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ORIGINAL PAPER

Anxiety and heart rate in a real-life class test in undergraduates choosing real-time or prerecorded oral presentations

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Abstract

Most studies on acute stress stem from works conducted under artificial laboratory conditions. Inducing stress for experimental scrutiny is problematic and can be unethical. In this study, a 'research methods' course's curriculum included a demonstration study testing anxiety and heart rate responses to the midterm test. Fifty-four university students (35 males and 19 females) presented a research topic in-person ($n = 14$) or prerecorded while being present ($n = 40$). Students selected a test format they could change until the week before the midterm test. The measures were trait anxiety, test anxiety, state anxiety, heart rate (HR), the last two being measured before and after examination, and grades. All students manifested decreased state anxiety and increased HR from before to after the test. Females exhibited higher HR and state anxiety than males. Real-time presentations were associated with higher HRs but not higher state anxiety. Those who changed their planned presentation mode from in-person to prerecorded exhibited higher test anxiety but not trait anxiety than those who presented as planned. Students who presented in-person obtained lower grades than those who prerecorded their presentations. Grades were negatively correlated with state anxiety after the test, but test anxiety did not significantly mediate the grades. Pre-test state anxiety was positively associated with both trait anxiety and test anxiety. The findings suggest that test anxiety is unlikely to affect grades, but test-anxious students need more control over academic evaluation. A choice in test format could be helpful in this regard.

Keywords Academic evaluation · Oral presentation · Speech · Stress · University students

Introduction

Academic evaluation can be challenging for many students (Elsalem et al. 2020). It is closely associated with test anxiety, which despite being relatively stable over time (Ping et al. 2008), in test situations, can depend on many factors (Tsegay et al. 2019). These factors include the subject (Everson et al. 1993), the level or importance of the test (von der Embse et al. 2018), level of preparedness (Akinsola and Nwajei 2013), emotional states (Chin et al. 2017), social support (Tsegay et al. 2019), gender, ethnicity, and age (von der Embse et al. 2018), the form of the exam (Sparfeldt et al. 2013), or even personality traits (Bochis and Florescu 2018). Therefore, test anxiety has both trait and state components, with the former being more persistent than its state component (Ping et al. 2008), which varies according to the listed factors. Hence *state* test anxiety can be perceived as an acute *stress response to evaluation* characterized by excessive worry, uncertainty, and/or fear related to a *specific* test situation. In this study, test anxiety is conceived as a trait measure, but in recognition of its state aspect, its assessment is complemented with state anxiety (SA) measures. Although stress and state anxiety are often used interchangeably in acute challenge situations, the latter is a part of the former because the negative emotional responses (i.e., worry, fear, sadness) are basic components of the acute stress response (Epel et al. 2018).

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In contrast to test anxiety, state anxiety is a more situation-specific (i.e., evaluation) acute stress directly associated with challenges that exceed one's coping resources (i.e., not being fully prepared) or objective threats (having to do something novel or unfamiliar). Noteworthy is that state anxiety and stress trigger similar physical reactions, such as elevated heart rate (typical), sweaty palms, and churning stomach (Helgoe et al. 2005). These shared reactions are due to overlapping neuronal circuits (Shin and Liberzon 2010) because the brain cannot distinguish between perceived and actual threats. Much sensory information could reach the brain without being consciously perceived (Ádám 1998). Thus, evaluation-induced stress can be *active* (if one is or believes to be prepared, feeling in control) or *passive* (if one is or feels unprepared, feeling no control).

However, the form of anxiety-evoked stress, whether active or passive, depends on the form of evaluation. The students must account for their knowledge during both written and oral tests. In such cases, they cope actively *during* the test. In contrast, when a piece of work must be handed in, there are two phases of coping. One is the preparation phase (which usually poses stress only when it is close to the deadline); it requires active coping. In the other phase, *after handing in the test material*, the available coping is passive because the student no longer has control over the outcome (Rankin et al. 2019).

Oral examinations can be particularly stressful. The subjective stress response depends on several factors. For example, gender (Núñez-Peña et al. 2016) and personality traits like extroversion, introversion (Fraj-Andrés et al. 2018), or perfectionism (GhorbanDordinejad and Nasab 2013) may play a crucial role. Furthermore, other factors, including communication skills, fear of failure, and level of preparedness (Tercan and Dikīlītaş 2015), are also influential. Oral examinations are a form of public speech, a recognized stressor in the literature (Dietrich et al. 2020). Laboratory studies often use it as an artificial active stressor to study participants' acute stress responses (Hamidovic et al. 2020; Schoofs et al. 2008). However, the impact of real-life stressors is greater than those obtained in laboratories (Zanstra and Johnston 2011).

Even in the absence of academic evaluation, public speaking elicits stress from perceived social-evaluation threats (Dickerson and Kemeny 2004). During an academic oral evaluation, performance-related factors could trigger and fuel additional stress (Laurin-Barantke et al. 2016). Such stress is generally considered detrimental to academic performance. For example, a meta-analysis of 238 studies concluded that "*…test anxiety was significantly and negatively related to a wide range of educational performance outcomes, including standardized tests, university entrance exams, and grade point average*." (von der Embse et al. 2018, p. 483). However, Theobald et al. (2022) have recently provided robust contrary evidence. In a study with 309 medical students, these authors showed that test anxiety was not a significant factor in predicting exam performance beyond the *level of knowledge* assessed in mock tests or during exam preparation. These findings make sense considering that students mastering the test material are likely to feel that they have more control and, hence, are less stressed than those who are less prepared (Naveh-Benjamin et al. 1997).

