Comparing the Sensor Glove and Questionnaire as Measures of Computer Anxiety

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Abstract: Contradictory findings are reported in the literature concerning computer anxiety and how it affects the performance of individuals executing computer-related tasks. The discrepancies in the findings could be caused by the sole use of computer anxiety questionnaires. The aims of the present study were to establish whether using a sensor glove provided complementary information to an existing computer anxiety questionnaire; and to compare the computer anxiety of participants using a sensor glove and an anxiety questionnaire with relation to performance. The study results suggest that the sensor glove and the anxiety questionnaire provided different information concerning participants' anxiety before and after performing tasks on the computer. A negative correlation between computer anxiety and performance was found using both the sensor glove measurements and the computer anxiety scores. It is concluded that the sensor glove possibly measures a different variable from the anxiety questionnaire and further research is necessary in that regard. Additionally, it is concluded that the higher an individual's levels of anxiety, the poorer he/she performed on the assessment.

1 INTRODUCTION

Computer anxiety is defined as an emotional fear or phobia experienced by individuals when using computers or when thinking of using computers (Chua et al., 1999). According to Blignaut, Burger, McDonald and Tolmie (2005, p.500) it is "a diffuse, unpleasant, and vague sense of discomfort and apprehension when confronted by computer technology or people who talk about computers". Concerning these definitions of computer anxiety, it is evident that computer anxiety involves emotional "fear" or "apprehension" when interacting or anticipating interaction with computers.

1.1 Computer Anxiety and Stress

Researchers agree that individuals experiencing computer anxiety exhibit certain physiological reactions. These reactions may include sweaty palms, dizziness or light headedness, rapid breathing, a pounding heart, feelings of unreality, chest pain, shaking or trembling (Appelbaum and Primer, 1990; Beckers and Schmidt, 2001; Mayo Clinic, 2012). Some of these physiological reactions are similar to those of individuals experiencing stress. According to Rogge (2011), the symptoms of stress include pain in the abdomen, headaches and muscle tightness or pain. For highly stressed individuals, the symptoms may include a faster heart rate, skipped heartbeats, rapid breathing, sweating, trembling and dizziness. It is apparent that, based on these symptoms of anxiety and stress, it is easy to misinterpret anxiety for stress or vice versa. To distinguish between the two, Merrill (2013) states that stress is instigated by an existing stress-causing factor or "stressor", whereas anxiety is stress that remains after the "stressor" is gone. Despite this distinction, anxiety and stress are sometimes used interchangeably with the understanding that they have a similar meaning (Princeton University, 2013). In this paper we also use the terms anxiety and stress interchangeably.

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1.2 Computer Anxiety and Performance

Individuals experiencing computer anxiety tend to score poorly in tests which require them to use computers (Glaister, 2007; Parayitam et al., 2010). In the study conducted by Glaister (2007), the student nurses who reported having medium to high anxiety levels performed poorer than those with low levels of computer anxiety. According to Parayitam et al., (2010), students experiencing computer anxiety obtain low grades as a consequence of avoiding assignments or exercises which necessitate them to use computers. Despite these findings, a recent study conducted by Olufemi and Oluwatayo (2014) revealed a non-significant difference in the performance of students with high, moderate and low computer anxiety. The performance was based on the scores obtained by the students in a computer-based test.

Since reports in the literature disagree about how computer anxiety affects performance of individuals, extensive investigations regarding computer anxiety and performance are necessary.

1.3 Computer Anxiety Questionnaires

In many research studies concerning computer anxiety, computer anxiety questionnaires have been used as the sole instruments for measuring anxiety. Examples include studies conducted by Aziz and Hassan (2012), Hismanoğlu (2011), Korobili, Togia and Malliari (2010), Longe and Uzoma (2007), and Ursavas and Teo (2011). According to Isen and Erez (2006), the exclusive use of questionnaires is insufficient for drawing conclusions about emotions. This is because of the limitations posed by this method. For example, the participants may experience ambiguous emotions which can be difficult to interpret accurately. Moreover, factors such as incentives or even rules can influence the participants to respond the way they think is appropriate or expected by the researcher (Bandura, 1971 cited in Isen and Erez, 2006). Other possible measurements are therefore worth investigating.

1.4 Physiological Measures

Physiological measures are defined as physical signals of the human body which are produced when the body undergoes psychological changes. These measures are also termed psychophysiological measures where the preceding word "psycho" emphasizes that a measurement is taken of the psychological state of an individual (Dirican and Göktürk, 2011).

