Does Gender Influence Emotions Resulting from Positive Applause Feedback in Self-Assessment Testing? Evidence from Neuroscience

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ABSTRACT

Computerized self-assessment testing can help learners reflect on learning content and can also promote their motivation toward learning. However, a positive affective state is the key to achieving these learning goals. This study aims to examine learning gains and emotional reactions resulting from receiving emotional feedback in the form of applause during computerized self-assessment testing of university students. The participants were asked to solve mathematics problems in a computer-assisted self-assessment system with or without pre-recorded applause as emotional feedback while EEG measurements were taken. Using psychological evidence from neuroscience technology, we tested the hypothesis that the part of the brain that generates feelings of reward is more active in male students than in female students during computer-assisted self-assessment testing. The results of this study provide support for the belief that it is useful to reduce negative emotional states in students by using emotional reactions such as applause during computer-assisted self-assessment testing, especially in the case of male students. It is suggested that instructors may wish to create such a positive emotional self-assessment learning environment to encourage students to learn by themselves more efficiently.

Keywords

Evaluation methodologies, Gender studies, Interactive learning environments, Teaching/learning strategies

Introduction

As one of the indispensable instruments in the educational domain, assessment is often carried out by teachers to measure students’ learning gains. From the perspective of students, however, assessment may likely turn into stress and anxiety if they fail to achieve expected grades (Caraway, Tucker, Reineke, & Hall, 2003; Huang, Huang, & Wu, 2014). To this end, self-assessment test systems have been typically considered as an effective instructional strategy for training students not only to evaluate their own learning progress, but also to help them relieve anxiety and other negative emotional states while facing real tests (Moridis & Economides, 2012). Indeed, anxiety relief is plausibly a positive factor for real test achievement, which may be attributable to training in self-assessment (Gretes & Green, 2000; Snooks, 2004). Moreover, through self-assessment, students are able to review the course content being taught, retrieve what they have learned and even promote reflection (Kulik, Kulik, & Bangert, 1984).

Although self-assessment is beneficial for students with regard to enhancing what they have learned through review and reflection, it often creates a stressful experience similar to that carried out by paper-based tests (Cassady, 2004; Ricketts & Wilks, 2002). The stress is presumably linked to the fact that the majority of real tests most students face are still paper-based. Studies have indicated that computer-based assessments, hereafter CBAs, with a user-friendly interface are a sound alternative for self-assessment purposes (Kaklauskas et al., 2010; Ricketts & Wilks, 2002). Thanks to information technology, today’s CBAs can not only provide instant feedback but can also adaptively generate questions for students, reducing the time and cost of such assessments (Terzis & Economides, 2011). As a consequence, CBAs become an ideal platform by which learners can engage in self-assessment (Moridis & Economides, 2012; Nicol & Macfarlane-Dick, 2006). Due to the adaptivity of this method, computerized self-assessment tests have been widely adopted.

Research has supported the argument that computerized self-assessment testing can provide efficient feedback to help improve student reflection and learning motivation, and it can promote higher levels of learning achievement (Black & Wiliam, 1998; Wilson, Boyd, Chen, & Jamal, 2011). However, other studies have indicated that students...
Affect is the basis of human experience. There are two types of affect, positive and negative (Economides & Moridis, 2008), where positive affect (e.g. acceptance, joy, confidence, etc.) has a positive impact on learning, memory and thinking, resulting in learning within an optimal range of human functioning. On the contrary, negative affect (e.g. anxiety, anger, fear, sadness, etc.) has a negative impact on motivation and leads to inattentiveness and even distraction. Moridis and Economides (2012) and Huang and Liang (in press) indicated that negative affect adversely impedes learners. Negative affect occurs mostly when the students' final learning outcomes do not meet their expectations, such as when they answer a question wrongly or fail a test. As affect can significantly influence learning, understanding learners' affect throughout the learning process is crucial for understanding their learning motivation. However, it is impossible to put learners' affect into perspective and to give them immediate feedback when it comes to paper-based assessments (Sung, Chang, Chiou, & Hou, 2005).