Before and during an academic test, physiological arousal increases as manifested by an increase in heart rate (Daly et al. 2011). Heart rate (HR) can be conceived as a 'crude' index of sympathetic arousal (Péronnet and Szabo 1993). It is often viewed as a measure of anxiety-induced arousal (Roos et al. 2020). However, HR can increase even further when cognitive performance (i.e., mental arithmetic) is tested in a physiologically aroused state, such as during exercise (Szabo et al. 1994). Early evidence suggests a positive relationship between HR and test anxiety (Deffenbacher 1986). Yet other research suggests no such relationship (Daly et al. 2011). However, the former study was based on a real-life test, while the latter relied on a mock test. Several other factors could mediate this relationship. Nevertheless, HR response to academic tests theoretically should vastly *vary* due to different levels of preparedness (Akinsola and Nwajei 2013), trait anxiety, state anxiety, test anxiety, and the test conditions perceived differently by the students. Although a few studies examined HR responses during real-life academic tests, such studies are challenging to perform due to technical and ethical reasons.

Therefore, real-life oral examinations represent a form of *acute* active stress (Merz and Wolf 2015), the level of which is determined by the factors already discussed above. In many cases, it could be more potent than an artificial laboratory stressor. While few studies looked at anticipatory stress in a real-life oral examination, they suggest that there should be some pre-learning desensitization (Tercan and Dikīlītaş 2015) or simulation to reduce anxiety (Sparfeldt et al. 2013). Providing a choice in the form of an exam could alleviate anxiety (Zeidner et al. 2007). The choice is instrumental in coping with perceived threatening situations. For example, an earlier study found that anticipation of having options decreased perceived stress and increased feelings of *control* when sufficient information was provided to 144 psychology students (Paterson and Neufeld 1995). Indeed, a sense of control can reduce stress, increasing feelings of competence and decision-making power in stressful situations (Wen and Sin 2022).

Given that control could be associated with less anxiety or acute stress during academic evaluation, choosing between *real-time* and *prerecorded* in-class oral tests could provide control. Regardless of choice, performance-related uncertainty could trigger similar increases in state anxiety and arousal (i.e., HR) before the test in both groups. Therefore,

in the anticipatory period, no differences in these measures could be expected between students presenting in real-time or prerecorded. However, during the test, the means of coping are different; real-time presentations require students to cope actively. In contrast, their counterparts who have prerecorded their presentation have to watch themselves passively and await the evaluation of their product.

Therefore, this study aimed to evaluate state anxiety and HR before and after a real-life university midterm oral examination in which students can present in-person or prerecord and watch their presentations. Further, given that oral exams are very stressful (Merz and Wolf 2015), the link between pre and post-test stress, as assessed through state anxiety and HR, to trait anxiety and test anxiety and academic performance was also examined. Finally, differences between the planned and actual modes of presentation were tested in both state and trait measures.

The first hypothesis was that students choosing a prerecorded oral presentation for their midterm test would demonstrate lower state anxiety and HR than those choosing a real-time (in-person) presentation after but not before the test. The second hypothesis was that trait anxiety and test anxiety would be related to state anxiety and HR both before and after the test. A third hypothesis was that test anxiety would be greater in those who changed their mind concerning the presentation mode. Furthermore, in a fourth hypothesis, it was conjectured that prerecorded presentations, due to mandatory time spent on their preparation and the obligatory—assumedly repeated—occupation with the material and self-evaluation before finalizing it, would result in higher grades. Finally, the fifth hypothesis was that state anxiety and HR mediate the relationship between the presentation mode and performance. In this context, at an exploratory level, the effect of test anxiety on grades was also examined to test the new evidence-based presumption (Theobald et al. 2022) that test anxiety is unrelated to academic performance.

Materials and methods

Participants

Participants were native English speakers. Apart from three, all were Caucasians (white Europeans) studying at a large urban university. All were second-year undergraduate sports science students taking a compulsory research methods course. There were 19 females and 35 males in the class. While there is no record of the individual ages, they were between 19 and 24. Their study curriculum involved a field (real-life) experiment *on themselves* during the midterm test. It comprised an oral presentation of a chosen research topic in sports and exercise sciences. It was agreed with the students that after making it fully anonymous, the data obtained in this study will be shared, analyzed, and discussed together during the second half of the semester. Its various stages were part of the final test. Consequently, this study was exempt from ethical clearance for the university's research ethics board because it was considered 'teaching material' with active student participation. While the presentations were mandatory, students could refuse cooperation in completing questionnaires or providing their HR data. None of them did.

Materials

The validated short Test Anxiety Inventory (TAI; Taylor and Deane 2002), assessed students' *general anxiety* concerning academic evaluation. It was rated on a 5-point Likert-type scale with the following rating options: (1) *never*, (2) *rarely,* (3) *sometimes*, (4) *often*, and (5) *always*. A sample item is: "*During tests, I feel very tense,*" while another is "*I wish examinations did not bother me so much.*" Its items measure general tendencies rather than momentary feeling states. The reported internal reliability of the short TAI is good (Cronbach's alpha [α] = 0.87; (Taylor and Deane 2002).

Spielberger's state and trait anxiety scale (STAI; Spielberger et al. 1983) measured situational and general anxiety. The STAI is a 40-item subjective measure of anxiety. It employs a 4-point Likert-type scale to assess each item on two scales reflecting the state (Form Y-1) and trait anxiety (Form Y-2). Each scale consists of 20 statements; while the state scale has ten reverse-scored items, the trait scale has only seven. Sample items are: "*I feel nervous*" (item 12 on Y-1) and "*I have disturbing thoughts*" (item 11 on Y-2). This instrument has good psychometric properties (Barnes et al. 2002). Its internal reliability coefficients range from $\alpha = 0.86–0.95$, while its test–retest reliability coefficients are between (r) 0.65 and 0.75 over 2 months (Spielberger et al. 1983).

