



# Examining the role of post-event processing in test anxiety—Pilot testing in three student samples

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## ABSTRACT

This work investigates the occurrence of post-event processing (PEP) in the context of test anxiety; PEP involves rumination and self-critical thinking following an event and commonly observed in social anxiety. Three short-term longitudinal studies in student samples examined whether PEP occurs after exams and how it is associated with test anxiety. University students ( $N = 35$  in Study 1,  $N = 146$  in Study 2, and  $N = 37$  in Study 3) completed measures of trait and state test anxiety before an actual exam; PEP related to the exam was assessed at various time points afterward. Results revealed that PEP occurred to a meaningful extent after exam situations. Overall, it was positively associated with trait and state test anxiety, although some variations in the relations were found across the three studies. These findings underscore the relevance of PEP in the context of test anxiety, as PEP might contribute to maintaining test anxiety in the long term. Implications for future studies are discussed.

## 1. Introduction

Test anxiety has been intensively researched for many years. Folkman and Lazarus (1985) already divided the course of test anxiety into three different stages (time before the exam, time between the exam and announcement of the grades, and time after grades were announced). Yet, only very few models explicitly include the phase after an exam (Cassady, 2004) and only very few studies examine the question of what happens after a test (Lotz et al., 2021). When observing pupils or students discussing an exam after it has been taken, it becomes clear that the exam is not finished when it is handed in, but that people are still thinking about it afterwards. As the “after” of one exam usually is the “before” of another, it is essential to study what happens after one test as this might influence the “before” of another and thus possibly the subsequent experience of test anxiety. This article has taken one possible process from social anxiety theory and research, namely post-event processing (PEP). In the following, we argue why this type of cognitive processing of a situation might play a role in test anxiety, as well. Three consecutive studies were devoted to the questions of whether this process also occurs in relation to exam situations and whether higher levels of test anxiety are related to more PEP. To examine these questions, we measured students’ trait test anxiety some time before an exam, their state anxiety right in the minutes before the exam started and their PEP (i.e. how they thought and felt about the exam afterwards)

at one or two times after the exam.

### 1.1. Test anxiety

Test anxiety was described by Spielberger and Vagg (1995) “as a situation-specific anxiety trait” (p. 7) that manifests as persistent, excessive, and heightened anxiety during test-taking – and even during exam preparation (Fehm & Fydrich, 2011). About 15 to 22 % of students suffer from high test anxiety (von der Embse et al., 2018), which correlates with lower well-being and mental health and more negative affectivity (Huntley et al., 2019; Steinmayr et al., 2016), on the one hand, and with unfavorable academic characteristics such as lower intrinsic motivation and engagement or poorer performance in academic settings (Richardson et al., 2012; von der Embse et al., 2018), on the other hand. Historically, test anxiety has first been conceptualized as a one-dimensional construct and has later been divided into one dimension capturing physiological and emotional arousal and one cognitive dimension (von der Embse et al., 2018). At the moment, there is agreement that test anxiety is a multidimensional construct, yet different conceptualizations use different dimensions (Putwain et al., 2021). Most current models conceptualize a physiological-affective component as well as worry and interference as cognitive components (Hodapp et al., 2011; P. A. Lowe et al., 2008; Putwain et al., 2021).

Most people are certainly familiar with a certain degree of anxiety,

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excitement, or tension before exams – of course this should not be seen as pathological. The severity of test anxiety can be imagined on a continuum from very mild to quite severe. People with severe test anxiety feel the fear and tension much more intensely, and they often experience worry before and during exams, which can also affect their ability to concentrate, for example (Fehm & Fydrich, 2011). The diagnosis of an anxiety disorder is justified if test anxiety causes significant distress or a significant impairment; the latter would be fulfilled, for example, if a person significantly delays their school or academic career due to test anxiety and the associated avoidance of exams. However, clinically relevant manifestations of test anxiety are categorized differently in the two common diagnostic systems: The Diagnostic and Statistical Manual of Mental Disorders in its current fifth version (DSM-5; Falkai et al., 2015) does not explicitly list the term test anxiety anywhere. However, the category of social anxiety disorder offers the possibility of classifying this diagnosis. On the other hand, the eleventh version of the International Classification of Diseases (ICD-11; World Health Organisation, 2023) clearly classifies fear of exams as a specific phobia.

From the literature on anxiety disorders, it is known that avoidance behavior contributes to the perpetuation of anxiety – and that seeking out feared situations should reduce anxiety in the long term (which is utilized in exposure-based therapy) (Hofmann & Hay, 2018). Keeping this in mind, the question arises as to why the fear of exams is not reduced in test-anxious people who nevertheless continue to take tests. To our knowledge, this has not been studied to date. However, the same question has been asked for social anxiety disorder: Why do social anxieties persist although socially anxious individuals do not (and cannot) avoid all social situations in everyday life (Brozovich & Heimberg, 2008; Fehm et al., 2008)? The answer to this question is, among other things, a mechanism that describes a particular form of cognitive processing after social situations, the so-called post-event processing (Clark & Wells, 1995; Ehling & Watkins, 2008; Fehm et al., 2007; Hofmann, 2007; Laposa et al., 2014; Wong & Rapee, 2016). The present study aimed to investigate whether this process also occurs in test-anxious individuals after exams and could – analogous to a social phobia – also contribute to its maintenance.

### 1.2. Post-event processing

PEP can, besides rumination and worry, be subsumed under the broader construct of repetitive negative thinking (McEvoy et al., 2010; Wong, 2016; Wong et al., 2016), which refers to “perseverative and focused cognitive processing of the negative aspects of one’s current, past, or future experiences” (Wong, 2016, p. 106). When introducing PEP in their cognitive model of social phobia, Clark and Wells (1995) defined it as a detailed review of a (social) interaction socially anxious individuals engage in afterward and which is characterized by a negative bias (in terms of self-perception, feelings, and evaluation of the respective situation). People “doing” PEP analyze how they behaved in a particular situation and how they might have appeared, focusing on negative aspects. Sometimes, the term “post-event rumination” is used, as well (Modini & Abbott, 2017; Wong, 2016), or “rumination” and “post-event processing” are used as equivalents (e.g., Grant & Beck, 2010). However, Fehm et al. (2007) distinguished PEP from rumination or post-event rumination since it is specified in more detail and also includes other processes (such as a memory bias) that are not determinant in rumination; further, rumination “rather represents a more general, trans-situational style of thinking” (Čolić et al., 2020, p. 3), while PEP refers to a particular event. This is why we stick to the term post-event processing in its narrow definition in this paper.

PEP was theoretically introduced (Clark & Wells, 1995) and empirically studied in social anxiety (Rachman et al., 2000). Even in the early days of research on PEP, the question arose as to whether this process is specific to social phobia or also occurs in other mental disorders – especially anxiety disorders (Rachman et al., 2000). Wong (2016) helpfully breaks down the question regarding the transdiagnostic

occurrence of PEP in two aspects: The first perspective asks whether PEP – in its original conceptualization of reviewing a social situation – occurs in disorders other than social anxiety. The other, second aspect of the question is whether “post-event processing occurs in response to anxiety-provoking events generally regardless of whether the events are social in nature” (Wong, 2016, p. 111). In the present paper, we would like to contribute to investigating the latter perspective, which has, to our knowledge, not yet been studied frequently.

### 1.3. Post-event processing in test anxiety

One early study on whether other than social situations are subject to PEP was conducted by Fehm and colleagues (2007) in a German non-clinical student sample ( $N = 217$ ). Participants were asked to report one social and one phobic event about which they had negative thoughts in retrospect; PEP with respect to these events was measured using a questionnaire. Fehm et al. (2007) then compared PEP after social situations with PEP after phobic situations and found that it occurred after phobic situations, as well, yet was more frequent and intense after social situations. Thus, they concluded that PEP “is not restricted to social situations” (p. 18). They cite the ambiguity of social situations as an explanation for the fact that PEP is more prominent after social situations; in contrast, specific-phobic situations are not ambiguous: Often, social situations do not provide direct feedback on how a person “performed” and the criteria for a “good” social performance are less clear. On the other hand, in the context of specific phobia, the feared outcome is relatively clear and narrowly defined – and after the situation, it is straightforward whether the fear has come true or not. Concerning the ambiguity of the situation, test anxiety is closer to social phobia, as the outcome is usually ambiguous, as well: After a written exam, it usually takes at least a few days, often considerably longer, until the results or grades are announced. Moreover, although one knows the tasks after the exam and can develop a very rough idea of how one has done, it is often a look into the crystal ball as one cannot recapitulate all the questions and answers in detail and does not know the claims made. Thus, when the ambiguity of the situation plays a role in how strongly one engages in PEP, it can be expected that persons do engage in it after test-taking situations, as well.

