University students' negative emotions in a computer-based examination: The roles of trait test-emotion, prior test-taking methods, and gender

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University students' negative emotions in a computer-based examination: The roles of trait test-emotion, prior test-taking methods, and gender

Although the effectiveness and experiences of computer-based examinations is a widely investigated area of research, the question of whether and how computer-based assessment limits or heightens the experience of negative test emotions remains largely unexamined. Drawing from the Control-Value Theory of achievement emotions, we investigated undergraduate students' emotions during an authentic, course-based assessment in a computer-based testing environment, as well as predictors and outcomes associated with their emotions. We found that students (N = 74) in a computer-based testing environment reported lower levels of negative emotions than their typical negative test emotions. Females and males performed equally in the examination, yet females reported higher retrospective negative emotions. Consistently, females reported higher levels of typical test-taking anxiety in prior examinations, but they reported lower anxiety in a computer-based environment. Finally, although typical and retrospective emotions were correlated, only retrospective emotions were associated with examination performance. We discuss the importance of testing environments and time-frames in understanding how to support students' emotions in testing with particular emphasis on implications for online assessment.

Keywords: Computer-based assessment; emotion; test environment; gender

Introduction

In an evolving educational landscape where computer-based assessment is becoming more widely used, much research has focused on students' experiences of computer-based testing and associated educational outcomes (Beller, 2013; Nguyen et al., 2017). However, relatively little

research has focused on students' emotional experience in a computer-based testing environment. While test anxiety is one of the most widely investigated areas of academic achievement emotion research (Pekrun, Goetz, Perry, Kramer, Hochstadt, & Molfenter, 2004; Cheung, 2006; Schutz, Benson, & Decuir-Gunby, 2008; Pekrun & Perry, 2014), the role of the testing environment itself in limiting or heightening the experience of negative test-taking emotions (e.g., shame, hopelessness) has yet to be evaluated. Indeed, this gap in the literature has persisted despite research and theory implicating environments as a critical factor in influencing how students feel (Pekrun & Perry, 2014; Harley, Pekrun, Taxer, & Gross, 2019). This question is particularly relevant as new test-taking environments gain traction in an increasingly digital 21st century (Daniels & Gierl, 2017).

The present study aims to address this gap by examining undergraduate students' self-reported negative emotions during an authentic, course-based assessment that took place in a computer-based testing environment. Furthermore, students reported the negative emotions they typically experienced during test-taking and whether negative emotions tended to be associated with computer-based or pen-and-paper testing environments. To our knowledge, this study represents the first empirical comparison of students' emotional experiences beyond test anxiety in these two testing environments. We also compare the similarity and differences between trait emotions (e.g., emotional tendencies when taking examinations) and activity emotions (e.g., emotional experiences when taking a particular computer-based examination), as well as their roles in examination performance. This comparison in time-frame of self-reported emotions is rare in the literature, despite the prominence of trait-test taking anxiety (a trait emotion) and popular self-report instruments, such as the *Academic Achievement Emotion Questionnaire* (Pekrun, Goetz, Frenzel, Barchfeld, & Perry, 2011) being designed to measure a broader array of

such emotions. Finally, this study also aims to advance the understanding of gender in generating emotions, including the use of an inclusive approach that differentiates gender identity from sex. This approach offers participants more than binary gender options (i.e., male vs. female; American Psychological Association, 2009) relative to the majority of research that has examined gender and emotions in achievement settings to-date (Frenzel, Pekrun, & Goetz, 2007; Goetz, Lüdtke, Nett, Keller, & Lipnevich, 2013).

Prior Research

Achievement emotions

The control-value theory provides a rich understanding of students' emotional responses in different achievement contexts (e.g., self-studying, test-taking, and attending lectures; Goetz et al., 2013; Pekrun & Perry, 2014). The theory proposes that students' emotional experiences in achievement settings are determined by their appraisals of control (i.e., perceived controllability) and value (i.e., perceived importance) of their achievement activities (Pekrun et al., 2011). Furthermore, achievement emotions can be categorized based on valence, activation, focus, and time-frame (for a more detailed discussion of the taxonomy, see Pekrun & Perry, 2014). Valence refers to the pleasantness of emotions (e.g., enjoyment [positive] vs. anxiety [negative]), whereas activation refers to high and low levels of physiological arousal (e.g., shame [high] versus hopelessness [low]). The focus of achievement emotions can break down to activities and achievement outcomes. For example, emotions experienced during a group discussion and when studying in the library are activity emotions, whereas emotions associated with receiving a test score are achievement outcome emotions. This "object" focus is further sub-categorized based on time-frames in relation to the activity or outcome. Retrospective emotions focus on the past (e.g., when thinking about a previous examination), concurrent emotions are rooted in present

experiences (e.g., during an examination), and prospective emotions focus on the future (e.g., the anticipation of an upcoming examination). For example, anxiety and hope are outcome-oriented, prospective emotions regarding one's anticipation of failure and success in future events. In contrast, shame and pride are outcome-oriented, retrospective emotions concerning failure and success of past outcomes (Zeidner, 2007).

Emotions play a critical role in students' motivation, learning, and achievement in different learning environments (Pekrun et al., 2011; Hall, Sampasivam, Muis, & Ranellucci, 2016; Lim, Dawson, Gašević, Joksimović, Pardo, Fudge, & Gentili, 2020). Research has shown that positive activating emotions such as hope, pride, and enjoyment foster self-regulation and predict achievement in most situations (Harley et al., 2019). In contrast, negative deactivating emotions such as boredom, hopelessness, and sadness suppress self-regulation and negatively impact academic achievement (Goetz & Hall, 2013). However, positive deactivating emotions (e.g., relief) and negative activating emotions (e.g., anxiety and shame) produce mixed findings depending on the situation or the type of activity. However, research has shown that the maladaptive effects of negative activating emotions tend to outweigh its positive effects, leading to generally negative consequences on academic outcomes (Pekrun et al., 2011; Goetz et al., 2013; Hall et al., 2016). Moreover, negative emotions in general play a stronger role than positive emotions in predicting students' academic performance generally, and in the assessment context more specifically (Daniels, Stupnisky, Pekrun, Haynes, Perry, & Newall, 2008; Pekrun, Lichtenfeld, Marsh, Murayama, & Goetz, 2017). Therefore, in this study, we focused on students' negative emotional experiences in examination situations.