Heart rate (HR) was measured with a Merlin (Meditech) one-channel electrocardiogram (ECG) event monitor (Kearley et al. 2014). Requiring no chest contact, this wrist-portable cardiac event monitor is easily activated by placing a hand over its watch face. It can record and store up to 15 min, but in this study, only a short recording was required before starting the exam and immediately after completing the test to obtain the HR in those periods. The HR is calculated from an electrocardiogram strip, and the recordings are easily transmitted to a laptop or PC via an optical cable or a standard modem. Time stamps permit the differentiation of recordings obtained from different subjects.

Oral presentations were delivered with an HP Pavilion (Model a367c) Windows-based computer equipped with Microsoft (PowerPoint) and Windows Media Player software. Real-time presentations used PowerPoint, while

prerecorded presentations used WMV (Windows Media Viewer) or AVI (Audio Video Interleave) files. The presentation files were displayed with a Panasonic PT-L735NTU Projector.

Procedure

The Research Methods course was mandatory for all second-year BSc students and was worth three credits. It consisted of two progress evaluations, a midterm test, and a final examination worth 40% and 60%, respectively. The weekly classes lasted three hours, with a 10-min break after 80 min in a medium-sized classroom in the early afternoon. For the midterm test, students had to prepare a 5-min mini-oral presentation on any (preferred) subject related to sports or exercise research data acquisition, analyses, and interpretation. They were offered the choice to deliver the presentation in-person or *prerecord themselves* at home (or any other place) and project their recorded presentation *while being present* at the midterm test. At the beginning of the semester, they had to indicate to the instructor whether they planned a real-time or prerecorded presentation, which was numerically coded as one (1) or (2). They could change their mind concerning the form of their test until the week before the evaluation. If they did so, the change in the mode of delivery was coded with three (3).

Students were instructed that the midterm test would also be used as research with self-participation consisting of state and trait measures that would be shared in an electronic class forum after being anonymized by the instructor. Subsequently, in the second half term, the class would analyze and discuss the data that will be part of the final examination. Further, smaller groups of students (five to six) would look at various subsets of the data, like trait measures, state measures, change scores, sex differences, presentation mode differences, and so on. Grading by the instructor in both modes of presentations was based on organization, speech, visual clarity, relevance to research methods, take-home message, and keeping time.

On the test day, the order of the oral presentations was random, achieved with the help of an online program (https://www.random.org), so all students had an equal chance of being the first. All files, whether PowerPoint, WMV, or AVI, had to be uploaded to the classroom computer before the class. A male graduate student helped in uploading all presentation files. All students filled out the test-, trait- and state anxiety inventories at the beginning of the class. Next, the first presenting student placed the Merlin HR monitor on her wrist and recorded her HR. Upon reminder from the instructor at the end of the presentation, she obtained a second HR measure and then completed the state anxiety inventory a second time. Subsequently, all tests were identical to the first one.

Testing required two class sessions. The HR rate data were downloaded and identified based on the time stamps and the order of presentations. Further, the assisting graduate student anonymized and scored the questionnaires manually and recorded them in a Microsoft Excel file along with the HR scores and the grades. Another student verified the correctness of the data input. The post-test state anxiety scales were printed on yellow paper. Therefore, they could not be confounded with the pre-test of the same student.

Data analyses

To examine state anxiety and HR before and after presentations by mode of delivery and gender, a multivariate repeated measures analysis of variance (MRM-ANOVA) was used. To test trait- and test-anxiety differences between students who presented as planned and those who changed their minds and switched to a prerecorded presentation before the test, a multivariate analysis of variance (MANOVA) was calculated. Another MANOVA was used to test the differences in trait- and test anxiety between those who planned to present in-person at the beginning of the semester and those who planned a prerecorded presentation. Before all multivariate tests, the assumptions of homogeneity were calculated with Levene's tests of the equality of variances and Box's test of equality of covariance matrices.

Spearman's correlations were performed to determine the strength of the relationships between the trait and state measures. Change (delta[Δ]) scores were not calculated because HR and state anxiety assessed before the presentations could not be considered baseline measures. Instead, they were affected by anticipation stress (Merz and Wolf 2015; Schoofs et al. 2008), and examining their correlation with trait measures was more appropriate. However, their *direction* of change emerged from the MRM-ANOVA. Further, analysis of variance (ANOVA) was calculated to test whether there would be differences in performance (grade obtained) between those doing real-time or prerecorded presentations. Furthermore, mediation analyses were used to test whether state measures (state anxiety and HR) and trait (test and trait anxiety) mediate the relationship (if any) between the mode of presentation and grades.

Results

Initially, 37 students planned to fulfill the midterm exam via real-time oral presentation, and the other 17 planned to prepare a prerecorded presentation. From among the former, 62.2% ($n = 23$) changed their minds by the week before the midterm test. Consequently, only 14 students complied with the test by undergoing real-time oral presentations, and 40

others completed it by handing in and watching their prerecorded presentations.

Assumptions of homogeneity of variance and covariances were not violated, as indicated by the statistically not significant Levene's tests of the equality of variances and Box's test of equality of covariance matrices. Ensuing, an MRM-ANOVA resulted in statistically significant multivariate main effects for *gender* (Pillai's Trace = 0.289, F [2, 49] = 9.96, $p < 0.001$, effect size (partial ETA squared [η_p^2] = 0.289) and the *mode of presentation* (Pillai's Trace = 0.121, F [2, 49] = 3.39, $p = 0.042$, $\eta_p^2 = 0.121$), but no interaction between the two (Pillai's Trace = 0.006, F [2, 49] = 0.15, $p = 0.861$, $\eta_p^2 = 0.006$). There was also a statistically significant time main effect (Pillai's Trace = 0.736, F [2, 49] = 68.31, $p < 0.001$, $\eta_p^2 = 0.739$).