Further, test anxiety and social anxiety both have in common the concern about one’s performance. However, this is not true for other anxiety disorders like specific phobia or panic disorder. So, given that social anxiety and test anxiety share some aspects that seem to be relevant for the engagement in PEP, it seems plausible that this cognitive process also occurs in test-anxious individuals concerning exams. When further considering that it may contribute to the fact that test anxiety does not improve, even though affected students take exams (possibly even successfully), it is worthwhile to investigate the role of PEP in test anxiety.

So far, very few studies have considered the role of some kind of ruminative thinking in test anxiety. In a cross-sectional study, Aydın and Yerin Güneri (2022) measured rumination and cognitive test anxiety (along with other psychological constructs) in 715 students from a Turkish university. They found a medium-sized positive correlation between general rumination (which is not exactly the same as PEP; see Fehm et al., 2007) and test anxiety. However, they treated rumination as a predictor for test anxiety. In another cross-sectional study with 385 Spanish adolescents (14 to 19 years old), Pena and Losada (2017) measured self-rumination, self-reflection, and test anxiety (along with emotional attention and regulation). They found that the trait tendency to ruminate with a focus on oneself (i.e., self-rumination), but not self-reflection, is related to trait test anxiety. Although both studies did not research PEP, they showed that repetitive negative thinking plays an essential role in test anxiety.

To our knowledge, there is only one study that explored PEP after an exam situation. In a prospective study, Grant and Beck (2010) tracked the PEP of 127 undergraduate psychology students of a US university for

three days after midterm exams. Additionally, they collected data on trait test anxiety, trait rumination, anticipatory processing, and negative affect two days before the exam. They found PEP after the exam to be positively predicted by trait test anxiety and anticipatory processing. Nevertheless, they measured PEP using a questionnaire originally constructed for public speaking situations that asks how one's own performance is assessed retrospectively, and important aspects of the construct of PEP, such as uncontrollability or interference with concentration, were not assessed by this instrument (Fehm et al., 2008).

#### 1.4. The current study

To study the role of PEP in test anxiety, we conducted three consecutive longitudinal studies over short periods of time (several weeks to months) in the context of actual exams at a German university. The aim was to determine whether PEP occurred regarding the exams and whether it was related to students' test anxiety. In all studies, we assessed trait test anxiety some time before the index exams, state test anxiety in the minutes right before the exam, and PEP at different times from a few days up to three weeks afterward.

As many studies have shown that PEP is positively related to trait anxiety (Wong, 2016), we hypothesized that trait test anxiety should be related to PEP after an exam. State anxiety at the index situation has also been shown to predict PEP (Makkar & Grisham, 2011); thus, our second hypothesis was that state anxiety regarding the exam would be positively associated with PEP afterward. As Lundh and Sperling (2002) have shown that levels of PEP on different days were related, we assumed that PEP at different time points after the index exams should be related. Thus, we hypothesized the following relationships among the different variables:

**Hypothesis 1.** Trait test anxiety and PEP should be positively correlated.

**Hypothesis 2.** State test anxiety before the exam and PEP should be positively correlated.

**Hypothesis 3.** If measured at more than one measuring time, PEP at different measuring times should be positively correlated.

## 2. Study 1

### 2.1. Materials and method of Study 1

#### 2.1.1. Participants of Study 1

Participants were recruited in a psychology lecture that is usually attended in the second semester, and that is completed by a written test. The only criterion students had to meet for participation was that they were planning to take the exam at the end of the semester.  $N = 35$  students participated (age:  $M = 20.77$ ,  $SD = 1.59$ ; 30 women);  $n = 33$  were in the second semester of the psychology program. Students got credit for participation. Due to the exploratory character of this first study, no power analysis or sample size planning was carried out beforehand.

#### 2.1.2. Material of Study 1

Students' trait test anxiety, state test anxiety right before the exam, and PEP were assessed via questionnaires, both paper-pencil and online. Trait test anxiety was measured using the German Test Anxiety Questionnaire (Hodapp et al., 2011) consisting of 20 items rated on a scale ranging from 1 = *almost never* to 4 = *almost every time*. The questionnaire depicts an overall score for trait test anxiety ranging from 20 to 80. In our sample, internal consistency was good (Cronbach's  $\alpha = 0.86$ ) and comparable with the student norm sample ( $M = 22.85$  years,  $SD = 4.51$ , 59.0 % female, Hodapp et al., 2011).

Students' state test anxiety right before the exam was measured

using the state anxiety subscale of the German version of the State-Trait Anxiety Index (Laux et al., 1981). The STAI state scale consists of 20 items rated on a scale ranging from 1 = *not at all* to 4 = *very*. Ten items indicate a high level of arousal or anxiety (e.g., "*I am tense.*"), the other ten items indicate a low level of arousal and thus a high level of relaxation (e.g., "*I feel calm.*", reversed coded). The overall score of the state anxiety subscale ranges from 20 to 80. Internal consistency was excellent (Cronbach's  $\alpha = 0.91$ ) and comparable to that of representative (ages from 15 to over 60 years) as well as student norm samples (Laux et al., 1981).

As the outcome measure, we assessed PEP related to the written exam. As the concept of PEP originates from social anxiety research and has not been studied with regard to tests or test anxiety widely, there was no existing questionnaire asking for PEP after exam situations. Therefore, we adapted the German Post-Event Processing Questionnaire (PEPQ) established by Fehm and colleagues (2008) for use after exam situations. For this purpose, we replaced the word "experience" (referring to different social situations, e.g., talking in front of a group, hosting a party, being on a date) used in the original version with "exam" in every item. For example, we changed the first item from "After the event was over, did you think about it a lot?" to "After the exam was over, did you think about it a lot?" or the item "Did you ask yourself if you could have changed your behavior/feeling in the situation?" to "Did you ask yourself if you could have changed your behavior/feeling in the exam?". No further modifications were made to the questionnaire or the items. The same procedure had been applied by Fehm et al. (2007) when they changed the questionnaire to fit for PEP after phobic situations. The questionnaire consists of 17 items in total, 16 rating negative thoughts and feelings (e.g., rumination, self-criticism, shame, or regret) after the exam on a visual analog scale ranging from 0 = *no/never* to 100 = *very much*. The last item asks for the point of view the students see themselves when remembering the exam – whether from a first-person or a third-person perspective. Students were told to refer to the specified written exam our study applied to. Our adapted version of the PEPQ showed excellent internal consistency (Cronbach's  $\alpha = 0.92$  and  $0.94$  for the two different measuring times), being comparable to the reliability Fehm et al. (2008) and Fehm et al. (2007) assessed in their student samples. The original PEPQ has been found to have a good construct validity (Fehm et al., 2008; Wong, 2015, using a sample of psychology students,  $M = 21.91$  years,  $SD = 6.22$ , 79.8 % female).

#### 2.1.3. Procedure of Study 1

The study process is shown in Fig. 1. Trait test anxiety was measured seven to four days before the exam, either using paper-pencil questionnaires in the lecture the week before the exam or, for participants who did not attend this last lecture, online using SoSci Survey (Leiner, 2014). State test anxiety was measured right before the exam using paper-pencil forms: When students entered the room where the exam was to be written in, they all took their seats and made themselves ready for the test. State anxiety questionnaires were distributed and filled out by the participating students; non-participants were asked to wait quietly for the beginning of the exam. After all students had filled out the questionnaire, the exam was distributed, and students started working on it. PEP was measured online via SoSci Survey (Leiner, 2014) four to five days and 18 to 24 days after the exam.

Students provided written informed consent at the beginning of the first measuring time. The study was conducted following the Declaration of Helsinki and had been approved by the local ethics committee.

#### 2.1.4. Statistical analyses of Study 1

Analyzing missing data revealed that no single-item values were missing for any of the scales.

