in students' minds when they are asked about their test anxiety.

Trait versus state assessments

A further distinction that can be made when assessing anxiety are so called trait and state assessments of anxiety. In most studies of test anxiety the measure is not directly connected to specific test situations (i.e., participants have to indicate how they typically or generally feel in exams) and thus represents *trait test anxiety measure* (e.g., TAS, Sarason, 1978; TAI, Spielberger & Gonzalez, 1980; a typical sample item "How much anxiety are you generally experiencing in exams?"). The ecological validity of these measures is questionable given that they are general and not directly connected to a specific test situation. Their global nature is also not ideal for investigating the connection between test anxiety and performance in a specific testing situation (Kahneman, 2011; Wilhelm & Grossman, 2010). Furthermore, such trait measures are subject to bias, for instance by memory effects and generalized subjective beliefs (Buehler & McFarland, 2001; Goetz et al., 2013; Robinson & Clore, 2002).

So called *state test anxiety* scores obtained by multiple (state) assessments examine students momentarily experienced anxiety in a specific situation and reduce these effects because of the better proximity in terms of time (i.e., real time) and space of the assessment (e.g., in the school context during a test; Barrett, 1997; Wilhelm & Grossman, 2010). A typical sample item for these state anxiety measures would be "How much anxiety are you experiencing right now?". Furthermore, repeated state assessments allow for analyzing the control, anxiety, performance relationship on an intra-individual level (Hamaker, 2012; Murayama et al., 2017). This is more in line with CVT, which in fact describes intra-individual functioning, that is, within-person relationships between appraisals, emotions and performance (Pekrun et al., 2009). Understanding the intra-

individual functioning is also highly relevant when designing interventions for anxiety (Murayama et al., 2017). However, only a few studies have taken an intra-individual approach (Ahmed et al., 2010; Bieg et al., 2013). As findings indicate that between-person relations (i.e., inter-individual approaches) can sometimes be different from within-person relations and do not necessarily reflect internal psychological processes (i.e., intra-individual functioning; e.g., Hox et al., 2017; Molenaar & Campbell, 2009), in the current study, we investigated the relationship between control experience, anxiety components, and performance in a specific situation (i.e., when students are writing a math exam) on an intra-individual level (i.e., how control experience within a person is related to the anxiety experienced and how this relates to performance) using state measures at multiple points in time.

The present study

An overall goal of the present intra-individual study was to examine the relative importance of four different components of test-related anxiety in mathematics (i.e., cognitive, affective, physiological, and motivational) in the mediating mechanism that connects control and test performance. Furthermore, we were investigating which test anxiety component is hidden behind more frequently used single-item measures.

Our study was guided by the following research questions:

(1) (a) Is the effect of control on performance mediated by the test anxiety components)?
    (b) Does control affect the test anxiety components in similar ways?
    (c) Do the different test anxiety components affect performance in similar ways?
(2) What test anxiety component is mainly assessed with single-item self-report measures of test anxiety?

Hypothesis 1

Based on the described theoretical assumptions we hypothesized that in the context of a test, low levels of control would be associated with increased test anxiety and that increased test anxiety would be associated with decreased performance. It was expected that the different anxiety components would vary with regard to their antecedents and effects. In more detail, we hypothesized that test anxiety would mediate the relationship between control and performance and that the anxiety components would vary in the strength of their mediating effects (i.e., indirect effects). According to the CVT, control is a cognitive appraisal and therefore one could expect that it would have the strongest effect on the cognitive anxiety component (i.e., negative relationship; Goetz et al., 2006; Pekrun, 2006). Also, considering previous research that used inter-individual study designs and found strong associations between performance deficits and high levels of worry and cognitive interference, we assumed that the cognitive anxiety component would have the strongest effect on performance as well as the strongest mediating effect in our intra-individual approach (e.g., Cassady & Johnson, 2002; Morris & Liebert, 1970; Van Yperen, 2007; Zeidner & Matthews, 2011). In all instances, mediation is expected to be partial rather than complete, because other mediational processes, such as test emotions other than anxiety (e.g., joy, pride, anger) or study or test-taking strategies, are likely to be operative as well (Elliot et al., 1999; Pekrun et al., 2004).

Hypothesis 2

Regarding research question two, we predicted that when students are asked about their test anxiety with a single-item, their answer will most likely be related to the affective anxiety component because according to most models this is the key component (Scherer, 2005, 2009).

Methods

Sample

The sample of the present study consisted of $N = 137$ high school students (from 6 classes at 3 schools, $M_{age} = 13.82$, $SD = 0.55$, 44.5% female). The students went to eighth grade and attended the highest track of the German school system (i.e., *Gymnasium*; approximately one third of the total student cohort in Germany attend this track; Federal Statistical Office, 2015).

Ethics statement

Data collection, data protection and ethical issues of the present study were handled according to the guidelines of the German Association for Psychology (Deutsche Gesellschaft für Psychologie, (DGPs), 2016) and the American Psychological Association (2010). All participants, the students' parents, the principals, and teachers were informed about the study's purpose, duration, and procedure. Participation was voluntarily and written informed consent was received by both students and parents as well as principals. All data was completely anonymized.