The within-subjects time main effect (i.e., overall, disregarding categorical variables of gender and mode of presentation) univariate tests indicated that both state anxiety (F [1, 50] = 115.92, $p < 0.001$, $\eta_p^2 = 0.699$) and HR (F [1, 50] = 40.76, $p < 0.001$, $\eta_p^2 = 0.499$) were statistically significantly different, but in the opposite direction, before and after presentations as illustrated in Fig. 1a, b.

The between-subjects univariate results showed that men exhibited lower overall state anxiety (F [1, 50] = 4.07, $p = 0.049$, $\eta_p^2 = 0.075$) and HR (F [1, 50] = 13.90, $p < 0.001$, $\eta_p^2 = 0.217$) than females (Fig. 2a, b). As observable in Fig. 2a, there was a trend in the time by gender interaction in state anxiety (F [1, 50] = 3.11, $p = 0.084$, $\eta_p^2 = 0.059$). However, the interaction did not reach the conservative level of statistical significance. Further, Chi-square tests revealed that there were no statistically significant differences in the proportion of women and men planning or performing real-time and prerecorded presentations.

State anxiety scores did not differ statistically significantly between real-time and prerecorded presentations (F [1, 50] = 2.09, $p = 0.155$, $\eta_p^2 = 0.040$). However, overall HR was lower in the prerecorded test condition (F [1, 50] = 5.61, $p = 0.022$, $\eta_p^2 = 0.101$). These results are illustrated in Fig. 3a, b. While Fig. 3b might suggest a presentation mode by HR interaction, this effect was a weak nonsignificant (F [1, 50] = 2.15, $p = 0.149$, $\eta_p^2 = 0.041$) trend.

After ensuring that the assumptions of homogeneity of variance and covariances were not violated, as indicated by the statistically *not significant* Levene's tests of the equality of variances and Box's test of equality of covariance

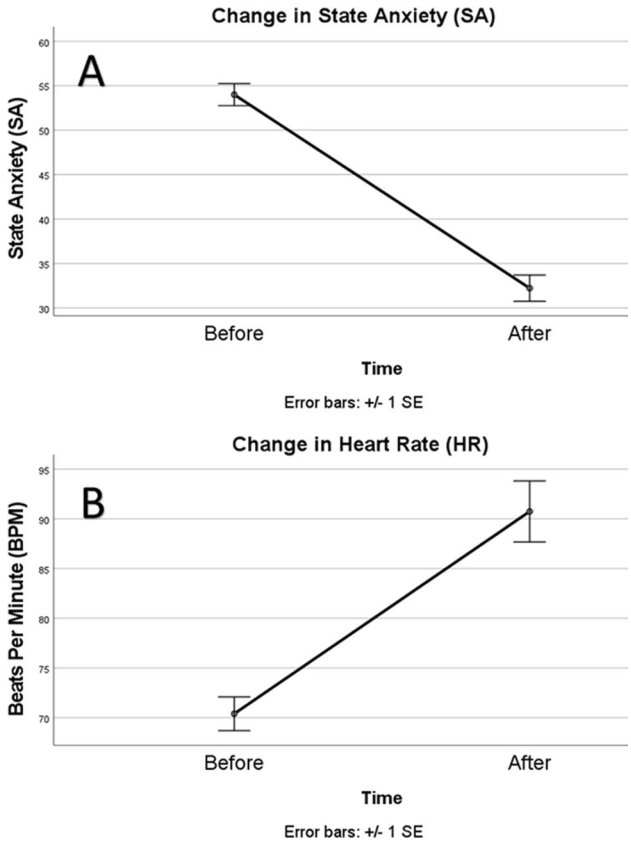

Fig. 1 Changes in state anxiety (SA) and heart rate (HR) from before to after the five minutes of presentations (SE = Standard Error)

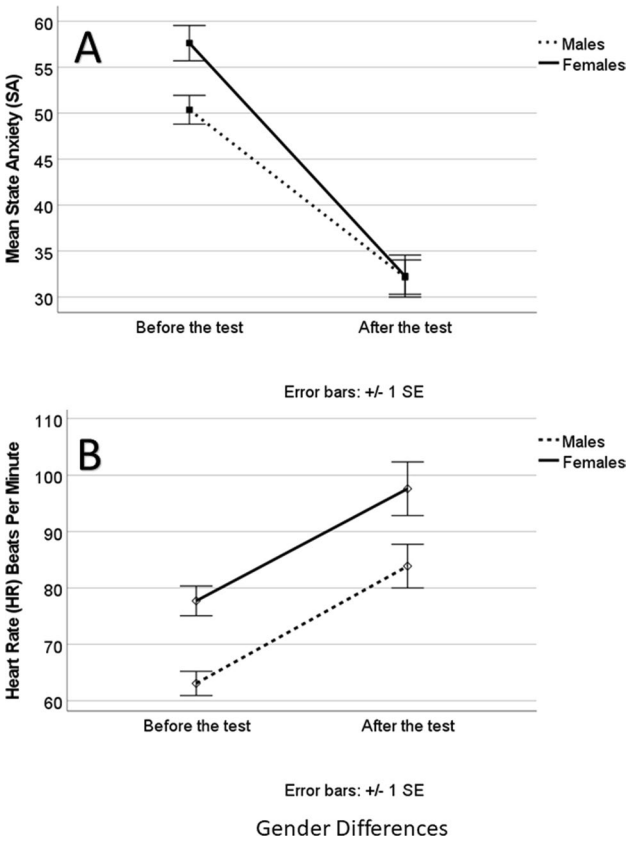

Fig. 2 Differences in state anxiety (SA) and heart rate (HR) between males and females across the test (SE = Standard Error)