Bivariate correlations between the variables were calculated to test the hypotheses. Due to the directionality of the hypotheses, the significance level of  $p < 5\%$  test was applied one-tailed. To take into account the multiple testing, a Bonferroni correction was performed, resulting in

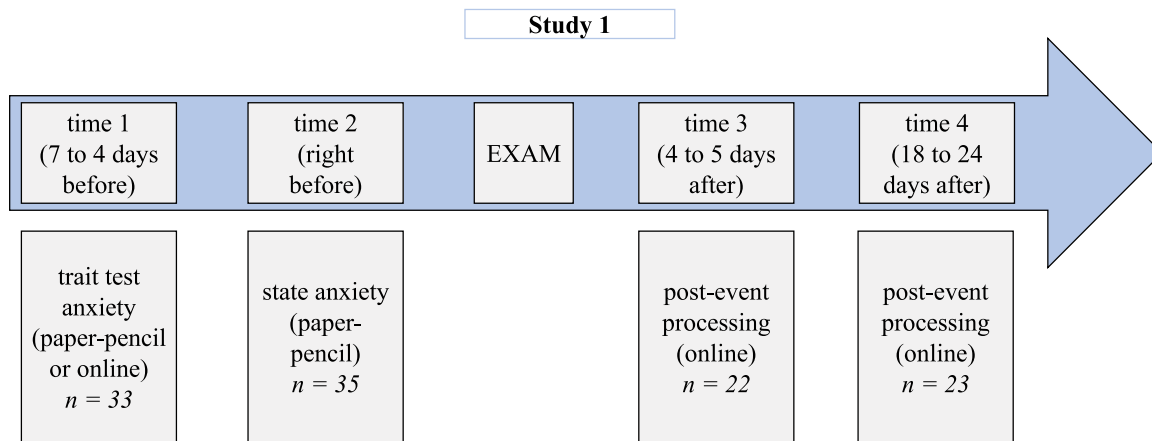


Fig. 1. Study procedure of Study 1 including measuring times and number of participants.

a corrected  $\alpha$  level of  $p < 1\%$ . We excluded data on a pairwise basis, which resulted in different-sized samples for the different correlations that were calculated. All analyses were performed using SPSS (Version 28).

2.2. Results of Study 1

Of the  $N = 35$  students who agreed to participate in this study,  $n = 19$  took part in all four measuring times. Participant numbers for the different measuring times can be found in Fig. 1.  $n = 1$  student took part in one measuring time,  $n = 9$  students took part in two, and  $n = 6$  in three measuring times. Two students only agreed with the participation and gave sociodemographic information at time 1, yet did not fill out the test anxiety questionnaire, resulting in  $n = 33$  instead of  $N = 35$  participants at this first measuring time. We performed Little's  $\chi^2$  test to check whether data were missing completely at random (MCAR); with  $\chi^2(12) = 15.65, p = .208$ , a completely random missing of the data can be assumed. Further, dropout analyses using independent  $t$ -tests showed that students who participated fully did not differ significantly from those who did not participate at all measuring times regarding their trait test anxiety ( $t(31) = 1.36, p = .184, d = 0.48$ ) nor their state anxiety right before the exam ( $t(33) = 0.91, p = .370, d = 0.31$ ).

Descriptive statistics are shown in Table 1; on a descriptive level, it can be seen that the strength of PEP after exams was roughly at the level of PEP after phobic situations (as reported by Fehm et al. (2007):  $M = 29.51, SD = 17.02$ ).

Bivariate correlations are in Table 2. The first hypothesis that trait test anxiety would be positively related to PEP was confirmed, meaning that the more test-anxious students were in general, the more they tended to brood about the exam afterward. Correlation coefficients indicate moderate to strong relationships; still, only the effect between trait test anxiety and PEP four to five days after the exam,  $r = 0.54, p = .005$ , was significant at the level of  $p < 1\%$ , whereas the correlation of trait test anxiety with PEP after about three weeks,  $r = 0.47, p = .013$ , was just not significant. The second hypothesis that state test anxiety

Table 1  
Descriptive statistics for the study variables of Study 1.

	<i>M</i>	<i>SD</i>	Range	Skewness	Excess kurtosis
Trait test anxiety	47.09	8.74	34–68	0.53	–0.43
State anxiety	52.14	9.21	35–72	0.04	–0.66
PEP after 4 to 5 days	29.70	19.15	5.59–70.59	0.85	–0.14
PEP after about 3 weeks	33.48	22.51	3.59–81.00	0.59	–0.65

Note. PEP = post-event processing.

positively correlates with PEP could not be confirmed. The measuring of PEP three weeks after the exam indicated a moderate relationship,  $r = 0.44, p = .018$ , yet was just not significant at the  $1\%$  level. The correlation between state test anxiety and PEP after four to five days was only small,  $r = 0.10$ , and not significant,  $p = .333$ . The third hypothesis that PEP at different measuring times should be positively correlated was not confirmed as the effect was just not significant,  $p = .011$ . However, the correlation showed a large effect size,  $r = 0.51$ , so the more students ruminated a few days after the exam, the more they still ruminated some weeks later. Post-hoc power analyses conducted with G\*Power (Buchner et al., 2020) revealed that for the bivariate correlations (Table 1), the power was only between 0.52 and 0.57 and must thus be considered too low.

Interestingly, PEP increased from t3 to t4 on a descriptive level. Nevertheless, a post-hoc dependent  $t$ -test revealed that the difference depicted a null effect,  $t(19) = -0.30, p = .769, d = -0.07$ .

2.3. Brief discussion of Study 1

The overall results of this first study were promising. We found that PEP indeed occurred after exam situations and depicted the same level as reported for phobic situations by Fehm et al. (2007). When interpreting the correlations, the strict significance level, as well as the small power due to the small sample size, have to be kept in mind; except for the relation between state test anxiety and PEP after four to five days, all relations were of moderate or high effect size and showed relatively small  $p$ -values. This first study showed links between test anxiety and the construct of PEP. Particularly interesting is the finding that state test anxiety right before the exam was very well related to PEP after about three weeks, yet it was not, or at least only to a small extent, related to PEP after a few days. Possible reasons for this are difficult to pinpoint, as this was the first study in this area with a small number of participants. It might be that shortly after the index exam, other exams were prepared or taken, which could have distracted or masked post-event processing during that time; this may be why PEP only became more apparent later on.

Further, the differences in the relations depending on whether trait or state test anxiety is measured may have to do with the fact that state anxiety, as assessed by Laux et al. (1981), represents the emotional-physiological component of anxiety. Cognitive components such as worry or interfering thoughts in exam situations that are pretty relevant in measuring trait test anxiety are not depicted in measuring state anxiety. Thus, the emotional-physiological facet might be related to brooding differently than the cognitive facets of test anxiety, as measured for trait test anxiety.

A unique feature of the exam studied was that it was not graded on the usual scale but was simply a question of "pass" or "fail". It is well

**Table 2**  
Bivariate correlations between the study variables of Study 1.

	State test anxiety				PEP after 4 to 5 days				PEP after about 3 weeks			
	<i>r</i> / <i>r</i> <sub>B</sub>	<i>p</i> / <i>p</i> <sub>B</sub>	<i>n</i>	95 % CI for <i>r</i> <sub>B</sub>	<i>r</i> / <i>r</i> <sub>B</sub>	<i>p</i> / <i>p</i> <sub>B</sub>	<i>n</i>	95 % CI for <i>r</i> <sub>B</sub>	<i>r</i> / <i>r</i> <sub>B</sub>	<i>p</i> / <i>p</i> <sub>B</sub>	<i>n</i>	95 % CI for <i>r</i> <sub>B</sub>
Trait test anxiety	0.46 / 0.66	.003 / .001	33	[0.35, 0.85]	0.54 / 0.50	.005 / .014	21	[-0.04, 0.84]	0.47 / 0.40	.013 / .046	22	[-0.13, 0.72]
State anxiety					0.10 / 0.17	.333 / .240	22	[-0.34, 0.59]	0.44 / 0.25	.018 / .155	23	[-0.30, 0.66]
PEP after 4 to 5 days									0.51 / 0.51	.011 / .014	20	[0.06, 0.80]

Note. Bivariate Pearson correlations are presented as standardized coefficients, significance tests were performed one-tailed. PEP = post-event processing. *B* = bootstrapped; CI = confidence interval. Bootstrapping was calculated using 2000 samples, sample size for the bootstrapping procedure was  $n = 19$ .

known among students that the percentage of those who fail is usually relatively low in the respective exam – thus, it might have caused less anxiety than other exams, which might have influenced the studied relationships.

Overall, these initial results were promising but urgently needed replication.

### 3. Study 2

For replicating and extending the results of the first study, another similar study was performed. This was conducted over a longer time, consisting of slightly different measuring times, and a larger sample was planned to be tested. Again, we hypothesized that both trait and state test anxiety should be related to PEP. As PEP was only measured at one time after the exam, the third hypothesis was not tested in this study.

#### 3.1. Materials and method of Study 2

##### 3.1.1. Participants of Study 2

Again, psychology students were recruited for this study. Based on the effect sizes from the first study, sample size planning was carried out using G\*Power (Buchner et al., 2020). To detect moderate correlations of anxiety measures with PEP of about  $r = 0.40$  on a level of  $\alpha = 5\%$  and with a power of 0.90, a sample size of  $N = 47$  participants was planned.