Employing physiological measures is advantageous in that the measurements are objective −they do not depend on the views of the participants (unlike questionnaires). Physiological measures are also unobtrusive in that they do not interfere with the participant's natural behavior. Moreover, the signals can be measured in real-time because they are continuous (Kivikangas et al., 2011).

Special equipment is required to measure physiological signals. Examples of the equipment include the BodyMedia SenseWear armband (SwordMedical, 2010), Galvactivator (Picard and Scheirer, 2001), and the Emotion RECognition sensor system (EREC) (Kaiser and Oertel, 2006). Physiological measures are employed in a research area named affective computing. The goal behind affective computing is to provide computers with emotional intelligence and make them understand emotions in a similar way as a human being would do (Picard, 1997).

From the above-mentioned definition of computer anxiety by Chua et al., (1999), which is in agreement with Cambre and Cook (1987), computer anxiety is specified as an emotional state. As a result, it can be inferred that computer anxiety is an emotion. Since emotions have successfully been investigated using physiological measures in affective computing, it was deemed appropriate that computer anxiety be investigated using these measures.

The physiological measure employed in the present study was skin conductance. When an individual experiences increased sympathetic activation, for example, in cases of stress and nervous tension, the individual's palms become damp because increased sympathetic activity causes the sweat ducts and the surface of the skin to be hydrated. This hydration (sweating) causes the skin resistance to decrease while the conductance will increase (Barreto, 2008).

When describing changes in electrical conductance of the skin, the term generally used is EDA rather than skin conductance. EDA is reflective of the changes in autonomic sympathetic arousal associated with emotional and cognitive states (Critchley, 2002). It is among the signals that are used in polygraph ('lie-detector') tests and in studies that involve stress and cognitive workload (Picard and Scheirer, 2001). EDA is considered to be very sensitive to physiological changes (Barreto, 2008).

It is difficult to determine the cause of a certain change in skin conductance as it can be triggered by

various stimuli. However, the skin conductance level swiftly elevates in events which are major or of intense nature (for example when experiencing stress and anxiety). When executing tasks that involve mental workload, the level is inclined to increase suddenly and then decrease slowly. Normally this response occurs at the beginning of new and engaging experiences (Picard and Scheirer, 2001).

1.5 Purpose of the Study and Hypotheses

Traditionally, computer anxiety has been investigated using computer anxiety questionnaires solely. The goals of the present study were to: (1) establish whether using a sensor glove provided complementary knowledge to an existing computer anxiety questionnaire; (2) compare the computer anxiety of participants using a sensor glove and an anxiety questionnaire with relation to performance.

The following statistical null hypotheses were tested:

H1: There is no correlation between existing computer anxiety questionnaire scores and conductance readings of the sensor glove before and after interaction with a computer.

H2: There is no correlation between computer anxiety and performance according to computer anxiety questionnaire scores and skin conductance readings.

2 METHODS

2.1 Participants

Purposive sampling was used to recruit 58 participants for the study. The participants were computer illiterate individuals who had recently been enrolled in a partnership programme at a local university. In this programme, the participants received free computer literacy training for one week. The participants were recruited for this study after completing the programme. The participants had basic education (with Matric or Grade 12 as the highest qualification) and the majority of them did not have access to computers at home. Because of their background, it was expected that the participants would exhibit anxiety when working with computers. An informed consent form was issued to each participant before the data collection commenced.

2.2 Measures

As mentioned earlier, data were gathered using an existing computer anxiety questionnaire and an instrument for measuring physiological data. Additional methods for collecting data were pre-test and post-test self-developed questionnaires, observations and interviews.

2.2.1 Computer Anxiety Rating Scale

The questionnaire instrument used in the present study was the Computer Anxiety Rating Scale (CARS), developed by Heinssen, Glass and Knight (1987). CARS consists of 19 items with a five-point Lickert type scale rated from 1 (strongly disagree) to 5 (strongly agree). The CARS scores range from 19 to 95 where the higher scores reflect higher levels of computer anxiety (Heinssen et al., 1987). The CARS questionnaire was completed by each participant before and after executing tasks on the computer. The aim was to measure and compare the levels of computer anxiety of the participants at these two instances.

2.2.2 Emotion RECognition System

The physiological measuring instrument used in the study was the Emotion RECognition system (EREC II) sensor glove. According to Kaiser and Oertel (2006), the EREC system was developed in Germany at the Fraunhofer Institute for Computer Graphics Rostock (IGD-R).