Issues of immediate affective feedback for computer-assisted self-assessment have been increasingly discussed in recent studies (Liu, Paphathanasiou, & Hao, 2001; Moridis & Economides, 2012). These studies all have suggested that immediate affective feedback for computer-assisted self-assessment can help promote student self-confidence and improve performance. Furthermore, they all confirmed that positive affective feedback for computer-assisted self-assessment can decrease students’ anxiety and can improve their levels of learning achievement.

Differences in terms of the behaviors or reactions of individuals using various computer applications, including computer-assisted learning, may be due to gender. One study indicated that the participation of females in ICT professional careers is low and even still falling in most western countries (Meelissen & Drent, 2008). Thus, an experiment was conducted to investigate those factors related to elementary schools or teachers in regard to their influence on female students' attitudes toward computers. The results revealed that female children's attitudes toward computers were less positive than that of males. Will this be the same when it comes to the issue of affect? It is a very interesting issue and worthy of investigation.

Moridis and Economides (2012) adopted applause as an achievement-based reward during a computer-assisted self-assessment test. They found that males who were not receiving applause during the test had a significantly higher state of anxiety than females who were not receiving applause either. The state of anxiety assessed in this study using the scores of the State-Trait Anxiety Inventory (STAI) was based on the students’ self-perceptions after the test, hardly realizing how continuously the state of emotion may have been changing during the test. In fact, we believe affect is a state and should therefore be observed instantaneously. Therefore, both the STAI and objective scientific evidence are required to explore the issue of affect.

In this study, we tackle gender differences in affect and explore why feelings of reward influence students' test performance using neuroscience technology, namely Electroencephalography (EEG). The research questions are as follows:

- What are the possible influences of applause on test performance?
- What are the differences in anxiety, if any, between different genders when stimulated by applause?
- To what extent can applause affect anxiety?

In this study, a neuroscience technology, an EEG, was used to measure the effect of applause on anxiety. Huang and Liu (2012) reported that EEG reflects the corresponding patterns of cognition or emotion in participants. Thus, EEG can precisely measure participant anxiety.

It is intended that the results of this study will provide psychological evidence by which to interpret the underlying reasons for the findings as well as useful suggestions for the design of more comprehensive self-assessment test systems. Furthermore, the results could serve as a reference to guide teaching and learning strategies regarding emotional reactions during computer-assisted self-assessment testing.

The purpose of this study is to provide psychological evidence using neuroscience technology to test the hypothesis that the part of the brain that generates feelings of reward is more active in males than in females during computer-assisted assessment testing. Therefore, EEG can be used to measure the effect of applause on anxiety. Huang and Liu (2012) reported that EEG reflects the corresponding patterns of cognition or emotion in participants. Thus, EEG can precisely measure participant anxiety.
assisted self-assessment testing. The findings could reflect the effect of emotional reactions on learning gains by receiving applause during a computer-assisted self-assessment test.

Methodology

Test design

The Hot Potatoes System was adopted in this study to design the computer-self-assessment tests. The design process is shown in Figure 1. In the first step, 15 single-choice questions were chosen to compose the tests for both the experimental and controlled tasks. Second, the mathematics questions administered in the tasks were a series of two-digit additions. The simple math problems were aimed at eliminating the influence of participants’ prior knowledge on their test achievement. Moreover, participant reactions evoked by complex math problems might potentially involve various levels of cognitive processing, and therefore, the main effect of applause on the test achievement investigated in this study would be difficult to explain from the results of such complex math problems. This task design (two-digit additions questions for undergraduates) was also employed in studies conducted by Cates and Rhymer (2003) and Sheffield and Hunt (2006). The choice of 15 single choice tests in both the experimental and controlled task was a result of concern about the participants' attention processing load. As suggested by general EEG methodology, people can pay the best sustained attention for 5 minutes. Third, the test carried out in the experimental task used the applause sound for right answers to questions, whereas the test carried out in the controlled task did not. Fourth, the web page-based tests for the experiment were generated by the Hot Potatoes system.