The sample consisted mainly of first-semester students as the study was conducted in the context of a statistics lecture usually attended in the first semester. As the study started at the beginning of the semester and measuring times were spread over four months, we did not restrict the sample to students who had a fixed plan to take this exam at the end of the semester.  $N = 146$  students agreed to participate (age:  $M = 20.90$ ,  $SD = 2.85$ ; 117 women),  $n = 126$  of them were in their first semester of the psychology program,  $n = 104$  in their first semester at university at all. Again, students got credit for participation. Additionally, two vouchers of 25€ each were raffled among those students who participated in all measuring times.

##### 3.1.2. Materials of Study 2

Again, students' trait test anxiety, state test anxiety right before the exam, and PEP were assessed via questionnaires (online and paper-pencil).

Trait test anxiety was again measured using the German Test Anxiety Questionnaire (Hodapp et al., 2011). In this sample, Cronbach's  $\alpha$  was good, with  $\alpha = 0.88$  for the total scale, and thus comparable with the norm sample (Hodapp et al., 2011). Students' state test anxiety before the exam was again measured with the state anxiety subscale of the STAI (Laux et al., 1981) and had an excellent internal consistency (Cronbach's  $\alpha = 0.93$ ). To measure PEP, our adapted version of the PEPQ (Fehm et al., 2008) was used, showing excellent internal consistency with Cronbach's  $\alpha = 0.92$ .

##### 3.1.3. Procedure of Study 2

The study was conducted in accordance with the Declaration of

Helsinki and had been approved by the local ethics committee. Students gave their informed consent in written form before the first measuring time. The study started right at the beginning of the semester by measuring trait test anxiety in a paper-pencil form in the first lecture (t1). About four months later, students' state test anxiety was measured right in the minutes before the exam (t2) that was written at the end of the semester in paper-pencil form. The procedure of the measurement before the exam was similar to Study 1. PEP was measured online using SoSci Survey (Leiner, 2014) only once, namely three to nine days after the exam (t3). Fig. 2 shows the procedure of the study.

#### 3.1.4. Statistical analyses of Study 2

An analysis of the missing values revealed that for the trait test anxiety measure assessed at t1,  $n = 7$  students did not answer one or two items each; these values were replaced by calculating the mean of the answered items, multiplying this by 20 and rounding up to the following total number. This procedure was recommended by Hodapp et al. (2011). For the state test anxiety at the beginning of the exam,  $n = 4$  participants had missing values on one item each; these were replaced as recommended by Laux et al. (1981) using the same procedure described for the trait test anxiety measure above.

To test the first and second hypotheses, bivariate correlations between trait and state test anxiety with PEP were calculated. Due to the directionality of the hypotheses, the significance level of  $p < 5\%$  was applied one-tailed. To take multiple tests into account, a Bonferroni correction was performed, resulting in a corrected  $\alpha$  level of  $p < 2.5\%$  (please note that the corrected  $\alpha$  level differed from Studies 1 and 3 as PEP was only measured once in Study 2). Again, we excluded data on a pairwise basis. All analyses were performed using SPSS (Version 28).

#### 3.2. Results of Study 2

Of the  $N = 146$  students who participated in the first measuring time, only  $n = 42$  took part in all three measuring times;  $n = 47$  students took part in one measuring time, and  $n = 57$  in two measuring times. The number of participants for each measuring time can be found in Fig. 2. One important reason for the relatively high dropout rate was that about a third of those who started participation in the study did not take the exam (dropout from t1 to t2).

Again, we performed Little's  $\chi^2$  test to check whether data was missing completely at random (MCAR); with  $\chi^2(3) = 8.33$ ,  $p = .040$ , we cannot assume that data was missing completely at random. However, there were indications that data was missing at random: Dropout analyses using independent *t*-tests showed that students who participated fully did not differ significantly from those who did not participate at all measuring times regarding their trait test anxiety ( $t(144) = 1.40$ ,  $p = .165$ ,  $d = 0.26$ ). However, they indeed differed regarding their state anxiety right before the exam ( $t(97) = 2.46$ ,  $p = .016$ ,  $d = 0.50$ ); students with full participation showed higher levels of state anxiety ( $M = 58.95$ ,  $SD = 11.81$ ) than students who did not participate in t3 ( $M = 53.42$ ,  $SD = 10.47$ ). This means the students who gave data on their PEP tended to be more anxious right before the exam.

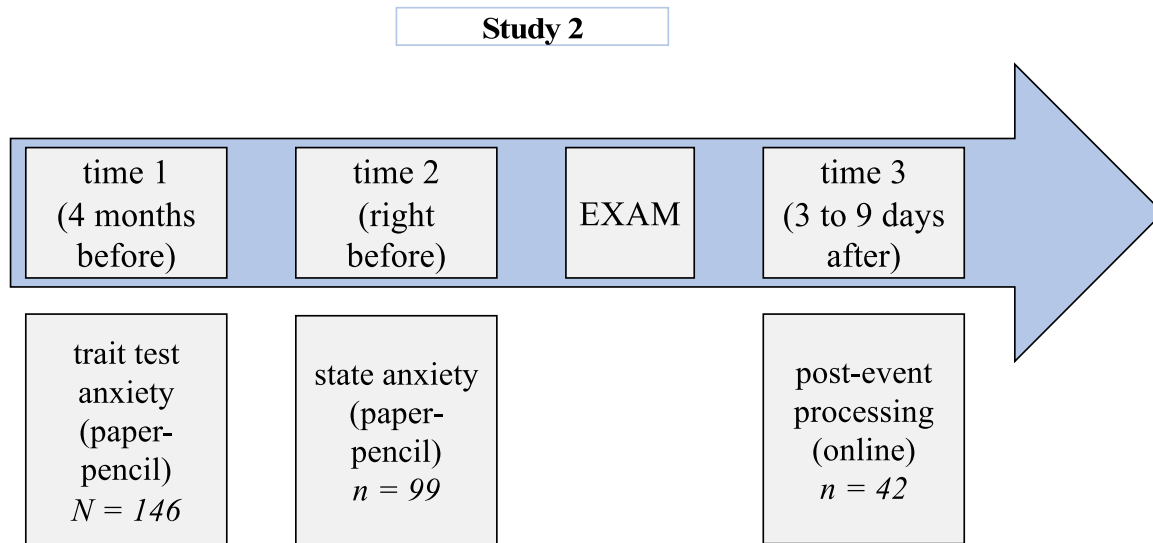


Fig. 2. Study procedure of Study 2 including measuring times and number of participants.

Descriptive statistics are shown in Table 3. Inspecting the descriptive values roughly showed that PEP after exams was higher than after phobic situations (as in Fehm et al., 2007) and was even almost as high as PEP after social situations (as in Fehm et al., 2007:  $M = 40.29$ ,  $SD = 19.86$ ).

Bivariate correlations between the study variables can be found in Table 4. As trait test anxiety was not significantly correlated with PEP, depicting a null effect,  $r = 0.02$ ,  $p = .454$ , (post-hoc power analysis revealed a power of 0.89), the first hypothesis has to be rejected for this study. State anxiety right before the exam showed a significant positive correlation of moderate effect size,  $r = 0.39$ ,  $p = .005$ , with PEP (post-hoc power analysis revealed that the power of 0.52 was not sufficient in this case); thus, the second hypothesis was confirmed.

On a descriptive level, the state test anxiety before the exam reported in Study 2 was higher than in Study 1; a post-hoc independent  $t$ -test revealed that the difference was only marginally significant when tested two-tailed,  $t(132) = 1.70$ ,  $p = .091$ ,  $d = 0.34$ .

### 3.3. Brief discussion of Study 2

Again, in this second study, PEP after the exam reached a level comparable to that found by Fehm et al. (2007), even being equal to the level reported after social situations. Again, this means that PEP is also clearly evident after exam situations. Further, it was significantly related to state test anxiety right before the exam with a moderate effect size, yet it was not related to trait test anxiety. Especially the results regarding the missing relationship between trait test anxiety and PEP are remarkable as they contradict the findings from Study 1. This might be due to some differences between both studies: First, the time interval between measuring trait test anxiety and PEP was different, with about one week in Study 1 and four months in Study 2. Second, participants in Study 1 were mostly in their second semester, whereas the sample of Study 2 consisted mainly of first-semester students. The latter were thus

Table 3  
Descriptive statistics for the study variables of Study 2.

	<i>M</i>	<i>SD</i>	Range	Skewness	Excess kurtosis
Trait test anxiety	47.01	9.52	26–66	0.17	–0.78
State test anxiety	55.77	11.34	27–78	–0.35	–0.32
PEP after 3 to 9 days	38.81	20.74	3.88–88.59	0.27	–0.56

Note. PEP = post-event processing.

predominantly in an academic transition phase between school and university, and test anxiety was measured directly at the beginning of their studies. This, together with the large interval between the measurement of trait test anxiety on the one hand and the exam respective measurement of the PEP on the other hand, could have led to a lack of correlation between the two. A third difference between Study 1 and Study 2 concerns the time of the measurement of PEP, as it was measured a few days as well as about three weeks after the exam in Study 1; on the other hand, PEP in Study 2 was assessed only once after three to nine days – and thus covered the period that was not captured in Study 1. Forth, state anxiety right before the exam was slightly higher in Study 2 compared to Study 1, which could also have influenced the PEP that appeared afterward. Another difference between the two studies was that participants who took part in t3 (meaning those who reported their levels of PEP) tended to be more anxious before the exam.