Emotions in testing situations

Tests and examinations often represent the most significant evaluative factors of students' grades across subjects and are critical determinants of their goals, self-worth, as well as academic and professional success (Zohar, 1998; Pekrun et al., 2004; Lim et al., 2020; Myyry et al., 2020). It is therefore no surprise that negative emotions, such as anxiety and frustration, are often the focus of research examining emotions in examination-taking contexts. Not only are such emotions prominent in this context, but they are also associated with lower examination grades (Pekrun et al., 2004; Schutz et al., 2008; Myyry et al., 2020). These emotions can be problematic because they can undermine interest and intrinsic motivation (Pekrun & Perry, 2014). These emotions also consume cognitive resources, such as attention, needed for the achievement task (Meinhardt & Pekrun, 2003)—especially when they are experienced at higher levels of intensity (Harley et al., 2019).

Although testing is normally categorized as an individual high-evaluative situation, it is important to consider whether the testing involves a single student (e.g., online testing at home) or occurs in a social, group testing situation. Students' emotions vary across these situations because these settings vary in meaningful ways. Specifically, the high- versus low-evaluative nature of a situation, as well as individual versus social contexts within a situation, are key factors that influence learners' emotional responses (Harley et al., 2019). Also, testing situations can vary depending on the level of evaluation involved as well as on the stake and formality of the test. However, previous research on test emotions pays little attention to the impact of the testing situations and tends to generalize the way in which individuals respond (Harley et al., 2019).

Emotions in computer-based assessment

In an evolving educational landscape where computer-based testing is becoming more widely used (Beller, 2013; Daniels & Gierl, 2017), research is needed to understand how non-traditional environments affect students' emotions and educational outcomes. Although some studies suggest that students experience higher anxiety in computer-based examinations than in paper-based examinations (Schult & McIntosh, 2004; Stowell & Bennett, 2010), more recent research has shown that students reported little negative emotion after a computer-based examination (Daniels & Gierl, 2017). Similarly, negative emotions play a stronger role than positive emotions in predicting performance in this situation (Daniels & Gierl, 2017). Although computer-based testing environments can take different forms (e.g., at home or in computer laboratory), they generally involve taking examinations with fewer students, often hiding students from the view of others. These contextual details in achievement situations can elicit different types of emotions, which are often overlooked in previous research (see Harley et al., 2019).

In this study, we aim to understand students' emotions during a computer-based examination taken in separate workspaces in a small and sparsely populated room. If, as social construction theories of emotion posit, emotions are elicited from individuals monitoring and reacting to the emotional expressions of others (Gross & Barrett, 2011), then negative emotions can spread from one student to another (i.e., emotional contagion) simply from students observing anxious or irritable behavior from others (e.g., through facial expressions; Ekman, 1992). Emotional contagion refers to the process through which a person is exposed to others' emotions and resembles others' emotions due to the exposure (Parkinson, 2011). Although emotional contagion is widely studied in cognitive and social psychology (e.g., Parkinson, 2011; Kramer et al., 2014; Goldenberg & Gross, 2020), little research has focused on educational

contexts (see Harley et al., 2019). In a classroom setting, for example, seeing others' frustration during an examination may help students to interpret the situation, to understand that they may share the emotion with others, and to regulate their own emotions (Gross & Barrett, 2011). This phenomenon can also be understood from a cognitive appraisal perspective using the control-value theory of achievement emotions (Pekrun & Perry, 2014) where social expressions of emotion provide achievement-related feedback with the potential to influence learners' appraisals of control (e.g., their perceived ability to succeed in the examination). In other words, social manifestations of emotions such as anxiety stand to change the way learners think and feel about their own chances of success. According to the integrated model of emotion regulation in achievement situations (Harley et al., 2019), in a testing situation with separated workspaces and limited attention to social connections, students may mostly rely on their intrapersonal strategies (e.g., cognitive change rather than situation modification/ situation selection) to regulate their emotion.

The *object focus* and *time-frame* may also impact students' emotions in computer-based testing. Considering that students may have prior experience in computer-based testing and paper-and-pen testing, we also aim to understand whether students who typically take paper-and-pen examinations would have different emotional experiences than those who typically take computer-based examinations. Students' experiences in prior testing situations may impose different influences on students' emotional experiences and regulations. Students who typically engage in testing in *social situations* may be used to attending to others' emotional expressions which can generate emotions (e.g., "he looks worried, should I be too?"). Similarly, social testing situations can also present unique opportunities to regulate emotions (e.g. "I'm freaking out over question one! Are other people? Doesn't look like it. Maybe the examination gets better").

Removing social cues in a computer-based examination may affect the emotions that students experience. Thus, another goal of this research is to explore whether students accustomed to traditional classroom settings would have different negative emotional levels than students who are used to computerized examination environments.

Gender and test emotions

Students' individual characteristics impact their appraisals of control and value in their computer-based testing situations which give rise to different emotions in achievement contexts (Pekrun et al., 2011). Specifically, gender is shown to be an important individual factor that predicts emotional experiences in achievement contexts (Hannon, 2012). For example, women tend to report more negative emotions, such as anxiety and shame, because they perceive themselves as having lower control in their learning and testing (Frenzel et al., 2007). Research has suggested that gender is an antecedent of achievement emotions partially because of the influence of gender stereotypes on appraisals (Frenzel et al., 2007; Goetz et al., 2013).