Procedure

After students and parents consented to participate in the study, students' general cognitions, motivation, and emotions in mathematics were assessed and demographic data was collected using a paper-and-pencil. Approximately one week later, this general assessment was followed by the state assessments during a mathematics exam specifically developed for the current study.

Procedure during the mathematics exam

The exam was a written mathematics test designed in cooperation with a mathematics teacher. It included standardized tasks adapted from the VERA8 exam – a standardized exam all students from 8th grade all over Germany have to take at the same time of the school year (developed by the Institute for Educational Quality Improvement; IQB, Berlin, Germany). We chose an exam that is very similar to an authentic exam to ensure ecological validity. An actual exam could not be used for ethical considerations and to ensure consistency between exams across all participating classes. This was essential to allow for reliable comparisons between the tasks within the exam and the emotional reactions to these tasks. The mathematics exam consisted of six task-blocks and task difficulty varied within the exam to create variation in students' appraisals of control (i.e., we induced the feeling of losing control by difficult tasks (e.g., task-block three), to examine whether loss of control goes along with increased anxiety). Each of the six task-blocks had to be solved within five minutes. After these five minutes, students had to hand in the task sheet and fill in the short state-questionnaire (i.e., paper-pencil questionnaire). Following the completion of the questions, students started the next task-block. Thus, there were six measurement points of all state study variables per student. In total, the exam lasted approximately 60 min. To incentivize students to take the exam seriously, a monetary prize was awarded to the class with the best performance (most points). Therefore, the performance of each student, not only the high performing students, contributed to the overall class performance and therefore to winning the prize.

Measures

Assessment of performance

Students performance in each task-block served as performance measure in our analysis. The tasks in the math exam were corrected following the recommendations from the IQB by three independent

raters. The original standardized tasks were adapted, but the concept of the tasks did not change. We conducted a pilot study in which ten students solved the tasks and talked about their experience. Because the different tasks yielded a different number of raw points, we used the percentage of correctly solved tasks per task-block rather than raw points to allow for cross-task comparisons. As expected, our performance measure was highly correlated with students' grades, which suggests that this measure is a reliable indicator of actual performance (for exact values see *Descriptive statistics and correlations*).

Assessment of state control and state anxiety components via questionnaire

All items in the questionnaires referred to the student's experience during the previous task (i.e., "*During this task I … .*").

Assessment of control. Since we wanted to assess the perception of being in control during the test situation and keep the state assessment short, control was assessed with one item. The single-item used to measure control was from the Perceived Academic Control Scale (PAS; Perry et al., 2001) and a similar item was used in a previous study by Weinstein et al. (2002). A five-point Likert scale was used ranging from 1 (*strongly disagree*) to 5 (*strongly agree;* "*During this task I had a great deal of control*"). This single-item approach to assessing state appraisals of control is consistent with prior research (e.g., Goetz et al., 2007; Jarrell et al., 2016).

Assessment of the anxiety components. The assessment of control was followed by the assessment of the anxiety components (cognitive, affective, physiological, and motivational component) which were measured by three items for each component from the test related anxiety scale of the Achievement Emotions Questionnaire (AEQ; Pekrun et al., 2011), a well established questionnaire in the field of emotion research (Zembylas & Schutz, 2016). One important strength of the AEQ is that it measures the experience of anxiety (and other emotions) based on the contemporary four-component perspective (e.g., Zeidner, 2007). As with subjective control, responses were provided on a five-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Example items: "*During this task*: … *I worried whether I will perform poorly* (cognitive); … *I was very nervous* (affective); … *my heart was beating faster* (physiological); … *I was so anxious that I'd rather be anywhere else* (motivational)." The sample-specific internal consistency across all six measurement points of these three item scales were $\alpha = .84$ for the cognitive, $\alpha = .89$ for the affective, $\alpha = .83$ for the physiological, and $\alpha = .89$ for the motivational component. The sample specific internal consistencies per task were all higher than .80.

Single-item measure to assess students' test anxiety over the course of the exam

The single-item test anxiety measure was assessed at the end of the exam in such a way that students were asked to draw a profile of the course of their anxiety during the exam. In this profile they indicated their anxiety for each task as well as their anxiety 30 min before the exam, at the beginning of the exam (i.e., when receiving the instructions), at the end of the exam (i.e., after handing in the final task), and right now (i.e., when filling in the last questionnaire). The scale was ranging from 0 (*no anxiety at all*) to 5 (*very strong anxiety*). For an example, see Figure 1. In the present study we were only interested in the anxiety values during the *six tasks*, as we wanted to compare them with what the students reported on the different anxiety components after each task (see *Assessment of the state anxiety components*).

Data analyses

Our analyses were conducted with M*plus* 7.11 (Muthén & Muthén, 1998–2017) and missing data was handled with full information maximum likelihood procedures (Rubin, 1976).