The two main parts of the EREC system are the sensor unit and the base unit. The sensor unit, in the form of a glove, contains the skin resistance and skin temperature sensing elements. Additionally, the sensor unit measures the environmental air temperature. The sensing elements are integrated in the glove, but the sensor circuitry is placed in a small wrist pocket (Peter et al., 2007). The components of the EREC II are shown in Figure 1.

Although EREC can be used to measure skin temperature, skin resistance and heart rate, in this study the researchers were particularly interested in skin conductance which was calculated from the skin resistance measurements. Skin resistance is measured in Kilo-ohms (kΩ) which was converted into conductance in milli-Siemens (mS). Conductivity is the reciprocal of resistivity, therefore the conversion was performed easily. The EREC system captured ten skin resistance readings per second and the data were recorded in a Microsoft (MS) Excel application.

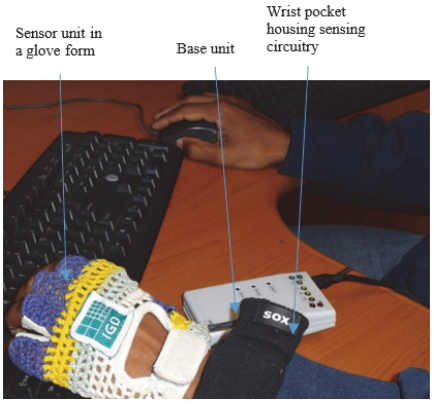

Figure 1: EREC II components (Picture taken in the usability lab at the research institution.).

2.2.3 Pre-test and Post-test Questionnaires

The pre-test questionnaire was used for capturing demographic data, for example age and gender. The post-test questionnaire was used to record the subjective emotions (anxiety and/or stress) experienced by the participants during the different stages of data gathering. The participants indicated which among the allocated nine tasks caused them to experience the two emotions. They also provided their perceived reasons for experiencing those emotions. Furthermore, the participants were required to rate their experiences with the glove in terms of comfort and time taken to set it up.

2.2.4 Observations

Each participant performed tasks on the computer in a usability lab. The recordings were taken according to a pre- designed schedule using pen and paper. Recordings of time-on-task and task success were noted. Time-on-task allowed the researchers to assess the various task durations. The task success rate (percentage of the tasks completed successfully) enabled the researchers to evaluate the performance of the participants by task. The tasks that were not completed in the given amount of time were also noted. Also of importance were the overt behaviours of the participants, such as body language, words uttered, and facial expressions.

2.2.5 Interviews

Interviews were conducted after the participant had completed the questionnaires to ensure that the researchers understood what was written in the questionnaire, as some responses to the questions were not legible or written in improper English.

2.3 Procedure

The data was collected in the usability lab of a local university. The usability lab offered a suitable environment for the use of the testing instruments, with one participant at a time performing tasks on a computer.

The participant wore the EREC sensor glove and completed the pre-test and CARS questionnaires before executing tasks using the MS Word application. The tasks were presented in a small moveable application window which was designed in such a way that only one task was displayed at a time. A “next” button appeared on the application window that allowed the participant to display the subsequent task. While the tasks were presented in the application window, the MS Word application was opened simultaneously on the screen behind the application window containing the tasks. Consequently, the participant was able to view the task to be performed as well as the MS Word application where the execution of tasks was performed. The participant was assigned three minutes for each task.

After executing all the tasks, the participant was required to complete the post-test questionnaire, and once again the CARS questionnaire. An interview was conducted with the participant to clarify responses to the questionnaires.

3 RESULTS

3.1 Demographics

Data were gathered from 58 participants of whom 25 were males and 33 females. The participants’ ages ranged from 16 to over 40 years. The largest proportion of participants (36.2%) was in the age group of 21 to 25 years, whereas only 3.4% of participants were older than 40 years. The largest group of the participants (70.7%) spoke Sotho or Tswana as their home language, followed by Xhosa (25.9%). Only one participant each (1.7%) spoke Afrikaans and Zulu as their home language. With regard to educational background, 47 (81%) of the participants had completed Matric, whereas 11 (19%) had not.

3.2 Hypothesis Testing

The participants were required to complete the CARS questionnaire before and after performing the tasks on the computer. The CARS scores (pre and

post assessment) were compared with the skin conductance readings of the EREC sensor glove before and after the assessment. The comparisons were made to address the first hypothesis stated as:

H1: There is no correlation between existing computer anxiety questionnaire scores and conductance readings of the sensor glove before and after interaction with a computer.