![Diagram](image1)

*Figure 1. The design for the test process using the Hot Potatoes System*

The flow of the experimental task is shown in Figure 2. In the experimental task, a pre-recorded sound of applause was embedded into the question feedback. If a student answered the question correctly, the system instantly reacted with the applause sound, accompanied by the word “correct” shown on the computer screen (Figure 2a). If the student got the wrong answer, no applause sound was emitted, and the word “wrong” was shown on the screen (Figure 2b). In the controlled task, there was no applause sound played for the correct answer; however, the word “correct” still appeared on the screen (Figure 3a). If the student got the wrong answer, the word “wrong” was shown (Figure 3b), as in the experimental task. Finally, the computer-assisted self-assessment tests for the experimental and controlled tasks were exported for the achievement tests. It should be noted that the tests were developed in Chinese.

![Diagram](image2)

*Figure 2. The design of the computer-assisted self-assessment test for the experimental task (a) The sound of applause is played with the word “correct” displayed on the screen when the students answer correctly (b) The word “wrong” is shown on the screen when the students get the wrong answer*
Participants

This study was conducted at an urban university in Taiwan. Thirty participants (n = 30, 15 males, 15 females; mean age ± SD = 19.2 ± 2.0 years) participated in this experiment and were divided into two groups: one male group and one female group. All participants were asked to complete both the experimental and controlled task tests throughout the whole process to collect the psychological data. All participants were confirmed to be mentally healthy without a history of neurological or psychiatric disorders, and all gave voluntary consent to participate in the neuroscience experiments. This study conformed to The Code of Ethics of the World Medical Association (Declaration of Helsinki) and was approved by the ethics committee of National Kaohsiung Normal University.

Using an EEG (Electroencephalography) experiment to provide neuroscience evidence

Many cognitive processes are difficult to explain verbally (Bargh & Ferguson, 2000; Huang, Liu, Chen, Kinshuk, & Wen, 2014; Liu, Huang, & Wen, 2013); hence, some studies have suggested that the study of cognitive processes must combine neurophysiological methods with questionnaires (Wang & Chiew, 2010). Past neuroscience studies have found that humans show similar trends while responding to the same task in elicited EEG data, such as that derived during recognition or problem solving tasks (Cicconetti et al., 2007; Juckel et al., 2008; Lai, Lin, Liou, & Liu, 2010) and have also suggested that the EEG research method is suitable for exploring research issues related to emotions and cognitive processes.

In this study, the EEG supplied neuroscience data indicative of the effect of gender differences on emotional reactions during a computer-assisted self-assessment test, and to the best of our knowledge, this is the first study to provide concrete evidence regarding this issue. The participants were required to complete both the experimental and controlled task tests while neuroscience technology was used to collect the psychological data throughout the entire process. EEG is a procedure that measures the electrical activity of the brain through the skull and scalp (see Figure 4) (Rugg & Coles, 1995). For collecting the electrical activity of the brain, the participants were required to put on the electrode cap before doing the test. Figure 4 indicates the relative position of the different areas of the human brain on the cap. The standard for the relative position of the electrode cap in this study was adopted from the international 10-20 system. The character “F” means frontal lobe; the character “P” means parietal lobe; the character “C” means central lobe; the character “T” means temporal lobe, and the character “O” means occipital lobe. When participants experience emotional reflections, the corresponding electrical activities in the brain are induced (Huang & Liu, 2012).
The EEG was amplified (band pass, 0.01-40 Hz) using SynAmps/SCAN 4.4 hardware and software (NeuroScan, Inc., Herndon, VA) and a commercial electro-cap (Electro-Cap International, Eaton, OH) with electrodes at 32 scalp locations based on the 10-20 International system (see Figure 5).