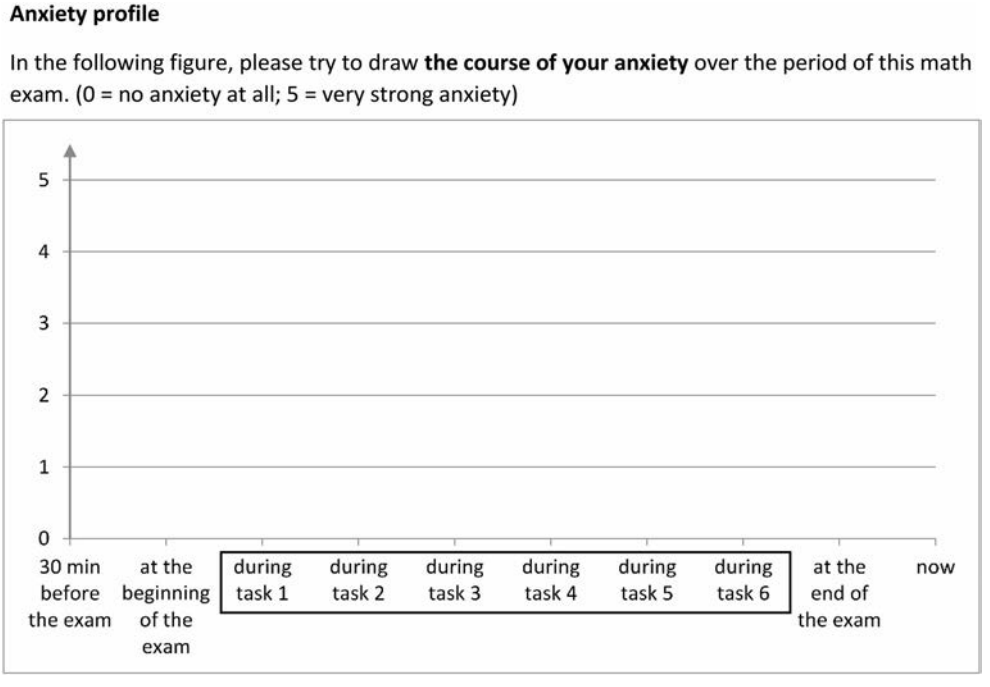

Figure 1 .#Anxiety profile. Single-item measure to assess student's anxiety over the course of the exam. The six tasks we are interested in in the current study are highlighted with a box.

Hypothesis 1

Mediation analysis with "type = complex" was conducted to examine the hypothesized mediation on the intra-individual level and to account for the nested data structure (multiple measurement points (6) of state anxiety, subjective control and task performance nested within student). We built one overarching model, in which we included performance as the dependent variable and control as the independent variable and the anxiety components as the mediating variables. By doing so, the model allowed for a simultaneous test of the antecedents (control) and effects (performance) of each anxiety component while accounting for the shared association between them (e.g., Hayes, 2013). Furthermore, it allowed us to identify the mediator (i.e., anxiety component) with the strongest effect. In our model we tested the following effects: The direct effect of control on performance and the indirect effects of control on performance via the different anxiety components (i.e., cognitive, affective, physiological, and motivational component) along with the total effect. Moreover, we report the direct effects of control on the anxiety components as well as the direct effects of the components on performance. Additionally, we included gender as a covariate in our analysis as some studies indicated that there might be gender differences in test anxiety (i.e., female students were more test anxious but there was no performance difference between girls and boys; Hembree, 1988; Zeidner, 1990) and in control experience in mathematics (i.e., female students experienced lower control in mathematics; Frenzel et al., 2007; Hyde et al., 1990). For all indirect effects, we used the "model indirect" option of Mplus to calculate unstandardized and standardized effects (Muthén & Muthén, 1998–2017).

Hypothesis 2

To test the second hypothesis, we built an intra-individual regression model with "type = complex" in which we included the test anxiety components as predictors for single-item test anxiety measure (i.e., outcome) as indicated in the anxiety profiles the students were drawing. This renders it possible

to find out which of the test anxiety component is the strongest predictor for the single-item measure (i.e., which component is more closely related to the single-item as indicated in the anxiety profiles).

Results

Descriptive statistics and correlations

Mean scores and standard deviations of the test anxiety components, control, and performance for each task of the exam (i.e., between-person) are depicted in Table 1. Figure 2 shows the means of the test anxiety components and control per task and across persons. It can be seen that more difficult tasks (i.e., tasks 2, 3, 5, 6 in comparison to tasks 1 and 4) are associated with less control and more test anxiety (especially the cognitive anxiety component). Task-block 3 was the most difficult task-block, which was also reflected in the lowest control experience and highest test anxiety which suggests that our study design worked as intended.