This study examines whether the relation between gender and emotions may be heightened or dampened depending on the test environments. A recent review suggests that little is known about whether gender differences manifest or mitigate different types of emotions in different testing situations (Harley et al., 2019). Therefore, exploring the interaction between gender and testing environments may contribute to the literature. One possibility is that female students may experience less anxiety in a more individual situation (e.g., computer-based) compared to in a classroom testing-situation. Research has indicated that women/girls generally experience more anxiety than men/boys in testing situations (Frenzel et al., 2007; Goetz et al., 2013). This may be due to women/girls being more self-conscious in social contexts (Sowa & LaFleur, 1986) and more susceptible to emotional contagion relative to men/boys (Doherty et al.,

1995). Therefore, if the social manifestations of emotions are constrained in the testing environment, then women may experience less anxiety.

Research Questions and Hypotheses

The main objective of this study was to provide a preliminary investigation of whether a computer-based testing environment, specifically the University of Alberta's Learning and Assessment Centre (LAC), was associated with less negative emotional experiences for students to take examinations than their typical examination settings (e.g., classrooms). We used the *Test Emotions Questionnaire* (TEQ; Pekrun et al., 2004) to measure test emotions because it includes multi-component emotions based on the conceptualizations of the Control-Value Theory and assesses students' emotions across different time-frames and different academic activities. In this study, we adapted the TEQ to focus on trait, concurrent emotions (e.g., typical anxiety tendncy during a test) and state, retrospective emotions (e.g., measuring shame right after the computer-based examination). In light of research suggesting gender as an antecedent of achievement emotions (Frenzel et al., 2007; Goetz et al., 2013), this study examined its effect on emotions and potential interaction with the test-taking environment to do so. In summary, our study was guided by the following research questions and hypotheses:

(RQ1) Is examination environment associated with undergraduate students' examination-taking emotions?" We hypothesized that students would report lower levels of negative emotions when taking a computer-based examination at LAC than they typically report feeling on account of the computer laboratory setting where other students' emotional states were hard to see, limiting negative emotional contagion.

(RQ2) Was undergraduate students' gender associated with their test-taking emotions? We hypothesized that females would report higher levels of negative emotions than males based on previous research (Frenzel et al., 2007; Goetz et al., 2013).

(RQ3) Is there an interaction effect between examination environment and gender on test-taking emotions? We hypothesized that an interaction effect would be observed, extending our hypotheses from RQ1 and RQ2.

(RQ4) Do students' test-taking emotions cluster students in a meaningful way and are they associated with their examination performance? We hypothesized that higher levels of negative emotions would be associated with lower levels of achievement on the examination in line with prior research on achievement emotions (Pekrun et al., 2004).

Method

Participants

The research was approved by the University of Alberta's ethical committee. We recruited 74 undergraduate students (49 females, 25 males), aged 19 – 50 years old (M = 25.05; SD = 5.82) from the Faculty of Education in a North American public university to participate in this study. Prior research on emotions and learning in a similar setting (i.e., university students) suggested n = 56 can detect pre-test–post-test differences (Chang et al., 2020). Furthermore, a sensitivity power analysis using G*Power (Faul et al., 2009) suggests that n = 74 is sufficient to detect a small to medium effect size (Cohen's d = .33) in paired-sample comparison (with α set as .05 and power as .80).

At the start of the course, students were informed that they would have the opportunity to participate in a brief study that involved filling out a survey before and after an examination. A consent form that provided information about the study and a link to the first survey was posted

on the course's webpage. A link to this information was also shared by the LAC center when students registered for their examination. None of the authors were instructors for the course and all advertisements for the study noted that it was entirely optional. Participants were compensated with a $10 gift certificate.

Examination ***environment***

The LAC is a computer laboratory at the Faculty of Education and it is where students took their examination as part of their course. See Figure 1 for a picture of the LAC that illustrates the separated workspaces students take examinations at.

[Insert Figure1]

Procedure

After completing an online consent form, participants were invited to fill out an online survey (Survey 1), which could be taken by students up to twenty-four hours before they took their examination in the LAC. Students reported their age and gender (i.e., students self-identified in an open-ended question) as part of the first survey, in addition to the TEQ. Students then completed an examination for their course. They spent an average of 41.54 minutes (*SD* = 18.56) completing the multiple-choice examination. Students completed a post-examination survey (Survey 2) in the LAC immediately following the completion of their examination.

Measures and materials

Typical and Retrospective Emotions

This study involved two online surveys. Survey 1 invited students to complete the test emotion questionnaire (TEQ; Pekrun et al., 2004) prior to taking their examination in the LAC to assess the emotions they *typical*ly experienced while taking examinations (i.e., trait test-taking emotions). Survey 2 involved students completing the TEQ again immediately after finishing

their examination in the LAC and reporting how they felt while taking the examination (i.e., retrospective test-taking emotions). The TEQ involves a five-point Likert scale where 1 corresponds to "strongly disagree" and 5 corresponds to "strongly agree" to measure eight emotions related to examination taking and normally consists of 77 items (Pekrun et al., 2002). We only measured TEQ items related to emotions experienced *during* examination-taking because we are interested in comparing the emotions students experienced during examination taking in different environments (typical vs. retrospective). We further narrowed the TEQ down to 20 items to reduce item fatigue because students had just finished an examination before taking Survey 2. We focused on negative examination-taking emotions: anger (two items), anxiety (seven items), hopelessness (six items), and shame (five items). Cronbach's Alpha indicated that the internal consistency of the scale was good or better for all typical ($\alpha = .86$) and retrospective ($\alpha = .81$) anxiety, typical ($\alpha = .91$) and retrospective ($\alpha = .84$) hopelessness, and typical ($\alpha = .90$) and retrospective ($\alpha = .79$) shame. Typical ($\alpha = .63$) and retrospective ($\alpha = .45$) anger were not, however, within an acceptable range and anger was therefore discarded from analyses.