The aim of the comparison was to establish whether the results provided similar or different information regarding levels of anxiety before and after the assessment (interaction with the computer). The existing computer anxiety questionnaire used was the CARS. A correlation test was performed in the following instances to investigate the following:

3.2.1 Anxiety before Assessment

3.2.1.1 The Correlation between Total Scores on the CARS Pre-test Questionnaire and the Average Skin Conductance Readings during the First Minute of Wearing the Glove

Results:
There was no significant correlation ($r = 0.144$, $p > 0.05$) between the pre-test questionnaire score and the average skin conductance reading for the first minute (see Figure 2 for the scatterplot).

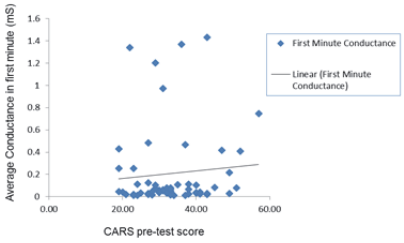

Figure 2: Average conductance in first minute as a function of CARS pre-test score.

Finding:
From this result we can conclude that the sensor glove (first minute) and the CARS pre-test questionnaire potentially provide different information regarding levels of anxiety before the assessment.

3.2.1.2 The Correlation between Total Scores on the CARS Pre-test Questionnaire and the Average Skin Conductance Reading on the Sensor Glove during the Entire Assessment

This correlation was calculated to investigate whether the result found in 3.2.1.1 was caused by inaccurate reading of anxiety during the first minute.

Results:
There was no significant correlation ($r = 0.168$; $p > 0.05$) between the total scores on the CARS pre-test questionnaire and the average skin conductance reading on the sensor glove during the entire assessment (see Figure 3 for the scatterplot).

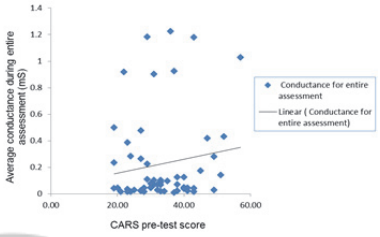

Figure 3: Average conductance during entire assessment as a function of CARS pre-test score.

Finding:
This result confirms the conclusion made in 3.2.1.1. The sensor glove and the CARS pre-test questionnaire potentially provide different information regarding levels of anxiety before the assessment.

3.2.2 Anxiety after Assessment

3.2.2.1 The Correlation between Total Scores on the CARS Post-test Questionnaire and the Average Skin Conductance Readings during the Last Minute of Wearing the Glove Was Calculated

Results:
There was no significant correlation ($r = 0.192$; $p > 0.05$) between the total scores on the CARS post-test questionnaire and the average readings during the last minute of wearing the glove (see Figure 4 for the scatterplot).

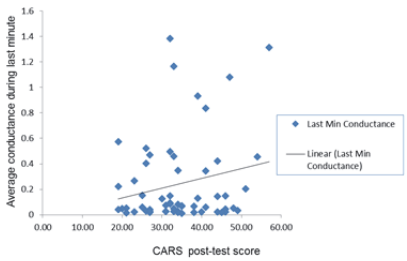

Figure 4: Average conductance during the last minute as a function of CARS post-test score.

Finding:
From this we can conclude that the sensor glove (last minute) and the CARS post-test questionnaire potentially provide different information regarding

levels of anxiety after the assessment.

3.2.2.2 The Correlation between Total Scores on the CARS Post-test Questionnaire and the Average Skin Conductance Readings on the Glove during the Entire Assessment was Calculated

This correlation was calculated to investigate whether the result found in 3.2.2.1 was caused by inaccurate reading of anxiety during the last minute.

Results:

There was no significant correlation ($r = 0.229$; $p > 0.05$) between the total scores on the CARS post-test questionnaire and the average readings of the glove during the entire assessment (see Figure 5 for the scatterplot).

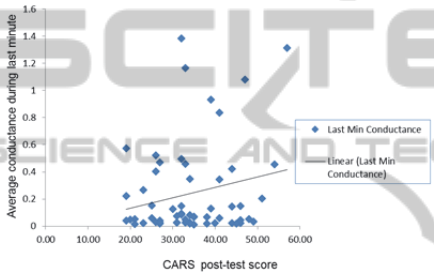

Figure 5: Average conductance during entire assessment as a function of CARS post-test score.

Finding:

This result confirms the conclusion made in 3.2.2.1. The sensor glove and the CARS post-test questionnaire potentially provide different information regarding levels of anxiety after the assessment.