Table 2 shows the correlations between the test anxiety components, control and performance across tasks (i.e., multiple measurement points) along with the respective means and standard deviations. All test anxiety components were significantly and positively correlated with each other (all *ps* < .01) with the affective and physiological components showing the strongest correlation ($r = .74$). All test anxiety components significantly and negatively correlated with subjective control (all *ps* < .01). Furthermore, the test anxiety components significantly negatively correlated with performance, with the cognitive component showing the strongest negative correlation ($r = -.25$, $p < .01$). Subjective control also significantly and positively correlated with performance ($r = .30$, $p < .01$). The within person correlations between the study variables across all tasks can be found in the supplementary material (Table S1).

The correlations between the performance measure (i.e., total performance in the math exam) and student's grades in their last math exam, in their last mid-term school report and in their school report were $r = .58$, $r = .52$, and $r = .61$, respectively. All correlations were significant (all *ps* < .01) and in the expected directions (i.e., better grades were associated with better performance) which supports the reliability of this measure. There were no significant gender differences in any of the performance measures.

Hypothesis 1: control – test anxiety components – performance mediation

To test our first hypothesis, we looked at the indirect effects of control on performance via the different test anxiety components (i.e., mediation).[1] For an overview of all relations of this mediation model, as well as direct, indirect, and total effects and the respective regression coefficients see Table 3. A graphical depiction of the results can be found in Figure 3. The results of our model show that control was significantly negatively associated with all test anxiety components, with the cognitive

Table 1. Mean scores and standard deviations of the study variables per task.

	Task 1		Task 2		Task 3		Task 4		Task 5		Task 6	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Cognitive	1.94	0.98	2.20	1.05	2.35	1.02	1.81	.83	1.76	0.91	2.07	1.07
Affective	1.91	0.96	1.98	0.98	1.96	1.05	1.68	.93	1.66	0.87	1.71	0.98
Physiological	1.65	0.86	1.72	0.90	1.70	0.93	1.56	.87	1.55	0.83	1.60	0.86
Motivational	1.25	0.53	1.35	0.76	1.34	0.81	1.28	.74	1.25	0.67	1.26	0.67
Control	3.75	1.08	3.10	0.97	2.98	1.08	3.55	1.08	3.66	1.05	3.37	1.16
Performance	80.47	19.45	28.52	15.16	10.68	13.28	77.74	13.18	68.75	16.86	47.01	22.90
Anxiety (SIP)	1.24	1.32	1.60	1.41	1.59	1.30	1.51	1.32	1.43	1.26	1.36	1.41

Note. $N = 137$. SIP = Single-item from the anxiety profiles.

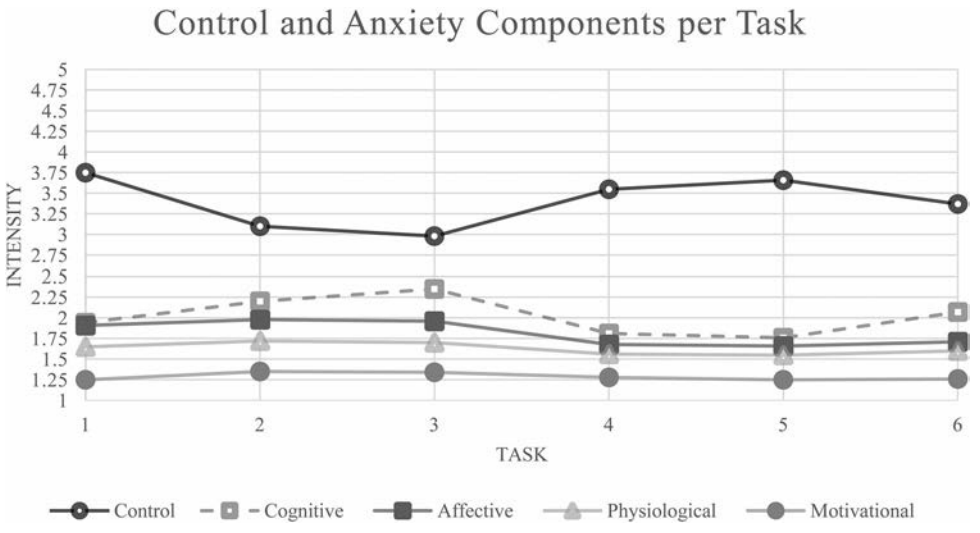

Figure 2 .#Control and anxiety components per task. Means of anxiety components (cognitive, affective, physiological, motivational), and control per task.

Table 2. Mean scores, standard deviations and correlations between the study variables across all tasks and persons.