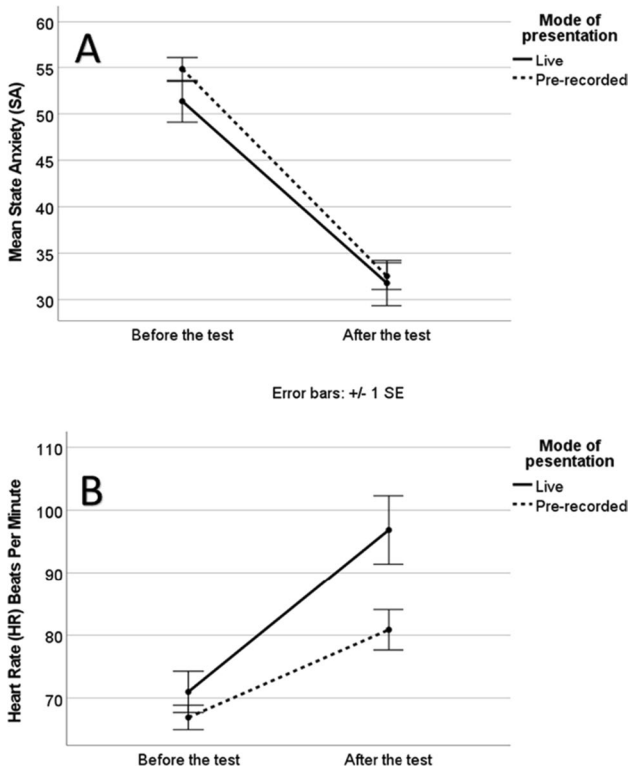

Fig. 3 State anxiety (SA) and heart rate (HR) in two test conditions (SE = Standard Error). Only the HR differed between the two modes of presentation (B)

matrices, a MANOVA was performed to examine the differences in anxiety between students who changed their mind concerning their mode of presentation and those who kept their planned mode of presentation. This test yielded a statistically significant multivariate between-groups effect (Pillai's Trace = 0.172, F [2, 51] = 5.31, $p = 0.008$, $\eta_p^2 = 0.172$). The univariate tests revealed that those who switched to prerecorded presentations exhibited higher test anxiety than those who presented as they had planned at the beginning of the semester. However, the two groups did not differ in trait anxiety. These results are summarized in Table 1.

Another MANOVA yielded no statistically significant differences in trait anxiety and test anxiety among those who planned to present in-person and those opting for prerecorded presentations at the beginning of the semester. However, female students, again, scored higher (mean = 18.11, ± SD = 4.94) than males (mean = 12.26, ± SD = 5.26) on test anxiety (F[1, 50] = 16–71, $p < 0.001$, $\eta_p^2 = 0.251$), but they did not differ in trait anxiety.

Because of the statistically significant Shapiro-Wilks tests for multivariate and bivariate normality, bootstrapped Spearman's rank-order correlations were performed. The calculations yielded statistically significant positive relationships between state anxiety before the trait anxiety and test anxiety. Although statistically significant, the HRs before and after the test were only weakly positively correlated, which prompted the individual profiling of the HR dynamics (Fig. 4) that revealed substantial individual variability. Finally, the grades obtained (performance on the test) were weakly and negatively, but statistically significantly, correlated with the state anxiety scores after the test. No other statistically significant correlations emerged. These results are summarized in Table 2.

After establishing that assumption of homogeneity of variance (Levene's test) was met, an ANCOVA, using gender as the covariate, was calculated to test the difference between the grades obtained by those doing a real-time presentation and students doing a prerecorded presentation. The results indicated that the latter group obtained higher mean grades than the former group ($M = 66.05 \pm SD = 5.58$ vs. $M = 62.57 \pm SD = 5.06$; F[1,52] = 4.02, $p = 0.05$, $\eta_p^2 = 0.072$). Gender, the covariate was statistically not significant.

Considering the state measures, a bootstrapped mediation analysis revealed a statistically significant direct positive effect of the mode of presentation on the grades obtained ($c = 3.70$, $z = 2.15$, $p = 0.03$, bootstrapped 95% confidence intervals (CI) = 0.38–7.23), and total effect ($c' = 3.48$, $z = 2.04$, $p = 0.04$, bootstrapped 95% CI 0.40–6.94). None of the indirect effects were statistically significant (Fig. 5), indicating that state anxiety and HR did not mediate the relationship between the mode of presentation and the grade obtained on the test. However, state anxiety after the test was negatively related to the grade ($b2 = -0.157$, $z = -1.20$, $p = 0.05$, bootstrapped 95% CI −0.37 to −0.04), and HR before the test was

Table 1 Comparison in trait- and test anxiety between students who made the test presentation as planned at the beginning of the semester and those who changed their minds and completed the test via a prerecorded presentation

	Presented as planned ($n = 31$)		Changed the mode of presentation ($n = 23$)				
Measure	Mean	SD	Mean	SD	F	p	Effect size (η_p^2)
Trait anxiety	36.52	5.55	35.57	7.04	0.31	.581	0.006
Test anxiety	12.42	5.17	16.87	5.79	8.83	.004	0.145