Typical test-taking method

After students reported their typical test-taking emotions, they were also asked to describe the physical environments that they were thinking of when they filled out the previous questionnaire about emotions experienced while taking tests/examinations (Survey 1). Students were asked to feel free to describe any characteristics that came to mind, including whether they took the test/examination using paper and pencil/pen. Two graduate research assistants individually reviewed the open-ended responses and coded whether students typically took the

test/examination was (a) computer-based or (b) by hand. Accordingly, the typical test-taking method was treated as a two-level variable.

Achievement

Students completed a multiple-choice-based examination for their course. Students were provided with a consent form for grade release for this research. Their grades on the examination were then collected.

Data analyses

To answer questions 1 to 3, we used the mean scores to run descriptive and correlational analyses, as well as mixed ANOVAs to examine the differences based on gender, time-frame (typical vs. retrospective), method (computer vs. paper-and-pen), and gender on test-taking emotions. To answer research question 4, in addition to correlations, we performed *k*-means cluster analyses on the pre- and post-exam self-reported emotions of anxiety, hopeless and shame to identify groups of students with similar emotion profiles. For the cluster analysis, each emotion was standardized (i.e., the Likert scale values were converted to z-scores) and analyzed using the *k*-means.

The *k*-means clustering algorithm is a commonly used unsupervised learning algorithm used to classify a data set into a certain number of clusters determined a priori (Meyers et al., 2013). The algorithm first selects a centroid for each cluster by identifying the most dissimilar cases and then subsequently assigns the next most similar case to the cluster. Similarity is determined relative to the cases in the data set and is calculated using Euclidean distance. The *k*-means procedure is iterative and proceeds until all cases have been assigned, when the final cluster centers and distances are determined. We examined how self-reported pre- and post-exam emotions clustered for exam scores. A total of 272 data points were entered into each cluster

model (i.e. three emotion z scores for each participant). Although there are no sample size requirements, one recommendation is 2^m, where m is the number of clustering variables (Mooi & Sarstedt, 2011). Based on these tentative guidelines, the sample size of the current study is acceptable.

There are different approaches to selecting the number of clusters. In this study, the number of clusters was based on previous empirical work and theory. This approach is consistent with guidelines for conducting k-means analysis (Meyers et al., 2013) and prior research (Daniels et al., 2008). In a study with similar measurement of self-reported emotions where both valence and arousal were measured, Jarrell et al. (2017) identified three clusters: a cluster for positive affect, negative affect, and low intensity, respectively. In the current study, because we only include negative affect in our measure, we have a priori expectation for a two-cluster solution based on varying arousal levels (high versus low).

Results

Preliminary and Descriptive Analyses of Typical and Retrospective Emotions and Examination Score

Levels of typical negative emotions

Our findings revealed relatively low levels of typical anxiety, hopelessness, and shame during examinations (see Table 1). According to paired-sample *t*-tests (see Table 2), anxiety was the most strongly endorsed emotion, followed by shame. Both emotions were found to be significantly higher than hopelessness.

[Insert Table1 & Table2]

Typical emotions and correlations with examination scores

Negative emotions were significantly and positively correlated with one another, as expected. None of the typical test-taking emotions were significantly correlated with students' examination scores (see Table 3).

Levels of retrospective examination-taking emotions in a computer-based examination

Our findings revealed relatively low levels of self-reported retrospective anxiety, hopelessness, and shame during the computerized testing examination (see Table 2). According to paired-sample *t*-tests, anxiety was the most strongly endorsed emotion and was significantly higher than hopelessness and shame.

Retrospective emotions and correlations with examination score and typical emotions

Negative emotions were significantly and positively correlated with one another, as expected. Retrospective hopelessness and shame were significantly and negatively correlated with examination score, as expected. Anxiety was negatively correlated with examination score, but not statistically significantly so (see Table 3).

[Insert Table3]

The Roles of Typical Test-taking Method and Gender in Typical and Retrospective Emotions

The Roles of typical test-taking method and gender on typical test-taking emotions

Of the 75 students who participated in the study, we were able to classify 64 of their typical examination-taking methods as either computer-based or by hand. Of these students, the majority (38; 59%) indicated that they used a computer-based examination as their reference point when recalling a typical examination-taking situation. We excluded one of the 64 students who identified as having a "non-binary" or "other" gender. As a result, we retained 63 samples for this analysis, with a two-level variable for gender (male vs. female) and a two-level variable for test-taking method (computer vs. by hand).

Entering each of these variables as an independent variable into an ANOVA, we investigated whether any main or interaction effects could be identified for each of the three typical test-taking emotions. We found a main effect of *gender*, $F(1, 59) = 17.00$, $p = .002$, $\eta^2_p = .22$, and an interaction effect of *test form* and *gender* $F(1, 59) = 5.10$, $p = .028$, $\eta^2_p = .08$ on students' typical test-related *anxiety*. A sensitivity power analysis using G*Power (Faul et al., 2009) suggests that $n = 64$ is sufficient to detect a medium to large interaction effect between gender and typical test-taking method ($f = .36$), with α set as .05 and power as .80). As shown in Table 4, although females reported higher levels of typical test-taking anxiety than males, females whose typical examination method was computer-based environment reported lower levels of anxiety than those whose typical testing method was by hand (see Figure 2).

[Insert Figure2]

We also found a main effect of *gender* on students' *typical test-related shame, *$F(1, 59) = 4.62$, $p = .036$, $\eta^2_p = .07$, where females reported more shame than males. We did not find any significant main or interaction effects for *hopelessness*.