	1	2	3	4	5	6
1. Cognitive Component	–					
2. Affective Component	.65**	–				
3. Physiological Component	.53**	.74**	–			
4. Motivational Component	.50**	.69**	.65**	–		
5. Control	−.40**	−.29**	−.29**	−.31**	–	
6. Performance (in %)	−.25**	−.08*	−.07*	−.08*	.30**	–
Mean	2.02	1.81	1.63	1.29	3.40	52.19
SD	1.00	0.97	0.88	0.70	1.10	31.09

Note. N = between 819 and 822 (resulting from 6 measurement points per student and N = 137 students). Pure descriptive values without control for nesting of data within persons (i.e., no type is complex). * $p < .05$, ** $p < .01$.

component showing the strongest effect ($b = -0.37$, $SE = 0.05$, $p < .001$). This effect was significantly different from the effects of the other components as indicated by the results of a scaled difference chi-square test ($p < .001$; Bryant & Satorra, 2013). Mediation analyses further revealed a significant positive direct effect (c) of control on performance ($b = 0.24$, $SE = 0.04$, $p < .001$) and a significant indirect effect via the cognitive anxiety component ($b = 0.09$, $SE = 0.02$, $p < .001$). Specifically, control had a negative effect on the cognitive component (a), which in turn had negative effects on performance (b; i.e., positive indirect effect). In sum, the cognitive component partially mediated the relationship between control and performance. When comparing the direct effect of control on performance ($b = 0.24$, $SE = 0.04$, $p < .001$) with the total effect ($b = 0.29$, $SE = 0.03$, $p < .001$), results show that including the test anxiety components as mediators indeed accounted for a better explanation of the variance. Furthermore, there was a significant negative effect of the cognitive component on performance ($b = -0.25$, $SE = 0.04$, $p < .001$; see Table 3). This means that higher anxiety measured by the cognitive component is associated with poorer performance. However, there was a significant positive direct effect of the affective anxiety component on performance when controlling for the effects of control and the effects of the other test anxiety components ($b = 0.12$, $SE = 0.06$, $p < .05$; i.e., higher affective anxiety is associated with better performance). The effects of the motivational and physiological did not reach significance.

Table 3. Total, direct and indirect effects of the proposed multilevel mediation model.

	Standardized coefficients	Standard errors
Control		
Total Performance on Control	.29***	.03
Total Indirect Performance on Control	.05***	.01
Indirect Performance on Control via Cognitive	.09***	.02
Indirect Performance on Control via Affective	−.03	.02
Indirect Performance on Control via Physiological	−.01	.01
Indirect Performance on Control via Motivational	.003	.01
Direct Cognitive on Control	−.37***	.05
on Gender	.21***	.06
Direct Affective on Control	−.28***	.06
on Gender	.10	.07
Direct Physiological on Control	−.28***	.06
on Gender	.07	.08
Direct Motivational on Control	−.26***	.05
on Gender	.02	.07
Direct Performance on Control	.24***	.04
Control on Gender	−.15*	.06
Anxiety components		
Direct Performance on Cognitive	−.25***	.04
Direct Performance on Affective	.12*	.06
Direct Performance on Physiological	.05	.05
Direct Performance on Motivational	−.01	.04

Note: All regression coefficients are standardized; Gender: male = 0, female = 1; standard errors are displayed in brackets; *p < .05; **p < .01; ***p < .001.

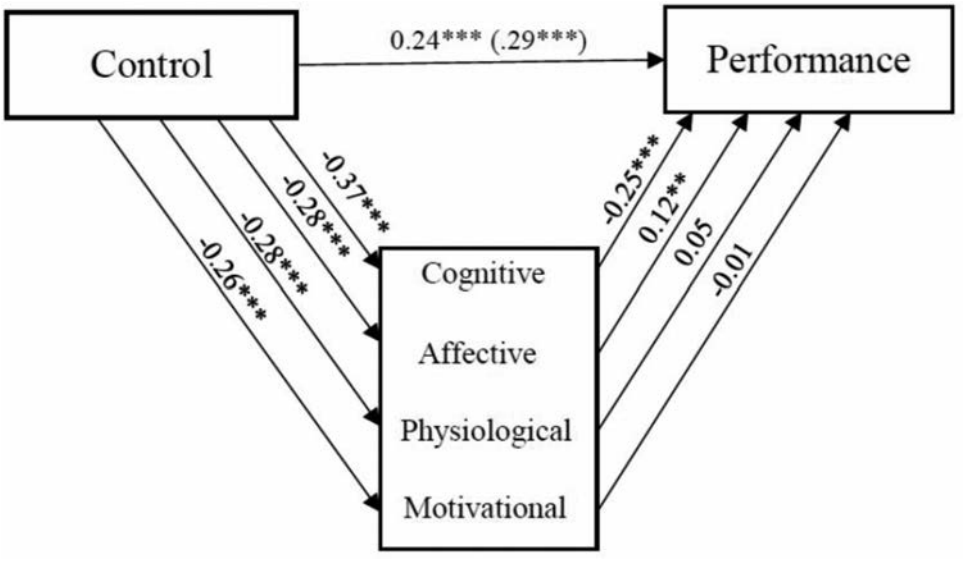

Figure 3 .#Results of the mediation analysis (N = 137). Indirect effects of control on performance through the test anxiety components. Model is controlled for gender. Standardized effects are presented. The effects on the direct path from control to performance depict the direct effect and the (total effect), *p < .05; **p < .01; ***p < .001.