SD = Standard Deviation; *η_p^2 = partial Eta squared

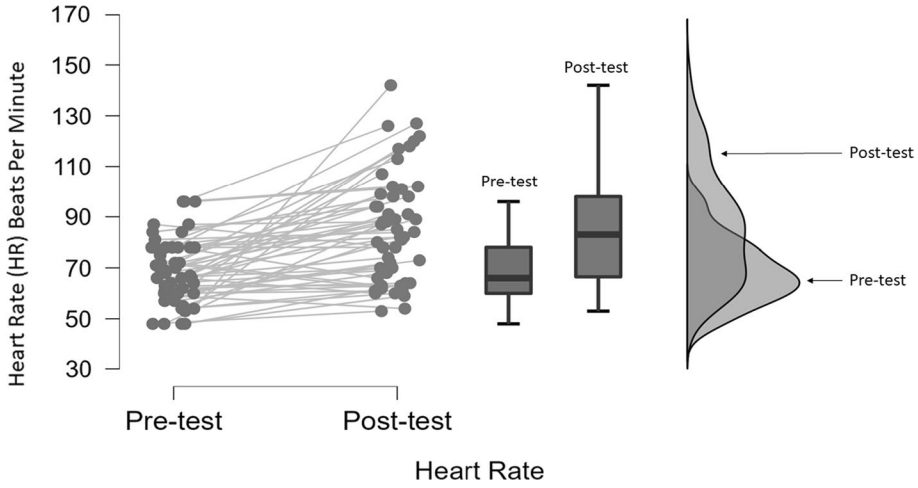

Fig. 4 Heart rate profiles of 54 students before (Pre-test) and after (Post-test) a midterm test

Table 2 Correlations between state and trait measures and performance (Grade)

Variable		Traitanx	Testanx	SA1	SA2	HR1	HR2	Grade
1. Traitanx	Spearman's rho	–						
	p value	–						
	Upper 95% CI	–						
	Lower 95% CI	–						
2. Testanx	Spearman's rho	0.260	–					
	p value	0.058	–					
	Upper 95% CI	0.497	–					
	Lower 95% CI	−0.011	–					
3. SA1	Spearman's rho	**0.392****	**0.369****	–				
	p value	0.003	0.006	–				
	Upper 95% CI	0.627	0.577	–				
	Lower 95% CI	0.114	0.126	–				
4. SA2	Spearman's rho	0.102	−0.121	−0.076	–			
	p value	0.461	0.385	0.586	–			
	Upper 95% CI	0.357	0.159	0.192	–			
	Lower 95% CI	−0.187	−0.387	−0.363	–			
5. HR1	Spearman's rho	0.160	−0.020	0.199	0.130	–		
	p value	0.249	0.888	0.150	0.350	–		
	Upper 95% CI	0.442	0.226	0.490	0.442	–		
	Lower 95% CI	−0.132	−0.281	−0.108	−0.171	–		
6. HR2	Spearman's rho	0.267	0.099	0.186	−0.151	**0.405****	–	
	p value	0.051	0.476	0.177	0.275	0.002	–	
	Upper 95% CI	0.489	0.360	0.473	0.134	0.650	–	
	Lower 95% CI	0.003	−0.156	−0.104	−0.413	0.127	–	
7. Grade	Spearman's rho	0.125	0.047	0.193	**−0.324***	0.243	0.017	–
	p value	0.368	0.736	0.162	0.017	0.077	0.903	–
	Upper 95% CI	0.384	0.338	0.454	−0.080	0.489	0.318	–
	Lower 95% CI	−0.166	−0.244	−0.098	−0.541	−0.019	−0.269	–

CI = Confidence intervals calculated based on 1000 bootstrap replicates

*$p < .05$; **$p < .01$; ***$p < .001$ (statistically significant correlations are bold); traitanx = trait anxiety; testanx = test anxiety; SA1 = state anxiety before the test; SA2 = state anxiety after the test; HR1 = heart rate before the test; HR2 = heart rate after the test

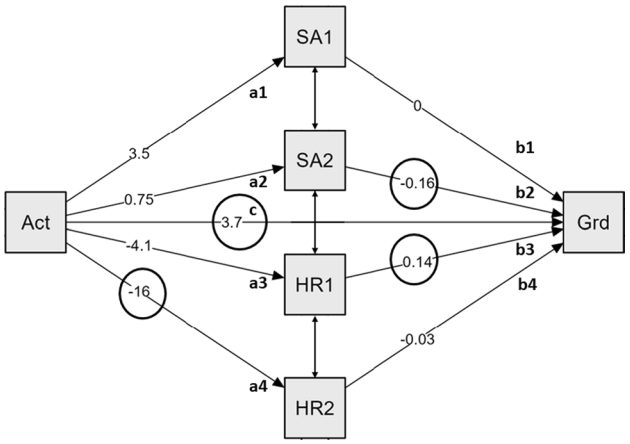

Fig. 5 Results of the mediatory effects of state measures: Act = Mode of presentation; SA1 = state anxiety before the test; SA2 = state anxiety after the test; HR1 = heart rate before the test; HR2 = heart rate after the test; Grd = Grade (The statistically significant path coefficients are encircled.)

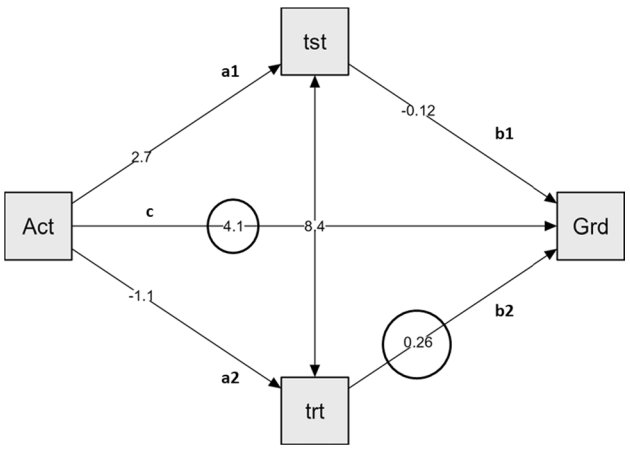

Fig. 6 Results of the mediatory effects of trait measures: Act = Mode of presentation; tst = test anxiety; trt = trait anxiety; Grd = Grade (The statistically significant path coefficients are encircled.)

positively related to grades ($b3 = 0.138$, $z = 2.26$, $p = 0.02$, bootstrapped 95% CI 0.006–0.245). Finally, the presentation mode was inversely related to the heart rate after the test ($a4 = -15.98$, $z = -2.58$, $p = 0.01$, bootstrapped 95% CI −31.89 to −2.98), indicating prerecorded presentations were related to lower HR after the test.