A possible issue could be the duration of the measurement period of the PEP, which covered a whole week. The intervals between the exam and the measurement of the PEP are therefore likely to vary considerably between subjects. Assuming that PEP is still changing in the days after the exam, this might be a problem.

## 4. Study 3

Since Study 1 and Study 2 showed different results in some respects, we conducted a third study. In this, we measured trait test anxiety in first-year students not at the beginning of the semester (as in Study 2), but closer to the exam (as in Study 1), and we collected PEP again at two measurement times. We thus tested again all three hypotheses that had been put forward. Further, we also wanted to find out which variables best predicted PEP, but we did not formulate hypotheses on this.

### 4.1. Materials and method of Study 3

#### 4.1.1. Participants of Study 3

As in Study 2, a sample size of  $N = 47$  was planned.  $N = 37$  students participated at t1. As the course was relatively small this semester, no socio-economic information was collected from the participants to ensure that their anonymity was preserved – and thus to ensure that participants answered honestly. Still, as the study was again conducted in the context of the statistics lecture usually attended in the first semester, it may be assumed that the sample was similar to that in Study 2. Again, students got credit for participation, and one voucher of 25€ was raffled among those who participated in all measuring times.

**Table 4**  
Bivariate correlations between the study variables of Study 2.

	State test anxiety		n	95 % CI for rB	PEP after 3 to 9 days			
	r / rB	p / pB			r / rB	p / pB	n	95 % CI for rB
Trait test anxiety	0.40 / 0.43	<0.001 / 0.003	99	[0.71, 0.67]	0.02 / 0.02	.454 / .454	42	[-0.29, 0.34]
State test anxiety					0.39 / 0.39	.005 / .005	42	[0.15, 0.60]

Note. Bivariate Pearson correlations are presented as standardized coefficients, significance tests were performed one-tailed. PEP = post-event processing. B = bootstrapped; CI = confidence interval. Bootstrapping was calculated using 2000 samples, sample size for the bootstrapping procedure was  $n = 42$ .

4.1.2. Materials of Study 3

As in the two previous studies, trait test anxiety, state test anxiety before the exam, and PEP were assessed via questionnaires (online and paper-pencil).

Again, we used the Germain Test Anxiety Questionnaire (Hodapp et al., 2011) to measure trait test anxiety. Cronbach’s  $\alpha$  was excellent ( $\alpha = 0.92$ ) for the total scale and thus comparable with the norm sample (Hodapp et al., 2011). State anxiety before the exam was measured using the state anxiety subscale of the STAI (Laux et al., 1981); with Cronbach’s  $\alpha = 0.94$ , it had an excellent internal consistency. We measured PEP with our adapted version of the original PEPQ by Fehm et al. (2008). For both measuring times, internal consistency was excellent (Cronbach’s  $\alpha = 0.94$  for t3 and  $\alpha = 0.95$  for t4).

4.1.3. Procedure of Study 3

The study was conducted in accordance with the Declaration of Helsinki and had been approved by the local ethics committee, as has been the case for Study 1 and Study 2. Students gave their informed consent at the beginning of the online survey (SoSci Survey, Leiner, 2014) at the first measuring time; this was performed eight to four days before the exam with assessing trait test anxiety (t1). Students’ state test anxiety was measured in the minutes right before the exam (t2) at the end of the semester with the procedure being similar to Study 1 and Study 2. PEP was measured online at two measurement times, i.e., one to two days (t3) and six to nine days (t4) after the exam. Fig. 3 shows the procedure of the study.

4.1.4. Statistical analyses of Study 3

Analyzing single missing data points revealed that for trait test anxiety,  $n = 1$  student did not answer one item, which was then replaced according to the recommendations of Hodapp et al. (2011). For state anxiety,  $n = 1$  participant had one single missing item; the value was replaced as recommended by Laux et al. (1981). For both measuring times of PEP, there were no single missing values.

Bivariate correlations between trait and state test anxiety with PEP at both measuring times and between PEP measures at t3 and t4 were calculated to test hypotheses 1 through 3. Due to the directionality of the

hypotheses, the significance level of  $p < 5\%$  was applied one-tailed, and to take multiple testing into account, a Bonferroni correction was performed, resulting in a corrected  $\alpha$  level of  $p < 1\%$ . Again, data were excluded on a pairwise basis.

All analyses were performed using SPSS (Version 28).

4.2. Results of Study 3

Of the  $N = 37$  students who participated in the first measuring time,  $n = 25$  took part in all four measuring times,  $n = 7$  in three measuring times,  $n = 4$  in two measuring times, and  $n = 1$  in only one measuring time. The number of participants for each measuring time can be found in Fig. 3. Little’s  $\chi^2$  test to check whether data was missing completely at random (MCAR) showed that we can assume this,  $\chi^2(12) = 6.67, p = .879$ . Again, as in Study 1, dropout analyses using independent  $t$ -tests showed that students who participated fully did not differ significantly from those who did not participate at all measuring times regarding their trait ( $t(35) = 0.85, p = .400, d = 0.30$ ) or state test anxiety ( $t(33) = 1.15, p = .250, d = 0.43$ ).

Descriptive statistics can be found in Table 5. Roughly speaking, one can say that on a descriptive level, PEP at both measuring times was higher than PEP after phobic situations and almost at the same level as after social situations (as reported by Fehm et al. (2007)).

Bivariate correlations between the study variables are depicted in Table 6. Trait test anxiety showed very high positive correlations with

**Table 5**  
Descriptive statistics for the study variables of Study 3.

	M	SD	Range	Skewness	Excess kurtosis
Trait test anxiety	50.70	11.73	32–74	0.27	-1.03
State test anxiety	56.63	12.67	33–78	-0.15	-0.85
PEP after 1 to 2 days	42.15	25.95	2.35–91.53	0.04	-1.23
PEP after 6 to 9 days	36.75	26.49	2.00–92.06	0.44	-0.82

Note. PEP = post-event processing.

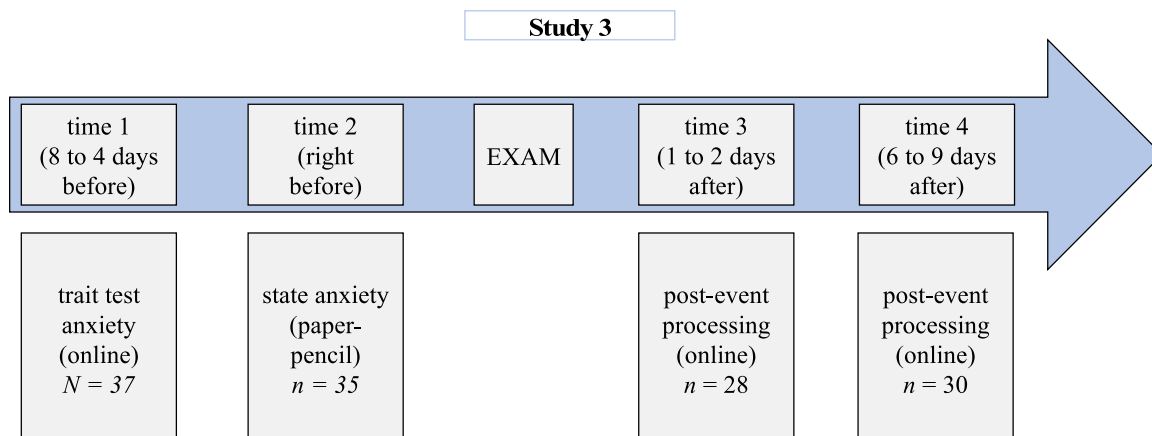


Fig. 3. Study procedure of Study 3 including measuring times and number of participants.

**Table 6**

Bivariate correlations between the study variables of Study 3.