The noise signals were filtered out automatically. The electrode impedance was kept below 5 kΩ. The averaging epoch was 1,024 ms, including 200 ms of pre-stimulus baseline. EEG channels were continuously digitized at a rate of 1,000 Hz using a SynAmp™ amplifier. The signal was analogy filtered (0.1-200 Hz), A/D converted with a sampling rate of 1,000 Hz, 14 bit precision and digitally filtered in the range of 0.1-30 Hz. All of the participants’ EEG signals were recorded while they were completing the experimental tasks (Figure 6).
The procedure and data collection

All of the students were advised that they were to take a computer-assisted mathematics test in this study (see Figure 7). They were also told that they could participate in a computer-assisted self-assessment test as practice before the test. All students in this study took the computer-assisted self-assessment test twice in a different order. One half of them took the controlled test first, which was then followed by the experimental test. The other half took the tests in the reverse order. The two tests were separated by an interval of one hour. The duration of each test was approximately 23 minutes. Students were asked to answer each question within four seconds. The state of anxiety questionnaire was distributed before and after the control tests. Also, the state of anxiety was written down before and after the experimental tests. The extracted data were then analyzed using a repeated-measures ANOVA analysis.

Figure 7. Timeline for both the controlled and experimental tasks

In the process of completing the tests, all participants had to wear a 32-channel electrode cap in order to collect the EEG data (see Figure 8a). The process for wearing the electrode cap includes the following steps: First, the cap is placed on the participant’s head, and the electrode holders are filled with electrode gel using a syringe. Second, the electrodes are plugged into the cap one by one. The procedure for putting on the electrode cap takes about 30 minutes. At the beginning of the EEG experiment, all students were asked to sit down and relax. The EEG for their rest state was collected as an individual brain wave baseline. Moreover, in order to avoid the participant's emotional state being influenced by the previous test, they were asked to relax and do nothing for 60 minutes between the two tests.

(a) Wearing the electrode cap (b) Answering the questions

Figure 8. The EEG instrument and the experiment in a EEG laboratory
All of the participants’ EEG signals were collected while they were participating in the experiments (see Figure 8b). Frequency analysis was performed in the delta (1–4 Hz), theta (4–7 Hz), alpha 1 (8–10 Hz), alpha 2 (11–14 Hz), beta (15–30 Hz) and gamma (>30 Hz) frequency bands. The evidence of brain activity from these frequencies and power values could help to verify the hypothesis that the part of the brain that generates feelings of reward is more active in males than in females during the computer-assisted self-assessment test. The most important power values in this study are alpha 2 and delta frequencies. Blackhart, Kline, Donohue, LaRowe, and Joiner (2002) indicated that the power values of the alpha 2 frequency reflect the induced participants’ positive emotions. In addition, the delta frequency in the frontal lobe of brain reflects high-level cognitive processing occurring in a participant (Ho et al., 2012).

Measurement scales

In this study, students' anxiety levels were measured by using the State-Trait Anxiety Inventory (STAI) (Spielberger, 2005) which was the same instrument used in the study of Moridis and Economides (2012). The self-report inventory included 20 items intended to assess the participants’ state of anxiety. Responses to the items ranged from 1 to 4, as follows: (1) not at all; (2) somewhat; (3) moderately so, and (4) very much, according to the students’ feelings. Scores range from a minimum of 20 (lowest anxiety) to a maximum of 80 (highest anxiety). The validity of the contents of the Chinese version was assessed by three professional psychologists, and Cronbach’s alpha was 0.91 for the state subscale.

Two mathematics tests on the addition of two-digit numbers were administered in this study, consisting of 15 single choice type questions with a perfect score of fifteen. The correlation of these two tests was 0.96 (The data was analyzed using a pilot study), and the Cronbach’s alpha values were 0.84 and 0.87 for the two tests. The high correlation indicates that these two tests are highly consistent with each other.

Results and discussion

Computer-assisted self-assessment tests with and without applause were administered in this study, and the statistical data from the state of anxiety questionnaire were collected before and after each test.