[Insert Table4]

The roles of typical test-taking method and gender in retrospective test-taking emotions

Entering each of these variables as an independent variable into an ANOVA, we investigated whether any main or interaction effects could be identified for each of the three retrospective test-taking emotions. We found a main effect of gender, $F(1, 59) = 4.56$, $p = .037$, $\eta^2_p = .07$, where females reported higher levels of retrospective test-taking anxiety than males. We also found a main effect of gender, $F(1, 59) = 4.36$, $p = .041$, $\eta^2_p = .07$ on students' *retrospective test-related hopelessness*, where females reported more hopelessness than males. We also found a main effect of gender, $F(1,59) = 4.62$, $p = .036$, $\eta^2_p = .07$ on students'

retrospective test-related shame where females reported more hopelessness than males. However, this result should be interpreted with caution as Levene's test of equality of variances was (narrowly) violated. In such situations, one typically uses a more conservative alpha value, such as $p < .01$ which would render the result for shame non-significant. Finally, we did not find any interaction effects for retrospective *shame.*

[Insert Table4]

The roles of time-frame (typical vs. retrospective), method, and gender in test-taking emotions

In order to examine whether students' time-frame in emotional reports (typical vs. retrospective), typical testing method (computer vs. by hand), and gender exhibited main or interaction effects on their examination-related emotions, we ran a series of repeated-measure ANOVAs. We found a main effect of time-frame, $F(1, 59) = 4.75$, $p = .036$, $\eta^2_p = .075$ and an interaction effect of time-frame and gender on anxiety, $F(1, 59) = 4.75$, $p = .036$, $\eta^2_p = .075$. We do not report findings automatically generated by SPSS associated with between-subject analyses for these repeated-measure ANOVAs because main effects and interaction effects were examined previously for typical and retrospective emotions, separately: an approach which better addressed our research questions. An examination of the descriptive statistics revealed that females reported higher levels of anxiety in all test forms and time-frames compared to males. The results also revealed that typical levels of test-related anxiety were higher than retrospective levels of examination anxiety (see Table 5).

We found a main effect of time-frames, $F(1, 59) = 10.25$, $p = .002$, $\eta^2_p = .15$ on shame. Specifically, typical levels of test-related shame were higher than retrospective levels of examination shame and that females had higher levels of shame across time-frames than males (see Table 5). We did not find any main or interaction effects for *hopelessness*.

Emotion profiles and their relationship with examination scores

Do self-reported emotions cluster students in a meaningful way?

The results from the k-means cluster analyses portrayed a robust pattern of pre-examination emotion clusters and post-examination emotion clusters (see Table 6). Cluster centers (reported as z-scores) were used to interpret and label each cluster. For each analysis, participants in cluster one appeared to experience low negative emotions (e.g., range of z = -0.35 to -0.75); cases in cluster two appeared to experience high negative emotions (e.g., range of z = 0.61 to 1.18).

[Insert Table6]

Is gender related to emotion cluster?

Chi-square tests revealed significant gender differences in high and low typical emotional clusters, $\chi^2(1) = 6.18$, p =.013, and retrospective emotions, $\chi^2(1) = 4.19$, p =.041. Specifically, females (35%) were more likely than males (8%) to be clustered in the typical, high negative affect profile. Similarly, females (57%) were more likely than males (32%) to be clustered in the retrospective, high negative affect profile.

Is there a significant examination score difference between groups of students clustered by self-report emotion?

An independent samples t-test revealed that there is no difference between high and low typical emotional clusters on examination score, $t(73) = -.08$, p =.94. Regarding retrospective emotional clusters, the high retrospective affect group (M = .75, SD = .10) performed significantly worse on examinations compared to the low affect group (M = .81, SD = .08), $t(73) = 2.77$, p = .007.

Discussion

This study addressed undergraduate students' emotions during an authentic, course-based assessment that took place in a computer-based testing environment, while considering students' typical (i.e., trait) emotional experiences during test-taking. Supporting hypothesis 1, students generally reported lower levels of negative emotions when taking examinations in a computer-based testing environment than they typically reported feeling, possibly on account of the computer laboratory setting. These findings contribute to the literature by comparing experiences beyond test anxiety in these two testing environments. Specifically, students experienced not only less anxiety, but also less shame in the computer-based testing environment than they typically would have in other testing environments. However, students experienced similar levels of hopelessness in the computer-based testing environment as they would typically experience in other testing environments. It is possible that hopelessness was unlikely to be triggered in typical examinations unless students perceived the situation as completely uncontrollable or felt certain about their failure (Pekrun et al., 2011). Supporting this idea, we also found that hopelessness was the lowest endorsed emotion among the three negative emotions.

Consistent with Hypothesis 2, we found that female students reported higher negative emotions during the examination (Frenzel et al., 2007), even though both groups performed equally well in the examination. It was also true that women reported stronger trait negative emotions before the examination (higher anxiety and shame, but not hopeless). Therefore, it is unlikely that gender differences in testing emotions are driven by their actual competence/performance; the differences are more likely to be attributable to their appraisal of the testing situation. One explanation is that even when they perform equally, because of gender-stereotypes, female (vs. male) students tend to have lower appraisals about their ability, which can lead them to experience stronger negative emotions (Goetz et al., 2013).

Addressing hypothesis 3 regarding the interaction between gender and testing environment on emotion, we found that females reported a lower level of typical test anxiety when their testing method was computer-based (vs. by hand). That is, although anxiety was the most strongly endorsed negative emotion, computer-based examinations (vs. paper-and-pen examinations) were associated with reduced anxiety for females. However, we did not observe any main or interaction effect of prior testing environment on any retrospective emotions, suggesting that typical examination experience was not associated with negative state emotions, regardless of gender.