	State test anxiety				PEP after 1 to 2 days				PEP after 6 to 9 days			
	<i>r</i> / <i>r</i> B	<i>p</i> / <i>p</i> B	<i>n</i>	95 % CI for <i>r</i> B	<i>r</i> / <i>r</i> B	<i>p</i> / <i>p</i> B	<i>n</i>	95 % CI for <i>r</i> B	<i>r</i> / <i>r</i> B	<i>p</i> / <i>p</i> B	<i>n</i>	95 % CI for <i>r</i> B
Trait test anxiety	0.47 / 0.54	.002 / .003	35	[0.19, 0.78]	0.78 / 0.75	<.001 / <.001	28	[0.44, 0.93]	0.80 / 0.79	<.001 / <.001	30	[0.58, 0.91]
State test anxiety					0.68 / 0.75	<.001 / <.001	27	[0.50, 0.92]	0.69 / 0.70	<.001 / <.001	29	[0.52, 0.86]
PEP after 1 to 2 days									0.87 / 0.86	<.001 / <.001	26	[0.74, 0.94]

Note. Bivariate Pearson correlations are presented as standardized coefficients, significance tests were performed one-tailed. PEP = post-event processing. *B* = bootstrapped; CI = confidence interval. Bootstrapping was calculated using 2000 samples, sample size for the bootstrapping procedure was  $n = 25$ .

PEP at both measuring times ( $r = 0.78, p < .001$  for PEP after 1 to 2 days, and  $r = 0.80, p < .001$  for PEP after 6 to 9 days); thus, the first hypothesis can be accepted. State anxiety right before the exam showed significant positive correlations of high effect size with PEP at both measuring times ( $r = 0.68, p < .001$  for PEP after 1 to 2 days, and  $r = 0.69, p < .001$  for PEP after 6 to 9 days), confirming the second hypothesis. As PEP at both measuring times was highly correlated,  $r = 0.87, p < .001$ , the third hypothesis was also confirmed. A post-hoc power-analysis revealed that the power for calculating bivariate correlations including measures of PEP was above 0.90 and can thus be considered sufficient.

As, on a descriptive level, PEP decreased from  $t_3$  to  $t_4$ , a post-hoc dependent *t*-test was conducted; the difference was significant,  $t(25) = 2.08, p = .048, d = 0.41$ .

As studies 2 and 3 were both conducted in the context of a statistics exam which – according to students – is quite anxiety-provoking, and Study 1 has been conducted in the context of a different lecture and exam which – according to students – is not that anxiety-provoking, we calculated a post-hoc single factor analysis of variance to check for significant differences in the state test anxiety between the three studies. State test anxiety did not differ significantly between the studies,  $F(2, 166) = 1.71, p = .185$ .

#### 4.3. Brief discussion of Study 3

In this third study, trait and state test anxiety showed very high correlations with PEP, and PEP at the two measuring times correlated highly, as well. Thus, all hypotheses were confirmed.

At this point, differences between the three studies we conducted come into play again. The sample of Study 3 consisted mainly of first-semester students (as in Study 2), yet unlike in Study 2, we did not measure trait test anxiety at the beginning of the semester and thus of their whole studies, yet about one week before the exam (as has been done in Study 1, as well). This is probably why trait test anxiety and PEP were again very closely related in this study.

Interestingly, unlike in Study 1, PEP decreased significantly from  $t_3$  to  $t_4$ ; yet, it has to be taken into account that PEP measuring times differed in both studies. Still, this could indicate that the course of PEP after an exam may not develop linearly.

## 5. General discussion

Research is rare on processes that happen after an exam has been taken. Still, further exams are usually already waiting once one is done. What happens during or after one exam likely influences what happens before and in the next (Cassady, 2004), including test anxiety. PEP as a cognitive process that is being conducted after an event is very well studied in social anxiety, and it is known to maintain the anxiety in the long term (Clark & Wells, 1995; Ehling & Watkins, 2008; Fehm et al., 2007; Hofmann, 2007; Laposa et al., 2014; Wong & Rapee, 2016). Therefore, we hypothesized that this process might also occur after exams and that higher test anxiety should be correlated to higher PEP after exams.

### 5.1. Post-event processing in test anxiety

In summary, all three studies showed that PEP plays a role in the context of test anxiety. On a descriptive level, PEP levels after exams we found in our studies were comparable to levels of PEP reported by Fehm et al. (2007) after phobic or even social situations. Generally, state test anxiety was positively related to PEP with a moderate or large effect size (except state test anxiety being positively yet not significantly related to PEP four to five days after the exam in Study 1 – this might be explained by the small power of Study 1). Regarding trait test anxiety, Study 1 and Study 3 showed that it was related to PEP with moderate to high effect sizes. Studies 1 and 3 showed that PEP levels at different measuring times were highly correlated, meaning that students who ruminated a lot shortly after the exam tended to ruminate a lot at a later date, as well.

The high level of PEP after exams is, on a descriptive level, roughly comparable to that reported after social situations (Fehm et al., 2007). The association of state and trait anxiety with PEP in the context of test anxiety we found in our studies is largely consistent with the findings of previous research on PEP in social anxiety showing that both state, as well as trait social anxiety, were related to PEP following social events with comparable moderate to large effect sizes (Fehm et al., 2007; Laposa et al., 2014; Lundh & Sperling, 2002; Rachman et al., 2000). Thus, we can answer the question as to whether “post-event processing occurs in response to anxiety-provoking events generally regardless of whether the events are social in nature” (Wong, 2016, p. 111) with a “yes, it does”. This finding plays a vital role in the long-standing question of the transdiagnostic meaning of PEP (Wong, 2016). Its level is more similar to PEP after social situations – i.e., higher than after phobic situations –, which speaks for the importance of appraisal processes and cognitions for PEP, as evaluation by others plays a role in social and exam situations, yet not in typical phobic situations (Fehm et al., 2007).

Further, bearing in mind that PEP contributes to perpetuating social anxieties, it is plausible that this process also plays a role in maintaining test anxiety (despite students’ continued participation in exams). This must, of course, be clarified in further studies, as we did not assess this. However, it could then offer an important new approach to the treatment of test anxiety.

Overall, our hypotheses were confirmed in the three studies, and we were able to show that PEP reaches relevant levels after exams and is related to trait and state test anxiety. Nevertheless, unexpected or contradictory results occurred at some points.

### 5.2. Unexpected findings

Unexpectedly, trait test anxiety was unrelated to PEP in Study 2 – contrary to the results of Studies 1 and 3. This is most likely due to the differences in measurement times for trait test anxiety: In Study 2, trait test anxiety was measured about four months before the exam, whereas it was measured only about a week before the exam in Studies 1 and 3 (for a more detailed discussion of this aspect, see next paragraph). PEP at two post-exam measuring times (examined in Studies 1 and 3) was highly correlated. In earlier studies (Fehm et al., 2007; Lundh &



Sperling, 2002), PEP after a social event decreased over time. Interestingly, Study 1 showed an increase in PEP from t3 to t4 on a descriptive level (with a dependent *t*-test not yielding significance), whereas Study 3 showed a significant decrease in PEP between the two post-exam measuring times; still, measuring points in time for PEP in those two studies were different.

There were some differences in the conduct of the three studies that may account for the slightly different results between the studies; at the same time, we can draw meaningful conclusions for further studies. First, the most unexpected result was probably that trait test anxiety was related to PEP in Study 1 and Study 3, yet not in Study 2 – this is particularly surprising in view of the fact that the same measures were used. A possible reason for this might be the differing time intervals between the measurement of trait test anxiety on the one hand, and PEP on the other hand: This period was shorter in Studies 1 and 3, as trait anxiety has been measured only about one week before the relevant test. In Study 2, the time lag was significantly longer with four months, and, additionally, trait test anxiety was measured at the beginning of the semester. Earlier studies have shown that test anxiety changes during the semester, yet findings regarding the direction are contradictory: Yerdelen et al. (2016) found that it decreased, whereas Lotz and Sparfeldt (2017) and Sommer et al. (2022) found that it increased. Keeping this in mind, the measuring time of trait test anxiety could definitely influence its assessment and its relation to other variables. A third aspect is that in Study 2, the measurement of trait test anxiety at the beginning of the semester was conducted with a sample of mainly first-semester students – so there was a combination of a very early measurement of test anxiety with participants who were mostly in a period of academic transition when trait test anxiety was measured in Study 2 as they had just finished school and started university. Only very few studies have been conducted on the development of test anxiety in the transition from secondary education to university. Results were mixed with hints of a slight increase in test anxiety during the first semester (Bischofsberger et al., 2021), while other researchers found that once students have started their university education, they experience lower levels of academic difficulties (e.g., test anxiety) than they had initially expected (H. Lowe & Cook, 2003). Nevertheless, both studies suggest that test anxiety might change in the first semester; additionally, self-concept is less stable when people only start studying compared to secondary school (Gorges, 2017). These changes at the beginning of or during the first semester might explain why the long time between measuring trait test anxiety and PEP after an exam yielded different results in first-semester students in Study 2. A second aspect that could have contributed to the mixed results could be the low power of especially of Study 1.