Effects of gender

Results revealed a significant effect of the gender covariate on control (b = −0.15, SE = 0.06, p <.05). Because of the coding of this variable, the effect indicates that female students experienced significantly less control than male students. Furthermore, there was an effect of gender on the cognitive component (b = 0.21, SE = 0.06, p <.001). Specifically, with the same levels of control female students reported significantly higher values on the cognitive anxiety component than male students.

Table 4. Results from the regression model with the anxiety components predicting the single-item anxiety measure (i.e., as indicated in the anxiety profiles).

	Single-item measure of anxiety		
	Standardized coefficients	Standard errors	Standardized correlation with single-item
Anxiety components			
Cognitive	.01	.06	.01
Affective	.43***	.08	.47***
Physiological	.21*	.09	.23*
Motivational	.05	.07	.05

Note: All regression coefficients and correlations are standardized. Standard errors are displayed in brackets; *$p < .05$; **$p < .01$; ***$p < .001$.

Hypothesis 2: single-item test anxiety measure

The results from the regression model with the test anxiety components predicting the single-item test anxiety measure are depicted in Table 4. Results show that the affective anxiety component was, as expected, the strongest predictor for the single-item test anxiety measure ($b = 0.43$, $SE = 0.08$, $p < .001$; correlation with single-item measure: $r = .47$; when controlling for the effects of the other components) followed by the physiological component ($b = 0.21$, $SE = 0.09$, $p < .05$; correlation with single-item measure: $r = .23$). The cognitive and motivational components were not significant predictors for the single-item measure. Thus, in line with hypothesis 2, results show that when students are asked to report their anxiety experienced during a test with a single-item measure (i.e., when drawing a profile of the course of their anxiety) their answer is mostly associated with the affective anxiety component.

Discussion

The present study examined four test anxiety components (i.e., cognitive, affective, physiological, and motivational components) in a sample of 8th graders and had two major goals. Based on assumptions of the CVT, the first goal was to investigate which of the test anxiety components is the most important mediating mechanism that explains the relationship between control appraisals and students' performance (i.e., has the strongest impact on student's performance). To draw upon previous findings from inter-individual studies and ensure high ecological validity, we examined this relationship during an authentic exam situation using multiple within person state measurements of these variables and analyzing this relationship on an intra-individual level (Murayama et al., 2017). In order to inform future research, decide whether and how to differentiate test anxiety, the second goal of the study was to investigate which test anxiety component is hidden behind a single-item measures of test anxiety.

Research question 1: Which test anxiety component is most central in the mediating mechanism that connects control and performance (*Hypothesis 1*)?

In order to determine which component is the most important predictor of performance, we examined the relationship between control, test anxiety components and performance. As expected, we found a relationship between control and performance mediated via the cognitive test anxiety component (i.e., significant indirect effect). Lower levels of control were associated with an increase in the cognitive anxiety component, which in turn resulted in lower performance. These findings support the assumptions of the CVT and show that this theory on intra-individual relations indeed also holds true when examining it on an intra-individual level. As the cognitive component was the only component for which we found such a mediating effect, our results further suggest that this component appears to be the most important for explaining the relationship between control and performance. This is consistent with the CVT and with information processing models of anxiety (e.g., Naveh-Benjamin, 1991; Schwarzer & Jerusalem, 1992) which state that thinking about negative

consequences of one's performance (cognitive component) consumes cognitive resources, which may interfere with optimal performance. Furthermore, these findings are in line with a strong line of research on cognitive test anxiety (e.g., Cassady & Johnson, 2002; Putwain & Aveyard, 2018; Thomas et al., 2017). Thus, this component seems to represent the main point of action for instructional techniques and anxiety interventions that are aimed at increasing student performance.

Regarding research question 1b, we found that appraisals of control affect all four anxiety components in the same direction (i.e., lower control was associated with increased anxiety; negative direct effect). However, the sizes of the effects differed, and control showed the strongest association with the cognitive anxiety component. This is in line with our hypothesis that since control is a cognitive appraisal, it would be more closely related to the cognitive anxiety component (Goetz et al., 2006). Furthermore, this is also nicely reflected in Figure 2, which shows that the moment to moment changes in control appraisals (i.e., from task to task) are tied to corresponding moment to moment changes in anxiety and performance in the expected direction. This finding suggests that if we can change these control appraisals, we can also change the emotional experience (Schutz & Davis, 2000). Along with the mediating effect of the cognitive anxiety component this demonstrates that it may prove helpful if students implement strategies during learning and test-taking that enhance perceptions of control and thereby indirectly target the cognitive anxiety component. This in turn may also contribute to shaping a positive test-taking environment that leads to performance facilitation and more favorable responses (Dresel & Haugwitz, 2008; Hall et al., 2006; Moore et al., 2012). There are many suggestions on how to influence students' control appraisals. For example, right at the beginning of a test, the task could be framed in a manner consistent with challenge, as this has the potential to increase perceived control (Feinberg & Aiello, 2010; Putwain et al., 2016). Furthermore, control appraisals can be influenced by providing transparency, autonomy support, and feedback during learning and test-taking (Pekrun, 2006), or by teaching students strategies such as cognitive-reappraisal or attributional retaining which they can apply in a test situation (e.g., Denny & Ochsner, 2014; Ruthig et al., 2004).