Finally, we found that although typical and retrospective emotions are correlated (cf. Cheung, 2006), only immediate retrospective emotions were associated with students' achievement in a particular examination, supporting hypothesis 4. Students in the profile of high-level retrospective negative emotions received lower examination scores compared to students in the profile of low-level retrospective negative emotions. However, the profiles based on typical testing emotions did not show any differences in examination scores. This is consistent with previous research showing that state emotions are more important than trait emotions in predicting test performance (Endler et al., 1994). Correlational analyses further showed that higher levels of hopelessness and shame, but not anxiety, were negatively associated with examination scores. One possibility is that students reported different levels of negative emotions of hopelessness and shame according to their perceptions of test performance, as it may reflect actual examination scores. These findings contribute to the literature of testing emotion beyond anxiety in computer-based examinations, as we found that retrospective hopelessness and shame are also keys to understanding students' performance.

Computer-based testing environment and emotions

This study provides preliminary evidence that a computer-based testing environment, such as the University of Alberta's Learning and Assessment Centre (LAC), provided a more emotionally supportive environment for students to take examinations in than those in which they typically completed examinations. Although students generally report a relatively low level of negative emotions in examinations, they reported even lower negative testing emotions after the examination at LAC than they would typically feel. We are cautious that this observation cannot draw a causal conclusion and that other factors, such as the examination difficulties and value to the students, may explain the differences. However, our findings generally supported the idea that a computer-based assessment environment, where students' emotional states were harder to see, is associated with weak negative emotions. Moreover, our findings are consistent with a previous study in a similar setting revealing that students experience relatively low negative emotions (cf. Daniels & Gierl, 2017). Future research might ask students about their level of awareness of other students and examine their awareness and emotions with and without the physical presence of other students. We should also note that we did not measure positive emotion, and it was not our goal to compare positive and negative emotions in this study.

Distance learning, taking examinations at home, and other self-selected environments have become more common, especially during the pandemic and its associated quarantine (Wang et al., 2020). However, little is known about how computer-based examinations at home can impact students' emotions and performance. Although this study did not directly examine emotions in online testing environments, our findings suggested that students may experience fewer negative emotions insomuch as they have limited social contact with other students when taking an examination at home. Instructors may also make sure not to broadcast students' faces during quizzes or examinations (e.g., zoom videos where students can see each other's facial

expressions) to create a more individual space during an examination. Students taking tests in *social situations* may attend to others' negative emotional expressions, which can affect their own emotions (i.e., emotional contagion) and increase their cognitive load during tasks.

Achievement and time-frames of test emotions

Our findings also emphasize the importance of considering time-frames in understanding the nuances of different testing emotions (cf. Pekrun et al., 2004). Consistent with previous research, we found that although anxiety is the most strongly endorsed negative emotion, it is not the most important/influential emotion in examinations (Pekrun et al., 2004). Because anxiety is a future-oriented emotion focusing on an activity (e.g., worry about failing an examination), anxiety may be more important in predicting examination scores when it is measured as anticipating a particular examination (Schult & McIntosh, 2004; Stowell & Bennett, 2010; Zeidner, 2007). Moreover, as students proceed through the examination, the role of anxiety may become less relevant and be replaced by other emotions (Spangler, Pekrun, Kramer, & Hofmann, 2002; Daniels & Gierl, 2017). As we examined retrospective emotions in this study, hopelessness and shame are more critical in understanding performance because they are often experienced when one expects failure after an activity (Harley et al., 2019; Pekrun et al., 2011).

Limitations and future directions

The results and limitations of this study give rise to important questions for future studies. First, it is important to note that this study was not a randomized control trial experiment, which prevents us from ruling out possible confounding variables (e.g., other environmental influences, the content of examinations) and from making causal conclusions about the role of the computer-based testing environment on emotions and achievement. In addition to testing the causal effect by having students take examinations in the different

environments (classrooms vs. computer laboratory), future research can extend the understanding of how different computer-based testing environments may affect students' emotions (e.g., home, laboratory, or other self-selected environments). To overcome the limitations, future research could examine students' emotions over multiple instances, where repeated examinations might occur (e.g., mid-term 1 and mid-term 2 in the same class) and/or examinations taken in different contexts (e.g., mid-term 1 in classrooms, and mid-term 2 in computer laboratory).

Second, the results of gender comparison should be interpreted with caution in light of the relatively small size of males (n = 25) compared to females (n = 49) in the study. A larger and more balanced sample in future research should further validate the current results regarding gender differences in different testing situations.

Third, future studies can also include different measures to understand the nuance of emotional experiences in different contexts. Although we did not observe any effect of prior testing environment on any retrospective emotions, future studies should include a more comprehensive measure of prior experiences (e.g., how many laboratory computer and home computer-based examinations did students have in the past?). This would allow researchers to examine *what* and *the extent to which* prior experiences affect students' emotions and testing outcomes. Further, future research can measure more comprehensive test emotions and emotional regulation, including physiological responses and facial expressions with web cameras, to reveal a full picture of emotional expressions and experiences during an examination in a computer-testing environment. To further understand the role of emotional contagion in different testing environments, future research could measure students' perceptions of others' emotions and test whether emotional contagion mediates the link between testing environments and outcomes (e.g., emotions and test scores).

Finally, future research could investigate how other individual characteristics (e.g., students of different age groups, socioeconomic background; cf. Pekrun et al., 2017) and testing subjects (e.g., math examination vs. English examination) impact appraisals and interact with different environments. For example, some studies showed that older adults are found to have higher computer-related anxiety compared to younger adults (e.g., Laguna & Babcock, 1997). However, secondary school students are more confident and have higher literacies in computers compared to primary school students (Jin et al., 2020). Understanding the individual differences in testing emotions may provide implications to help diverse students to create their own emotionally supportive environment for remote testing.