Differences between the results of the three studies regarding PEP could further be because measurement times of PEP were different for the studies. PEP might be quite fluent after an exam, so it might make a difference when it is measured. For further studies, it could be promising to map the time course of PEP after an exam in more detail.

### 5.3. Limitations, strengths, and implications of the current study

The most significant limitation of our studies is by far the small sample sizes of all three studies resulting in an insufficient power for Study 1 and Study 2. This has to be kept in mind when interpreting the results of the hypotheses we tested as well as of exploratory analyses and drop-out analyses, as well. Likely, the small sample sizes – together with the Bonferroni correction leading to rather conservative testing – partly explain why some moderate and even high effect sizes did not emerge as statistically significant. A second important problem is the comparably high dropout-rate, especially in the second study where less than half of the students who took the exam did answer the PEP-questionnaire afterward; further, analyses showed that students who did participate in all measuring times were those experiencing more state anxiety before the exam. Thus, we might have had a self-selection bias, at least in Study 2. Another limitation is that participants were all psychology students,

which makes generalization critical. Thus, findings should be replicated using larger samples examining not only university students, but also younger pupils and students from different academic subjects. A particular focus should be placed on keeping the dropout at a minimum.

Nevertheless, as the question of whether test anxiety and PEP are related has been studied only once before, the findings of the studies presented in this paper are promising. Still, at the moment, there are far more open than answered questions.

Characteristics like how anxiety-provoking an exam is or the measuring time of trait test anxiety may be relevant, and studying PEP after an exam should best be done using many more measuring times, delivering a more detailed picture of the course of PEP over time. Further, it is not clear which event in the process of test-taking is more relevant for rumination – whether it is doing the test itself or instead getting the result. In our studies, the exam itself has been defined as the event of interest as insecurity and ambivalence are more significant at this point, and “the ambiguity of the situation may be an important predictor for prolonged processing“ (Fehm et al., 2007, p. 11); yet taking the event of getting the grade into account could help to understand the course of PEP. Further, having feedback on the performance one has delivered might influence PEP differently depending on whether students are assessed better, worse, or somewhat as expected. In this context, studying PEP after oral exams could be interesting, as grades are usually announced directly afterward.

Another event that might influence PEP that was not standardized or recorded in our studies could be other exams taken by the students after the index exams. Further tests could, on the one hand, enhance PEP if insecurity sums up. It might as well, on the other hand, reduce PEP due to distraction from the index exam by learning for other tests or worry regarding these outstanding exams. This might also help to answer the question of why PEP was related to state anxiety only in one of two measuring times of PEP in Study 1. Further studies should, therefore, either standardize or capture other exams participants have to master in the period after the index exam studied.

Targeting the question of whether PEP contributes to maintaining test anxiety, it might be promising to put a particular focus on high-performing test-anxious students. Although in general, test anxiety seems to be related to worse academic performance (von der Embse et al., 2018), associations are pretty complex (Hoferichter et al., 2016; Schillinger et al., 2021) and early studies have found a substantial number of highly test-anxious students who achieve high academic success (Brown & Nelson, 1983; Bruch et al., 1986). For this group in particular, the question arises as to why corrective experiences (namely, doing well on exams) do not reduce test anxiety; PEP after an exam might – similar to the maintenance of social anxiety (Brozovich & Heimberg, 2008; Fehm et al., 2008) – provide an answer to this question.

### 5.4. Conclusion

Altogether, our findings indicate that PEP plays a role in the context of test anxiety and test-taking. This supports the latest theoretical considerations and empirical findings that PEP is not a disorder-specific symptom of social anxiety, but rather a transdiagnostic process. Still, as this study was one of the first to deal with the phenomenon in the context of test anxiety, it can only be a starting point for future studies. There are some aspects of the study design that need to be taken into account or changed to obtain more precise results in order to answer the crucial question regarding the role of PEP in maintaining test anxiety – and this is of high practical relevance when it comes to reducing test anxiety and the disadvantages that come with it. However, the first step for a model yielding an intertwining relationship between test anxiety and PEP has been done: Even if details have to be clarified, our studies strongly indicate that there is a significant relationship between test anxiety and PEP.

## CRedit authorship contribution statement

**Sarah Möcklinghoff:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Olga Rapoport:** Writing – review & editing, Conceptualization. **Eva Neidhardt:** Writing – review & editing, Supervision.

## Declaration of competing interest

The authors have no conflict of interest to disclose.

## Data availability statement

The data analyzed for this study are available in the Open Science Framework OSF at [https://osf.io/9bgze/?view\\_only=fc7e7da4cf5747e9b614548a19404e1c](https://osf.io/9bgze/?view_only=fc7e7da4cf5747e9b614548a19404e1c)