In response to research question 1c, our results showed that the individual anxiety components differed in their relative impact on performance. As previously stated, the cognitive component had the strongest effect. On the contrary, we found a significant direct positive effect of the affective component on performance (i.e., higher affective anxiety was associated with increased performance). This is in line with previous findings (e.g., Jamieson et al., 2013) and implies that in some cases it can be helpful to tell students that nervousness during a test is not always harmful for performance but rather the thoughts (i.e., cognitive anxiety component) about the consequences of failing can lead to poorer performance.

Finally, we found a direct positive effect of control on performance and thus, as expected, we found a partial mediation. This again underpins that control is important for test performance. On the other hand, the total effect we found demonstrated that including the anxiety components as mediators lead to a higher explanation of the variance in this model and suggests that they are worth considering. Another potential aspect to take into account is that the direct positive effect of control on performance could in part be explained by other variables (e.g., other emotions, or constructs like self-efficacy) that might play an additional mediating role between control and performance and also corresponds with assumptions of the CVT. Therefore, our results suggest that it might not only be necessary to increase control and regulate anxiety but also to look at other variables during test taking as they might have effects on performance as well (Goetz et al., 2007).

In sum, as expected and in line with hypothesis 1, the results of the study suggest that the components of anxiety indeed differ with regard to their control antecedents and achievement effects. For anxiety interventions, these findings imply that interventions must be carefully selected and that it is important to distinguish between the components of anxiety. In addition, the results suggest that to increase students' performance, strategies that target the cognitive anxiety component might be the most effective. This can be achieved for example with the above mentioned cognitive reappraisal strategies that aim to change how one thinks about the situation or about one's capacity

to manage the demands of the situation (Gross & Thompson, 2007) and consequently, increase student's perceptions of control and decrease the cognitive component of anxiety.

In addition to providing evidence that supported our first hypotheses, our findings demonstrated *further interesting results regarding the effects of gender* that although they were not the main focus of the current study will be briefly discussed here. Female students experienced significantly less control than male students which is in line with findings from Arch (1987) who found that in test situations females were more likely to rate themselves as less capable and confident in their abilities and felt more uncomfortable (i.e., less in control) than male students. Furthermore, with the same levels of control, female students reported significantly higher levels of the cognitive component of anxiety than male students, but we could not find differences in exam performance between females and males. This is in line with previous findings where females consistently reported higher levels of cognitive test anxiety than males (Hembree, 1988; Zeidner, 1990). In part, this may be due to differences in female and male students' capability and willingness to report their emotions (males are more reluctant to admit anxiety than females; Wigfield & Eccles, 1989) which, in turn, can be influenced by social desirability and gender-stereotypes in mathematics. These gender-stereotypes are also believed to be largely responsible for girls' lower levels of perceived competence in mathematics (Grossman & Wood, 1993; Wigfield et al., 2002). However, our study showed no gender difference in exam performance, despite female students reporting higher levels of cognitive anxiety. These results are confirming earlier findings which found gender discrepancies in emotional experiences even though girls and boys had achieved at similar levels in mathematics (e.g., OECD, 2004; Seipp, 1991).

Hence, our results show gender equity in terms of performance. However, there still remains a gap in terms of competence beliefs and emotions in mathematics tests. As these beliefs and emotions have far reaching consequences, for example for girls' well-being and future career in the STEM field, this calls for promoting positive affect (e.g., by interventions that address students' competence beliefs) and preventing anxiety in girls (Goetz et al., 2013).

Research question 2: What anxiety component affects undifferentiated single-item measures (*Hypothesis 2*)?

Also consistent with our expectations, our findings concerning the single-item measure of test anxiety showed that students will most likely report their affective anxiety when assessing test anxiety with a single-item. This is in line with the multi-componential model of emotions (Scherer, 2005, 2009) in which the affective component is seen as the core anxiety component and therefore confirms that single-item measures are able to gauge this key component of the test anxiety construct. Furthermore, the findings indicate that this component might be very important, as is seems to be most saliently represented in a student's mind when asked about her or his subjective anxiety with single items. Although, as shown by our first research question, the affective component did not show a significant indirect effect on achievement in our mediation model and therefore does not seem to be the most relevant component for performance. It may, however, be closely related to other factors such as psychological well-being, school attendance, self-esteem, or other stress related physical ailments (Austin et al., 1995; Damer & Melendres, 2011; OECD, 2016). All these factors can also be negatively affected by test anxiety and should be taken seriously as they might have long term consequences, for example for future career choice or mental and physical health (Diener, 2000; Wigfield et al., 2002). Therefore, the affective anxiety component should not be neglected in interventions or by researchers. Rather it should be more closely examined with regard to its effects on variables other than performance in future studies. The same is true for the physiological and motivational anxiety components for which we also did not find a significant indirect effect on performance in the current study – which however does not mean that they are not important for other factors.