The students' test performance and anxiety in the controlled test

The first to be administered was the controlled test without applause as emotional feedback. The results show that the male group scored 12.4 ± 1.5 points compared with 11.3 ± 1.8 points for the female group in the controlled task mathematics test. There was no significant difference between the two groups’ performance on the test. Furthermore, Table 1 shows that there was less difference in the state of anxiety of the female group before and after the test without applause. However, for the male group, the state of anxiety after the controlled test was higher than it was before the test.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female (n = 15)</td>
<td>20.27</td>
<td>19.93</td>
</tr>
<tr>
<td>Male (n = 15)</td>
<td>16.13</td>
<td>18.07</td>
</tr>
</tbody>
</table>

Then, repeated-measures ANOVA was used to assess the differences in the scores of the state of anxiety of the two gender groups before and after the controlled computer-assisted self-assessment test (see Table 2). The results show that there was no significant main effect for anxiety scores across gender groups: \( F(1,28) = 2.39, p = .13 \). This finding is in line with the results of the research by Moridis and Economides (2012), who suggested that the main effect of gender on state of anxiety is not significant. There was also no significant main effect across pre- and posttest time points: \( F(1,28) = 2.82, p = .10 \). However, there was a significant main effect across the interaction between gender group and time point: \( F(1,28) = 5.67, p = .02 \).
Table 2. Analysis of variance results for both genders and pre-posttest for anxiety in the controlled task

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>1</td>
<td>135.00</td>
<td>2.39</td>
<td>.08</td>
</tr>
<tr>
<td>Within subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time (pre/posttest)</td>
<td>1</td>
<td>9.60</td>
<td>2.82</td>
<td>.09</td>
</tr>
<tr>
<td>Gender x Time (pre/posttest)</td>
<td>1</td>
<td>19.27</td>
<td>5.67*</td>
<td>.17</td>
</tr>
</tbody>
</table>

*p < .05.

Figure 9 shows that the females had a higher state of anxiety before the test than the males. However, after completing the test without the applause affective feedback, the females showed a state of less anxiety, while the males still showed a significant increase in anxiety. Colley (2003) pointed out that female students tend to have more negative attitudes related to the use of computers than male students, which may explain why the female students had higher levels of anxiety before the computer-assisted self-assessment test. In addition, for some female students, mathematics represents a critical filter to keep females out of science learning (Matteucci & Mignani, 2009), which may be another reason why the female students had higher anxiety than the males. Finally, compared with male students, female students tend to prefer less competitive or challenging tests (McLean & Anderson, 2009). Therefore, the female students had more negative emotions before taking the computer-assisted self-assessment test with mathematics content than the male students.

![Figure 9. Mean anxiety scores across time points (pre/posttest) by gender in the controlled task](image)

However, as shown in Figure 9, during the controlled experiment without applause as affective feedback, the female students exhibited decreased anxiety, while the male students exhibited increased anxiety after completing the test. Some researchers have suggested that females do relatively worse on tests than males because of having lower confidence (Klein, 2007; Matteucci & Mignani, 2009). According to our findings, we propose that the female students were more anxious than the males before doing the test, but they felt more relaxed after completing the test since the operation of the computer was not difficult, and the participants needed only to click the correct answer by using the mouse. We additionally speculate that perhaps the males had lower anxiety than the females because the male students initially had higher self-confidence in their ability to complete the mathematics test using computers. A possible reason why the male students had higher anxiety after testing might be linked to the feeling that they faced competition from other students (Moridis & Economides, 2012). Therefore, the higher anxiety of male students after taking the test might be due to their expectations for high achievement.
The students' test performance and anxiety in the experimental test

The second test to be administered was the experimental test, which provided applause as positive feedback after each correct answer. The results of this test showed that the male group scored 13.9 ± 2.6 points compared with 13.5 ± 2.7 points for the female group. Although the scores for the experimental task for both the male and female groups were higher than the scores for the controlled task, there was no significant difference between the gender groups.

Moreover, Table 3 shows that there is less difference in the state of anxiety for the female group before and after the computer-assisted self-assessment test with applause. However, for the male group, the state of anxiety after the computer-assisted self-assessment test was found to be dramatically lower than the state before the test.