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## References

- Aydın, G., & Yerin Güneri, O. (2022). Exploring the role of psychological inflexibility, rumination, perfectionism cognitions, cognitive defusion, and self-forgiveness in cognitive test anxiety. *Current Psychology*, 41(4), 1757–1766. <https://doi.org/10.1007/s12144-020-00805-1>
- Bischofsberger, L., Burger, P. H. M., Hammer, A., Paulsen, F., Scholz, M., & Hammer, C. M. (2021). Prevalence and characteristics of test anxiety in first year anatomy students. *Annals of Anatomy - Anatomischer Anzeiger*, 236, Article 151719. <https://doi.org/10.1016/j.aanat.2021.151719>
- Brown, S. D., & Nelson, T. L. (1983). Beyond the uniformity myth: A comparison of academically successful and unsuccessful test-anxious college students. *Journal of Counseling Psychology*, 30(3), 367–374.
- Brozovich, F., & Heimberg, R. G. (2008). An analysis of post-event processing in social anxiety disorder. *Clinical Psychology Review*, 28(6), 891–903. <https://doi.org/10.1016/j.cpr.2008.01.002>
- Bruch, M. A., Pearl, L., & Giordano, S. (1986). Differences in the cognitive processes of academically successful and unsuccessful test-anxious students. *Journal of Counseling Psychology*, 33(2), 217–219.
- Buchner, A., Erdfelder, E., Faul, F., & Lang, A.-G. (2020). *G\*Power* (3.1.9.6) [Software].
- Cassady, J. C. (2004). The influence of cognitive test anxiety across the learning–testing cycle. *Learning and Instruction*, 14(6), 569–592. <https://doi.org/10.1016/j.learninstruc.2004.09.002>
- Clark, D. M., & Wells, A. (1995). A cognitive model of social phobia. R. G. Heimberg, M. R. Liebowitz, D. A. Hope, & F. R. Schneier (Hrsg.), *Social phobia. diagnosis, assessment, and treatment*. The Guilford Press. S. 69–93.
- Čolić, J., Latysheva, A., Bassett, T. R., Imboden, C., Bader, K., Hatzinger, M., Mikoteit, T., Meyer, A. H., Lieb, R., Gloster, A. T., & Hoyer, J. (2020). Post-event processing after embarrassing situations: Comparing experience sampling data of depressed and socially anxious individuals. *Clinical Psychology in Europe*, 2(4), e2867. <https://doi.org/10.32872/cpe.v2i4.2867>
- Ehring, T., & Watkins, E. (2008). Repetitive negative thinking as a transdiagnostic process. *International Journal of Cognitive Therapy*, 1, 192–205. <https://doi.org/10.1521/ijct.2008.1.3.192>
- Falkai, P., Wittchen, H.-U., & Döpfner, M. (2015). & American Psychiatric Association (Hrsg. *Diagnostisches und statistisches manual psychischer störungen DSM-5® [Diagnostic and statistical manual of mental disorders DSM-5®]*. Hogrefe.
- Fehm, L., & Fydrich, T. (2011). *Prüfungsangst [Test Anxiety]*. Hogrefe.
- Fehm, L., Schneider, G., & Hoyer, J. (2007). Is post-event processing specific for social anxiety? *Journal of Behavior Therapy and Experimental Psychiatry*, 38(1), 11–22. <https://doi.org/10.1016/j.jbtep.2006.02.004>
- Fehm, L., Hoyer, J., Schneider, G., Lindemann, C., & Klusmann, U. (2008). Assessing post-event processing after social situations: A measure based on the cognitive model for social phobia. *Anxiety, Stress & Coping*, 21(2), 129–142. <https://doi.org/10.1080/10615800701424672>
- 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. <https://doi.org/10.1037/0022-3514.48.1.150>
- Gorges, J. (2017). First-year students' initial motivational beliefs at university: Predicted by motivational beliefs derived from within and out-of-school experience and malleable regardless of the extent of students' out-of-school experience. *Frontiers in Psychology*, 8, 1258. <https://doi.org/10.3389/fpsyg.2017.01258>
- Grant, D. M., & Beck, J. G. (2010). What predicts the trajectory of rumination? A prospective evaluation. *Journal of Anxiety Disorders*, 24(5), 480–486. <https://doi.org/10.1016/j.janxdis.2010.03.004>
- Hodapp, V., Rohrmann, S., & Ringeisen, T. (2011). *Prüfungstestfragebogen (PAF)*. [Test anxiety questionnaire]. Hogrefe.
- Hoferichter, F., Raufelder, D., Ringeisen, T., Rohrmann, S., & Bukowski, W. M. (2016). Assessing the multi-faceted nature of test anxiety among secondary school students: An English version of the German test anxiety questionnaire: PAF-E. *The Journal of Psychology*, 150(4), 450–468. <https://doi.org/10.1080/00223980.2015.1087374>
- Hofmann, S. G., & Hay, A. C. (2018). Rethinking avoidance: Toward a balanced approach to avoidance in treating anxiety disorders. *Journal of Anxiety Disorders*, 55, 14–21. <https://doi.org/10.1016/j.janxdis.2018.03.004>
- Hofmann, S. G. (2007). Cognitive factors that maintain social anxiety disorder: A comprehensive model and its treatment implications. *Cognitive Behaviour Therapy*, 36(4), 193–209. <https://doi.org/10.1080/16506070701421313>
- Huntley, C. D., Young, B., Temple, J., Longworth, M., Smith, C. T., Jha, V., & Fisher, P. L. (2019). The efficacy of interventions for test-anxious university students: A meta-analysis of randomized controlled trials. *Journal of Anxiety Disorders*, 63, 36–50. <https://doi.org/10.1016/j.janxdis.2019.01.007>
- Laposa, J. M., Collimore, K. C., & Rector, N. A. (2014). Is post-event processing a social anxiety specific or transdiagnostic cognitive process in the anxiety spectrum? *Behavioural and Cognitive Psychotherapy*, 42(6), 706–717. <https://doi.org/10.1017/S135246581300074X>
- Laux, L., Glanzmann, P., Schaffner, P., & Spielberger, C. D. (1981). *Das state-trait-angstinventar (STAD) [The state trait anxiety inventory]*. Beltz.
- Leiner, D. (2014). *SoSci Survey* (2.5.00) [Software]. <https://www.socisurvey.de>.
- Lotz, C., & Sparfeldt, J. R. (2017). Does test anxiety increase as the exam draws near? – Students' state test anxiety recorded over the course of one semester. *Personality and Individual Differences*, 104, 397–400. <https://doi.org/10.1016/j.paid.2016.08.032>
- Lotz, C., Sparfeldt, J. R., & Ringeisen, T. (2021). A latent growth curve analysis of state test anxiety in successive days of before and after an examination and in relations to trait test anxiety. *Learning and Individual Differences*, 92. <https://doi.org/10.1016/j.lindif.2021.102080>. Article 102080.
- Lowe, H., & Cook, A. (2003). Mind the gap: Are students prepared for higher education? *Journal of Further and Higher Education*, 27(1), 53–76. <https://doi.org/10.1080/030987703005629>
- Lowe, P. A., Lee, S. W., Witteborg, K. M., Prichard, K. W., Luhr, M. E., Cullinan, C. M., Mildren, B. A., Raad, J. M., Cornelius, R. A., & Janik, M. (2008). The test anxiety inventory for children and adolescents (TAICA): Examination of the psychometric properties of a new multidimensional measure of test anxiety among elementary and secondary school students. *Journal of Psychoeducational Assessment*, 26(3), 215–230. <https://doi.org/10.1177/0734282907303760>
- Lundh, L.-G., & Sperling, M. (2002). Social anxiety and the post-event processing of socially distressing events. *Cognitive Behaviour Therapy*, 31(3), 129–134. <https://doi.org/10.1080/165060702320338004>
- Makkar, S. R., & Grisham, J. R. (2011). The predictors and contents of post-event processing in social anxiety. *Cognitive Therapy and Research*, 35(2), 118–133. <https://doi.org/10.1007/s10608-011-9357-z>
- McEvoy, P. M., Mahoney, A. E. J., & Moulds, M. L. (2010). Are worry, rumination, and post-event processing one and the same? *Journal of Anxiety Disorders*, 24(5), 509–519. <https://doi.org/10.1016/j.janxdis.2010.03.008>
- Modini, M., & Abbott, M. J. (2017). Negative rumination in social anxiety: A randomised trial investigating the effects of a brief intervention on cognitive processes before, during and after a social situation. *Journal of Behavior Therapy and Experimental Psychiatry*, 55, 73–80. <https://doi.org/10.1016/j.jbtep.2016.12.002>
- Pena, M., & Losada, L. (2017). Test anxiety in spanish adolescents: Examining the role of emotional attention, and ruminative self-focus and regulation. *Frontiers in Psychology*, 8, 1423. <https://doi.org/10.3389/fpsyg.2017.01423>
- Putwain, D. W., von der Embse, N., Rainbird, E. C., & West, G. (2021). The development and validation of a new multidimensional test anxiety scale (MTAS). *European Journal of Psychological Assessment*, 37(3), 236–246. <https://doi.org/10.1027/1015-5759/a000604>
- Rachman, S., Grüter-Andrew, J., & Shafraan, R. (2000). Post-event processing in social anxiety. *Behaviour Research and Therapy*, 38(6), 611–617. [https://doi.org/10.1016/S0005-7967\(99\)00089-3](https://doi.org/10.1016/S0005-7967(99)00089-3)
- Richardson, M., Abraham, C., & Bond, R. (2012). Psychological correlates of university students' academic performance: A systematic review and meta-analysis. *Psychological Bulletin*, 138(2), 353–387. <https://doi.org/10.1037/a0026838>
- Schillinger, F. L., Mosbacher, J. A., Brunner, C., Vogel, S. E., & Grabner, R. H. (2021). Revisiting the role of worries in explaining the link between test anxiety and test performance. *Educational Psychology Review*, 33(4), 1887–1906. <https://doi.org/10.1007/s10648-021-09601-0>
- Sommer, K., Odenwald, M., & Fehm, L. (2022). Stabilität und prädiktion von prüfungstest bei studierenden: ergebnisse einer längsschnitterhebung mit erstsemestern. *Zeitschrift für Klinische Psychologie und Psychotherapie*, 51(2), 87–95. <https://doi.org/10.1026/1616-3443/a000660>
- Spielberger, C. D., & Vagg, P. R. (1995). *Test anxiety: A transactional process model*. C. D. Spielberger & P. R. Vagg (Hrsg.). *Test anxiety. theory, assessment, and treatment*. Taylor & Francis. S. 3–14.
- Steinmayr, R., Crede, J., McElvany, N., & Wirthwein, L. (2016). Subjective well-being, test anxiety, academic achievement: Testing for reciprocal effects. *Frontiers in Psychology*, 6. <https://doi.org/10.3389/fpsyg.2015.01994>. Article 1994.

- von der Embse, N., Jester, D., Roy, D., & Post, J. (2018). Test anxiety effects, predictors, and correlates: A 30-year meta-analytic review. *Journal of Affective Disorders*, 227, 483–493. <https://doi.org/10.1016/j.jad.2017.11.048>
- Wong, Q. J. J., & Rapee, R. M. (2016). The aetiology and maintenance of social anxiety disorder: A synthesis of complementary theoretical models and formulation of a new integrated model. *Journal of Affective Disorders*, 203, 84–100. <https://doi.org/10.1016/j.jad.2016.05.069>
- Wong, Q. J. J., McEvoy, P. M., & Rapee, R. M. (2016). A comparison of repetitive negative thinking and post-event processing in the prediction of maladaptive social-evaluative beliefs: A short-term prospective study. *Journal of Psychopathology and Behavioral Assessment*, 38(2), 230–241. <https://doi.org/10.1007/s10862-015-9506-x>
- Wong, Q. J. J. (2015). Psychometric evaluation of the English version of the extended post-event processing questionnaire. *Anxiety, Stress, & Coping*, 28(2), 215–225. <https://doi.org/10.1080/10615806.2014.925546>
- Wong, Q. J. J. (2016). Anticipatory processing and post-event processing in social anxiety disorder: An update on the literature. *Australian Psychologist*, 51(2), 105–113. <https://doi.org/10.1111/ap.12189>
- International classification of diseases 11th revision. (2023). World Health Organisation. <https://icd.who.int/browse11/l-m/en#/http://id.who.int/icd/entity/239513569>.
- Yerdelen, S., McCaffrey, A., & Klassen, R. M. (2016). Longitudinal examination of procrastination and anxiety, and their relation to self-efficacy for self-regulated learning: Latent growth curve modeling. *Educational Sciences: Theory & Practice*. <https://doi.org/10.12738/estp.2016.1.0108>