Conclusion

Achievement emotion researchers have argued that testing environments and assessment procedures should be designed to support students' emotional experience before, during, and after an examination (Pekrun et al., 2004; Daniels & Gierl, 2017; Harley et al., 2019). Our study suggests that in an individualized laboratory-based computer testing context, students may experience a lower level of negative emotions compared to traditional paper-and-pen testing in the classroom. Our study also showed that state-retrospective emotions immediately after the computer-based examination, but not the emotions students typically experienced during test-taking, were associated with examination performance. These findings suggest that a computer-based testing environment that supports students' emotional experiences may promote students' achievement and emotional well-being which has potential implications for online testing, especially during the COVID-19 pandemic. Future experiments should design more controlled environments regarding students' social experiences to unpack the complex relations among testing environments, emotions, and achievement.

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Table 1.

Descriptive statistics

Variable	Descriptive Information						
	Min	Max	*M*	*SD*	Skewness	Kurtosis	α
Typical Emotion							
Anxiety	1.00	4.57	2.39	0.89	.41	–.62	.86
Hopelessness	1.00	4.17	1.80	0.85	.97	.11	.91
Shame	1.00	4.75	2.27	1.06	.58	–.72	.90
Retrospective Emotion							
Anxiety	1.00	3.57	2.07	0.69	.40	–.30	.81
Hopelessness	1.00	3.33	1.81	0.63	.59	–.45	.84
Shame	1.00	3.20	1.74	0.56	.66	–.33	.79
Exam Score	0.50	0.98	0.78	0.10	.96	.52	--

Table 2.

Paired sample t-tests

Comparison	*t*-statistics	Cohen's d
Typical Emotion		
Anxiety vs. Hopeless	5.69***	.66
Anxiety vs. Shame	1.06	.13
Hopeless vs. Shame	–4.02***	.46
Retrospective Emotion		
Anxiety vs. Hopeless	3.67***	.42
Anxiety vs. Shame	4.88***	.58
Hopeless vs. Shame	1.10	.13

Note. $N = 74$. *** $p < .001$. Within-subject *t*-statistics are presented above the diagonal. The values of 0.2, 0.5, and 0.8 in Cohen's *d* represent small, medium, and large effect sizes (Cohen, 1992).

Table 3

Correlation matrix

Variable	1	2	3	4	5	6	7
1.Typical Anxiety	--						
2.Typical Hopelessness	.47**	--					
3.Typical Shame	.55**	.45**	--				
4.Retrospective Anxiety	.47**	.33**	.23*	--			
5.Retrospective Hopelessness	.34**	.65**	.24*	.56**	--		
6.Retrospective Shame	.35**	.33**	.31**	.57**	.57**	--	
7.Exam Score	.10	–.12	.01	–.11	–.33**	–.45**	--

Note. $^{*}p < .05$ $^{**}p < .01$ (2-tailed). All retrospective emotions are post-outlier cleaned. $N = 75$.

Table 4

Descriptive information for emotions grouped by time frame, gender, and test form

Typical Emotion	Gender	Test Form	*M*	*SD*	*N*
Anxiety	Male	Computer	2.01	0.60	14
		By hand	1.59	0.49	7
		Total	1.87	0.59	21
	Female	Computer	2.42	0.93	23
		By hand	3.00	0.81	19
		Total	2.68	0.92	42
	Total	Computer	2.27	0.84	37
		By hand	2.62	0.97	26
		Total	2.41	0.90	63
Hopelessness	Male	Computer	1.71	0.69	14
		By hand	1.31	0.32	7
		Total	1.58	0.62	21
	Female	Computer	2.01	0.96	23
		By hand	1.77	0.87	19
		Total	1.91	0.92	42
	Total	Computer	1.90	0.87	37
		By hand	1.65	0.78	26
		Total	1.80	0.84	63
Shame	Male	Computer	2.02	0.78	14
		By hand	1.79	1.06	7
		Total	1.94	0.86	21
	Female	Computer	2.30	1.08	23
		By hand	2.70	1.02	19
		Total	2.48	1.06	42
	Total	Computer	2.20	0.98	37
		By hand	2.45	1.09	26
		Total	2.30	1.02	63

Note. The mean and standard deviation are based on the mean score of the Likert scale

Table 5

Descriptive information for emotions grouped by time frame, gender, and test form.

Retrospective Emotion	Gender	Test Form	*M*	*SD*	*N*
Anxiety	Male	Computer	1.95	0.65	14
		By hand	1.65	0.47	7
		Total	1.85	0.60	21
	Female	Computer	2.14	0.71	23
		By hand	2.28	0.74	19
		Total	2.20	0.72	42
	Total	Computer	2.07	0.68	37
		By hand	2.12	0.73	26
		Total	2.09	0.70	63
Hopelessness	Male	Computer	1.79	0.55	14
		By hand	1.41	0.42	7
		Total	1.66	0.53	21
	Female	Computer	2.03	0.70	23
		By hand	1.89	0.64	19
		Total	1.97	0.67	42
	Total	Computer	1.94	0.65	37
		By hand	1.76	0.62	26
		Total	1.86	0.64	63
Shame	Male	Computer	1.57	0.38	14
		By hand	1.57	0.31	7
		Total	1.57	0.35	21
	Female	Computer	1.78	0.61	23
		By hand	1.99	0.56	19
		Total	1.88	0.59	42
	Total	Computer	1.70	0.54	37
		By hand	1.88	0.53	26
		Total	1.77	0.54	63

Table 6

Final cluster z-scores on self-report emotion measures (2 clusters)

	Variable	Cluster	
		(1) Low negative affect	(2) High negative Affect
		n = 56	*n* = 19
Typical emotional cluster	Typical Anxiety	–0.38	1.11
	Typical Shame	–0.39	1.16
	Typical Hopelessness	–0.40	1.18
		n = 39	*n* = 36
Retrospective emotional cluster	Retrospective Anxiety	–0.56	0.61
	Retrospective Shame	–0.75	0.81
	Retrospective Hopelessness	–0.72	0.78

Note. Clusters were based on the *z*-scores (Meyers et al., 2013).

Figure 1.

Learning and Assessment Centre (LAC), a computer-based testing environment, at the University of Alberta.