Table 3. Anxiety pre and posttest mean scores, standard deviations results by gender in the experimental task

<table>
<thead>
<tr>
<th>State of anxiety</th>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretest M</td>
<td>Pretest SD</td>
<td>Posttest M</td>
<td>Posttest SD</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female (n = 15)</td>
<td>20.13</td>
<td>7.37</td>
<td>19.47</td>
<td>7.11</td>
</tr>
<tr>
<td>Male (n = 15)</td>
<td>16.20</td>
<td>3.26</td>
<td>8.00</td>
<td>3.05</td>
</tr>
</tbody>
</table>

The repeated-measures ANOVA was conducted to assess the differences in the state of anxiety between the male and female groups before the experimental test. The results show there to be no significant difference in their scores ($t = 1.89, p > .05$).

Moreover, the scores were analyzed using repeated-measures ANOVA to assess the differences in the state of anxiety between the male and female groups before and after the computer-assisted self-assessment test (see Table 4). The results show there to be a significant main effect for anxiety scores across gender group: $F(1,28) = 14.94, p < .01$. The anxiety scores were significantly higher for the female groups than for the male group in the experimental task. There was also a significant main effect across pre- and posttest time points: $F(1, 28) = 104.67, p < .001$. The anxiety scores were significantly higher at the pretest time point than at the posttest time point. Moreover, there was a significant main effect across the interaction between gender group and time point: $F(1,28) = 75.56, p < .001$.

Table 4. Analysis of variance results by gender and pre-posttest of anxiety in the experimental task

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between subjects</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>1</td>
<td>889.35</td>
<td>14.94**</td>
<td>.35</td>
</tr>
<tr>
<td>Time (pre/posttest)</td>
<td>1</td>
<td>294.82</td>
<td>104.67***</td>
<td>.79</td>
</tr>
<tr>
<td>Gender x Time (pre/posttest)</td>
<td>1</td>
<td>212.82</td>
<td>75.56***</td>
<td>.73</td>
</tr>
</tbody>
</table>

*p < .01. **p < .001.

Figure 10 shows that the males had a lower state of anxiety after the experiment with applause than the females. This finding is also similar to the results of Moridis and Economides (2012), which indicated that males experienced lower anxiety when they received encouragement. Beyer and Bowden (1997) noted that males tend to be concerned about their capacity to deal with the external environment, while females tend to underestimate themselves. This comment is echoed in the findings of this study, which indicate that male student performance is influenced by the external environment, while female student performance is influenced by their own feelings. Here, the applause could be regarded as an external factor.

The students’ EEG data in the experimental test

Our findings obtained by the anxiety questionnaire are mostly in line with those found in the literature. However, we argue that anxiety should be regarded as a continuous state rather than as an outcome of a period or event. Therefore, the data from the questionnaire following the test, which presumably measures and reports the subjects' emotional state, needs to be confirmed. In short, continuous observation is a substantial step to which complement the
questionnaire. For this purpose, the EEG data for the males and females who performed the experimental computer-assisted self-assessment test with applause were analyzed. A topographical map of the brain is shown in Figure 11. For the male group, the images reveal that the power values of the alpha 2 frequency were more active on the two sides of the frontal lobe than they were for the female group. Blackhart et al. (2002) explained that the power values of the alpha 2 frequency from the two sides of the frontal lobe are often induced by the appearance of positive emotions. In other words, higher power values of the alpha 2 frequency mean more positive emotion. Therefore, the findings indicate that in the experimental computer-assisted self-assessment test with applause, the part of the brain that generates feelings of reward is more active in males than in females during computer-assisted self-assessment testing.

![Figure 10](image1.png)

*Figure 10. Mean anxiety scores across time points (pre/posttest) by gender group in the experimental task*

![Figure 11](image2.png)

*Figure 11. Topographical map of the Alpha 2 frequency of the brain (The indicators of positive affective state: In each frequency, more areas changed into red colors indicated more active of the brain in this frequency domain)*
Huang and Liu (2012) reported that the frontal lobe of the human brain dominates high-level thinking, mental rotation and math calculations. Ho et al. (2012) also indicated that the delta frequency in the frontal lobe of the human brain is related to high-level cognitive processing. For this reason, the delta frequency power values in the frontal lobe (F4 electrode) were further analyzed, as shown in Figure 12. The results show that both the male and female groups had higher delta power values when completing the controlled computer-assisted self-assessment test without applause feedback than they did for the test with applause feedback (see Figure 12). That is to say, both the male and female students needed to exert more power value to complete the computer-assisted self-assessment test without emotional feedback.