Considering the trait measures (Fig. 6), test anxiety was unrelated to the grades, but trait anxiety was positively associated with the obtained grades ($b2 = 0.261$, $z = 2.14$, $p = 0.03$, 95% CI 0.022–0.496), but none of the two trait measures mediated the relationship between the mode of presentation and the grades.

Discussion

The current study examined state anxiety and HR before and after either real-time or prerecorded oral examinations to establish whether the latter is associated with lower stress and better academic performance and whether test anxiety and trait anxiety mediate the findings. The study also examined possible gender differences, the relationships between trait and state measures, and the connection between planned and actual presentation formats and dependent measures. Finally, the study examined whether the connection between the mode of presentation and grades (performance) is mediated by state and trait measures.

Is live presentation associated with greater state anxiety and HR than prerecorded presentation?

The first hypothesis was that students choosing in-person oral presentations would demonstrate greater state anxiety and HR than those choosing the prerecorded presentation after but not before the midterm test. The results partially supported this hypothesis. While there were no differences between the two groups in state anxiety, HR was lower in the prerecording group. (Fig. 3a, b). In this study, no baseline measures were obtained, which limits the work. Still, based on robust results from past works and a decrease in state anxiety after the test, it can be assumed that both groups' pre-test state anxiety and HR values mirrored anticipation stress (Merz and Wolf 2015). Some scholars posited that anticipatory stress could be to most apparent aspect of state anxiety before academic examinations (Ping et al. 2008).

Given that both groups anticipated evaluating their academic performance, the response similarity in the stress-anticipatory period was expected. The fact that the pre-test period was indeed affected by stress anticipation is illustrated by the overall time main effect (shown in Fig. 1a, b), revealing a decrease in state anxiety and an increase in HR. These dynamics reflect the *switch* from anticipation to the coping phase. As the worry or uncertainty diminishes, state anxiety decreases, while coping is associated with increased HR (Daly et al. 2011). However, as suggested by the nonsignificant interaction trend between HR and the mode of presentation (Fig. 3b), also supported by the mediation analysis, post-test active coping was related to higher HR than passive coping by those who only watched their presentation. This effect can be attributed to augmented cognitive work over the test period (Kennedy and Scholey 2000). Nevertheless, mere vocalization (absent in the prerecorded group) could also

elevate the HR (Seraganian et al. 1997) and contribute to the group differences. The observed trend in greater HR after presenting in real-time could most likely be attributed to both factors.

In accordance with past work, gender differences also emerged. In this study, female students exhibited overall higher state anxiety, HR, and test anxiety than male students. These findings agree with other works that women generally exhibit greater test anxiety than men (e.g., Chapell et al. 2005; Núñez-Peña et al. 2016; Pagaria 2020) HR (e.g., Biryukova et al. 2019; Hammoud et al. 2018) and state anxiety (e.g., Endler et al. 1994; Saltürk and Güngör 2021). The possible interpretations are that women are more anxious about their examination performance, as also indicated by their higher overall HR values (Fig. 2b), perceive such situations as more stressful than men, and/or are more aware of their perceived emotions (Ádám 1998; Harris et al. 2019). Despite these differences, there were no statistically significant differences in the proportion of men and women planning live or recorded presentations, changing their minds about this plan, and the actual examination forms. Hence, it appears that women's choice of test format might be unaffected despite higher test anxiety.

Relationship between test anxiety, state anxiety, and HR

The second hypothesis was that trait anxiety and test anxiety would be related to state anxiety and HR both before and after the test. This hypothesis received little support because these measures were only weakly correlated with state anxiety *before the test* and showed no significant association with HR either before or after the test, or state anxiety after the test. In fact, test anxiety bore no stronger relationship to state anxiety before the test than trait anxiety, both being below 0.40 (Table 2), which is in accord with (Meijer 2001) showing that the relationship between trait anxiety and state anxiety is weak in unstable (varied) stressful situations. Indeed, this finding is likely due to the high variability in the perception of the exam stress being determined by numerous factors (Tsegay et al. 2019) including, the importance of the test, preparedness, or emotional state (Akinsola and Nwajei 2013; Chin et al. 2017; von der Embse et al. 2018). This explanation may also be supported by high interindividual variability in HR (see Fig. 4) that in lack of a significant correlation with state anxiety cannot be attributed to anxiety only but rather a combination of anxiety and outcome (expectancy) anticipation in those coping passively (prerecorded) and speech characteristics and cognitive performance in those coping actively (real-time) (Kennedy and Scholey 2000; Seraganian et al. 1997). However, an alternative explanation is that there is a dissociation between perceived anxiety (psychological measures) and HR response to the anxiety-provoking situation (physiological measure). The existence of such dissociation has been purported by Ádám (1978, 1998) and others (i.e., Campbell and Ehlert 2012).

Is test anxiety higher in those who change their mind about the available evaluation format?