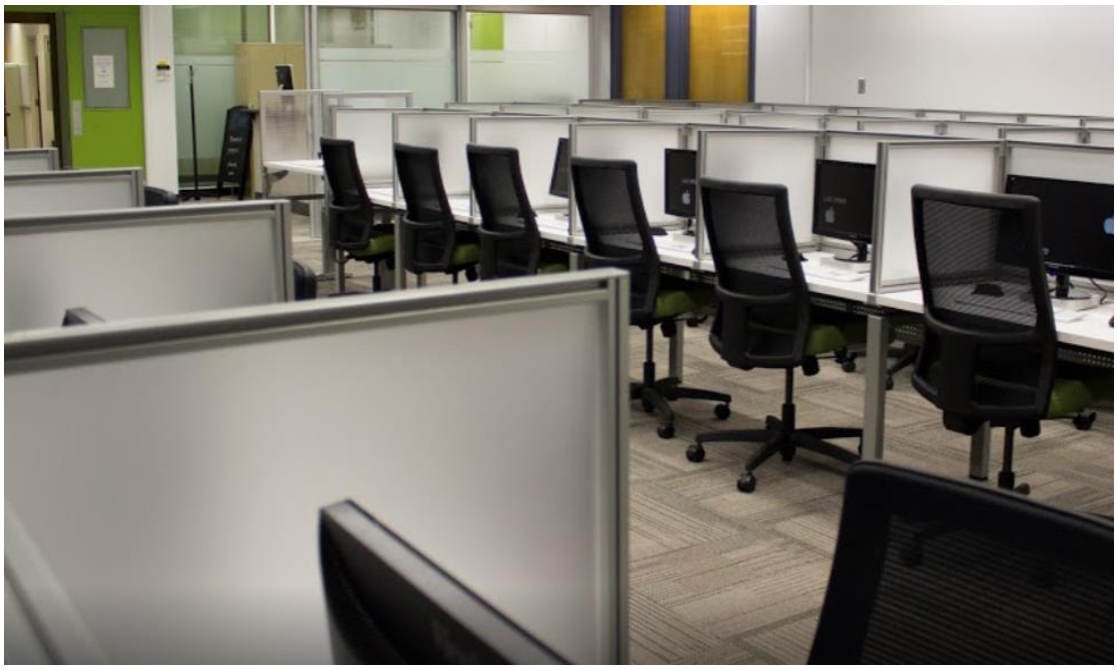
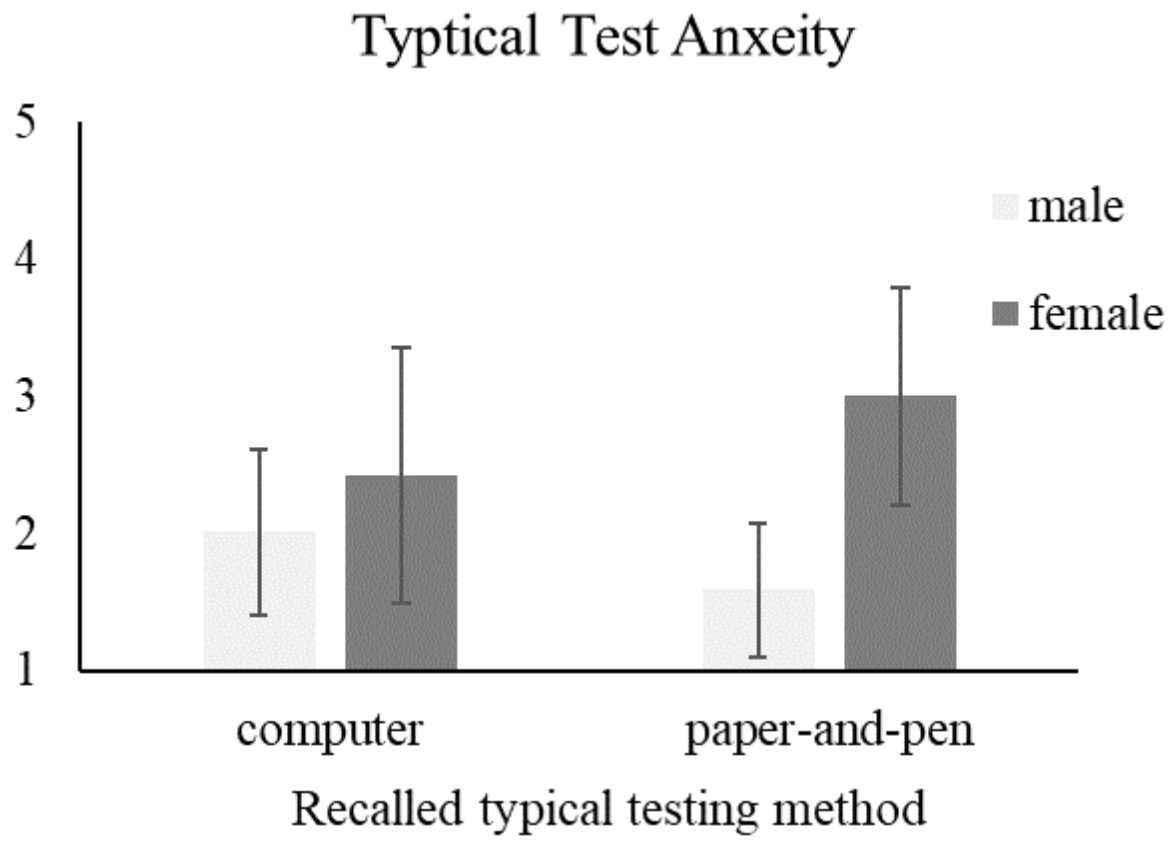


Figure 2

The interaction effect between gender and typical testing method on trait test anxiety



Note. Y-axis of the bar graph represents the mean of the 5-point Likert scale. The error bars represent standard deviations of the mean.