In sum, it is crucial for researchers to realize that when using single-item self-report anxiety measures they are most likely working with a predominantly affective measure. Therefore, they should carefully choose which measure of anxiety they are using depending on their research

question and the conclusions they want to draw. When examining performance outcomes in the context of the CVT, assessing anxiety with a single-item measure that is focusing predominantly on the affective component might not be sufficient. In this case, items that largely tap into the cognitive component might be more adequate as they are a better predictor for performance. However, for investigations of more distal outcomes, single-item measures that examine the affective component, or other multiple item measures that examine the physiological and motivational test anxiety components could eventually be a good choice.

Strengths, limitations, and future directions

An important strength of this study pertains to the study design. By examining the antecedents and effects of the test anxiety components on an intra-individual level, our approach offered a higher level of ecological validity than in most test anxiety studies, as the measures were taken directly in the evaluative situation at multiple time points (Hamaker, 2012). Furthermore, the investigation of the relationship in a realistic assessment environment allows for greater confidence in the approximation of the relative impact of the anxiety components on high school students performance. Thus, the results of this investigation may be more credible to the reality of test anxiety than in experimental settings in a laboratory environment. Morevover, in our data there was high inter-individual variance as well as variance within students from task to task (see Figure S1 in the supplementary material), which suggests that analyzing the relationship between control, anxiety components and performance on an intra-individual level (i.e., as done in the present study) might be more adequate than only looking at between-person associations. Thus, this once again underpins the importance of conducting intra-individual analyses when looking at intra-individual relationships such as those postulated by the CVT. Finally, another strength pertains to the age of our sample. To date the majority of research in this field has been conducted with university students. Our results demonstrated that the findings on the relationship between control, anxiety and performance hold true for younger samples (von der Embse & Hasson, 2012).

Our study also has some limitations, which suggests a number of directions for future research. First, the data of this study were based on student's self-reports. It would be interesting to investigate if what these students think they feel about their physiological arousal corresponds to their actual physiological arousal (e.g., heart rate or skin conductance) and how this relates to their performance. Furthermore, we assessed appraisals of control with a single-item since we wanted to keep the state assessment as unobtrusive as possible and to measure actual state situational control. While single-item measures of control have been used in prior research and are considered reasonable when long scales are not applicable (Gogol et al., 2014), we acknowledge that this might affect the psychometric quality of this measure in terms of measurement error, internal consistency, and content validity. Future research could consider also assessing state control experience with multiple items and establish a short scale that can be used in such state assessments. It is worth mentioning, however, that existing full scales assessing control might also be considered as problematic due to similarly worded or even reversed items, again challenging the reliability of the scale (Gogol et al., 2014; Yang & Green, 2011). An additional limiting factor is that although we assessed students' anxiety and control experience during a test situation, for ethical reasons it was not possible to interrupt students while solving the tasks and thus we assessed our variables directly after each task-block (Goetz et al., 2010). For the same reasons, students did not receive grades for their test performance. Therefore, it is possible that our results were impacted by the slightly artificial nature of the test situation. Future studies could try to optimize this research design and measure concurrent state control and anxiety experiences during a real testing situation.

Although not the focus of the current study, future research could test the relationship between control, anxiety and performance with a cross-lagged model (Hamaker et al., 2015). In this way, it would be possible to examine potential bidirectional effects between control, anxiety and performance, because although the CVT states that control is an antecedent of anxiety it might still be the

case that anxiety from the previous task transfers to the next task or that control in previous task affects the anxiety experienced in a subsequent task, especially in close temporal proximity. Another related possibility would be to consider additive effects of dispositional anxiety that might play a role in the control-test anxiety-performance relationship (i.e., additive model of anxiety; Zohar, 1998). Finally, we investigated students' test anxiety in a group of high school students in the domain of mathematics. Even though from a theoretical perspective, the proposed structural relations should be universal across different samples and domains, it would be interesting to investigate these effects in students from different school types, in different domains and age groups, or in students with another cultural background to confirm the generalizability of these findings. Despite these limitations, our study provides additional evidence that emotions are complex constructs by using an elaborate intra-individual real-time approach. Additionally, it proposes that extending research on the antecedents and effects of different test anxiety components on an intra-individual level may contribute to the development of more effective anxiety interventions and thereby facilitate not only learning and academic achievement, but also critical developmental outcomes including career choice, health and psychological well-being.

Note

1. As a first step we also ran a model in which we included a general measure of test anxiety items (i.e., a latent factor without a differentiation between the components and only one mediator). In this model we did not find a significant mediating effect of test anxiety (indirect effect: $b = 0.01$, $SE = 0.01$, $p = .58$). Only the direct effect of control on performance was significant ($b = 0.29$, $SE = 0.04$, $p < .001$). This suggests that looking at the different components is relevant. Thus, we ran our model with the different anxiety components as mediators.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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