![Graph showing EEG power values](image)

**Figure 12.** The EEG power values

Figure 12 further illustrates that applause as emotional feedback influenced the males more than the females. The higher power value indicates that the participants needed to recruit more brain resources to complete the task. In other words, the higher power value implies that the participants felt the task was difficult. In Figure 12, it can be seen that the males had the highest delta frequency power value (1–4 Hz) when the test was performed without applause (pink line), and the lowest value when with applause (red line). Although the females also had higher power values when the test was performed without applause (green line) than with applause (blue line), the gap between the power values of the two tests is smaller for the female group than for the male group. These findings may provide psychological evidence to support the argument that emotional feedback influences males more than females in computer-assisted self-assessment testing, especially in terms of encouraging positive emotions. The psychological evidence is in line with the results shown in Table 2, indicating that males had a lower state of anxiety after the experiment with applause than the females. By combining the self-report questionnaire with the psychological measures, the reliability of the self-report is supported by the results of the brain wave data. Moreover, the psychological measures can provide comprehensive observations and deeper insights into the learning process.

**Conclusions**

The purpose of this study was to provide psychological evidence based on neuroscience technology to explain the reasons for gender differences and why feelings of reward influence students’ affective states. To the best of our knowledge, this is the first study to provide concrete evidence regarding this issue.

Although the results of the test performances showed there to be no significant difference between the gender groups in either the controlled or experimental tests, there are three main findings about the affective states under
consideration in this study. Firstly, the females experienced significantly higher anxiety before the computer-assisted self-assessment test without applause than the males, but showed a decreasing state of anxiety compared with the males' significantly increasing state of anxiety after completing the test. The changes in the state of anxiety in the case of the female students might be because they were initially nervous about a computer-based mathematics test, but then found that it was relatively easy. On the other hand, we suggest that the males had lower anxiety because they had higher self-confidence in their ability to complete the test than was the case for the females. However, the male students experienced higher anxiety after completing the test perhaps due to their concern about their capacity with respect to the external environment.

Secondly, the males had significantly lower anxiety than the females after the experimental computer-assisted self-assessment test with applause as affective feedback. This finding confirms the first finding in this study suggesting that male student performance is influenced by the external environment, whereas female student performance is influenced by their own feelings.

Thirdly, the results from the psychological data indicate that the part of the brain that generates feelings of reward is more active in males than in females during computer-assisted self-assessment testing with applause. These findings suggest that positive emotional feedback influences males more than females in such a testing scenario. We therefore suggest that instructors need to design different types of feedback intended to address gender-based differences. Instructors should consider that although positive emotional feedback in computer-assisted self-assessment testing can enhance student learning, it is more beneficial for male students than it is for female students. Hence, instructors need to design other feedback or strategies to promote female student learning achievement.

To conclude, the results of this study suggest that the use of emotional reactions such as applause may improve students’ learning states during computer-assisted self-assessment testing, especially in the case of male students. This study suggests that computerized self-assessment testing can integrate a positive emotional feedback mechanism to encourage students so as to promote their learning states and increase motivation. In addition, this study asserts that neuroscience technology can provide substantial and necessary evidence to confirm the influences of emotional feedback on learning. Nevertheless, there are some limitations in this study. In our experiment, we adopted a mathematics test as the learning content of the task. Many previous studies have mentioned that female students dislike mathematics more than male students. The reaction to the mathematics test should therefore be considered as a variable affecting the gender differences in this study. We thus suggest that researchers explore gender differences in emotional reactions during computer-assisted self-assessment testing for different subjects and tasks.

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