A third hypothesis was that test anxiety would be greater in those who changed their mind concerning the presentation mode. Results supported this hypothesis because the students who changed their planned presentation mode from real-time to prerecorded exhibited significantly higher test anxiety, but not trait anxiety, than those who presented as originally planned. While this hypothesis has not been examined in the literature, it can be conjectured that higher test anxiety prompted students to seek more control over their oral presentation mode, leading them to change their minds.

Is the form of evaluation related to performance?

The fourth hypothesis was that prerecorded presentations would result in higher grades due to the required time spent on their preparation, the obligatory occupation with the material, and repeated self-evaluation before finalizing it. This hypothesis was supported by the results showing that those doing a prerecorded presentation obtained about 3.5% higher grades than those doing the real-time oral presentation. Noteworthy is that the effect size of the difference was between medium to large.

While the two forms of the evaluation required different coping (active vs. passive), the difference in grades could probably be attributable to the chance to improve performance (and self-evaluate it) by the students doing a prerecorded presentation rather than lower stress. Indeed, there were no differences in state anxiety before and after the presentation between the active and passive coping groups, but HR was higher in the active coping group, as expected based on presumedly higher physiological arousal due to the live test situation (Daly et al. 2011).

Do state and trait measures mediate the relationship between the form of tests and grades?

Finally, the fifth hypothesis stated that state anxiety and HR could mediate the relationship between the presentation mode and performance. While the latter two were related, as also supported by the ANCOVA results, state anxiety and HR did not mediate their relationship. However, HR before the test was positively connected to the grades, indicating higher performance in those exhibiting greater physiological arousal before the test. This is not a totally novel finding,

since half a decade ago already, it was shown that HR increases in those who await a rewarding task (Rakover and Levita 1973). Future studies should look at self-confidence and expectations associated with test outcomes to unveil the mechanism behind the here-found connection.

The presentation mode was inversely related to HR after the test, indicating that those choosing a prerecorded live presentation had a lower HR (see Fig. 5). This result was also emerging in the MRM-ANOVA results, which only yielded a nonsignificant group by HR interaction trend with a small to medium effect size (see Fig. 3b). Again, these findings can be attributed to active coping involving cognitive work and speech in the live presenting group (Kennedy and Scholey 2000; Seraganian et al. 1997).

State anxiety after, but not before, the test was negatively related to grades (see Fig. 5), possibly due to the performance's negative appraisal, whether live or prerecorded. This finding is not new, as several reports have documented the negative relationship between state anxiety and academic test performance (e.g., Gómez-Íñiguez et al. 2021; Seipp 1991). The here-found connection could be due to higher state anxiety, possibly due to negative performance appraisal toward the end of the test, by either group, which was later indeed mirrored in lower grades. However, this conjecture requires further experimental scrutiny.

While the trait measures did not mediate the relationship between the mode of presentation and grades, trait anxiety, but not test anxiety, moderated the grades. The association was positive (see Fig. 6), suggesting that higher trait anxious students may have worked harder to compensate for their trait anxiety. Nevertheless, higher trait anxious students may not have necessarily opted for doing prerecorded presentations because there was no difference in trait anxiety between those presenting live and those watching their prerecorded presentations. A while ago, King et al. (1976) disclosed a direct effect of trait anxiety on academic performance. However, this effect appears to be mediated by low perceived self-efficacy fueling harder work (Morales-Rodríguez and Pérez-Mármol 2019). Future research in this area should also assess perceived self-efficacy to understand the link between trait anxiety and academic performance.

Limitations

Despite its strengths in supporting the recently unveiled lack of a long-presumed connection between test anxiety and test performance (Theobald et al. 2022), a rarely reported positive connection between anticipatory HR and performance (Rakover and Levita 1973), and the slightly better performance in prerecorded oral presentations compared to live presentations, the study has several limitations too. First, no pre-test baseline measures were obtained. Second, situational factors could have affected test anxiety (trait) scores obtained before the test (Szabo and Ábel 2021). Third, participants and the subject area in which the research was conducted may not represent general academic environments. Fourth, despite having strict pre-established criteria, bias in grading cannot be ruled out. Fifth, since the data collection involved two class sessions, those taking the test in the second session might have had 'habituation' advantages over those taking the test in the first session despite the balancing of the mode of presentations. Finally, the sample size is relatively small to draw definite conclusion and, therefore, this study should be replicated with larger samples studying in different academic disciplines.

Implications for future biology

Despite its limitations, this study has several contributions to the extant knowledge:

1) The anticipation stress associated with an oral examination cannot be reduced by changing the mode of examination from active (live) to passive (prerecorded), which finding may render previous suggestions (Sparfeldt et al. 2013; Tercan and Dikilitaş 2015) concerning possible desensitization or greater control questionable.
2) Based on the crude HR index, the level of arousal is less during prerecorded than live presentations, but pre and post-test state anxiety do not differ. This discrepancy might be due to the dissociation between physiological and mental processes in stress situations (Ádám 1978; Campbell and Ehlert 2012)
3) Prerecorded oral presentations could be associated with higher grades, which might be linked to a chance of performance monitoring before handing it in for evaluation.
4) In accordance with Theobald et al. (2022), test anxiety is unlikely to be related to test performance as the correlation between the two is virtually nil. However, trait anxiety appears to be a moderator of academic performance.
5) Women exhibit greater test anxiety, state anxiety, and HR, regardless of the format of the academic oral test than men, but they are not more likely to choose a passive form of evaluation than men.
6) Anticipation HR is positively related to grades, possibly mirroring the expectancy of a rewarding contest or evaluation, but a clearer mechanism needs to be identified through future empirical work.
7) State anxiety after the test is negatively related to the test performance, regardless of the mode of presentation, which could be due to negative self-evaluation of the

performance. Still, again the precise mechanism begs for further empirical work.

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Declarations

Conflict of interest The authors have no conflict of interest to declare.

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