In order to confirm the finding that the sensor glove and the CARS questionnaire potentially provide different information regarding levels of anxiety, another statistical test, Multivariate Analysis of Variance (MANOVA) was conducted to confirm the findings that were established from using the correlation test.

Participants were divided into three categories: those with high anxiety scores, those with medium anxiety scores, and those with low anxiety scores, all according to the skin conductance readings of the sensor glove. The CARS pre-test scores and the CARS post-test scores were then compared among these three groups.

i. If the glove and the CARS questionnaires provide the same information, we would expect that there would be differences in the self-reported anxiety scores between these three groups.

ii. If the glove and the CARS questionnaires provide different information, we would expect that there would be no differences in the self-reported anxiety scores between these three groups.

Table 1: Summary of findings regarding anxiety before and after assessment.

Stat. Test	Variables	Result	Finding
CORRELATION	CARS pre-test total score, average skin conductance reading in first minute	No significant correlation ($r = 0.144$; $p > 0.05$)	Sensor glove (first minute) and CARS pre- test questionnaire potentially provide different information about levels of anxiety before the assessment.
	CARS pre-test total score, average skin conductance reading for the entire assessment	No significant correlation ($r = 0.168$; $p > 0.05$)	Sensor glove and CARS pre-test questionnaire potentially provide different information regarding levels of anxiety before the assessment.
	CARS post-test total score, average skin conductance reading in last minute	No significant correlation ($r = 0.192$; $p > 0.05$)	Sensor glove (last minute) and CARS post- test questionnaire potentially provide different information regarding levels of anxiety after the assessment.
	CARS post-test total score, average skin conductance readings for entire assessment	No significant correlation ($r = 0.229$; $p > 0.05$)	Sensor glove and CARS post-test questionnaire potentially provide different information regarding levels of anxiety after the assessment.
MANOVA	CARS pre-test scores, CARS post-test scores (among 3 groups of different anxiety levels according to sensor glove)	No significant differences ($F = 0.798$; $p > 0.05$)	Confirms that sensor glove and CARS questionnaire potentially provide different information regarding levels of anxiety.

Results:

No significant differences ($F = 0.798$; $p > 0.05$) were found in the self-reported anxiety scores (for the pre-test and the post-test) between these three groups.

Finding:

This result confirms that the sensor glove and the

CARS questionnaire potentially provide different information regarding levels of anxiety.

A summary of the statistical tests concerning the anxiety according to the sensor glove and the CARS questionnaire is presented in Table 1.

From these results the first hypothesis, H1 cannot be rejected, since $p > 0.05$. Although statistical tests showed no significant correlations between CARS scores and the glove readings, the scatterplots reflect the small positive correlation between conductance measurements and CARS scores; possibly those correlations are small (and not statistically significant) because of much noise in the data. Note the scatterplots show the conductance measurements to be close to zero (below 0.2) for most subjects. However, for about 18 other subjects the conductance measurements are very variable, some values are up to about 1.2. Moreover, the researchers encountered a challenge of non-continuous measurements of skin conductance. With some participants the EREC glove momentarily stopped recording the skin conductance because the sensors of the glove were no longer in contact with the skin despite the Velcro straps that were used to tighten the sensors to the skin. This could have caused noise in the data.

The second hypothesis was stated as:

H2: There is no relationship between computer anxiety and performance as measured by a sensor glove and a computer anxiety questionnaire.

This hypothesis was addressed by performing correlations between the CARS scores and performance scores, and the skin conductance readings with performance scores. Performance was measured as the percentage of tasks which were completed successfully/correctly by each participant.

Table 2: Summary of findings regarding anxiety and performance.

Stat. test	Variables	Result	Finding
CORRELATION	CARS pre-test score, performance score	Significant negative correlation ($r = -0.331$; $p < 0.05$)	The higher the levels of anxiety, the poorer the performance on the assessment.
	CARS post-test score, performance score	Significant negative correlation ($r = -0.332$; $p < 0.05$)	
	Average skin conductance readings during the entire assessment, performance score	Significant negative correlation ($r = -0.300$; $p < 0.05$)	

In order to determine whether there is a relationship between anxiety and performance, the analyses shown in Table 2 were performed.

Considering the results in Table 2, the second hypothesis, H2 can be rejected at $p < 0.05$ in all the related tests.

3.3 Observations

When the participants performed the nine tasks on the computer, two measurements were recorded, namely the time-on-task and the task success rate. Moreover, the behaviours which were exhibited by the participants when performing the tasks were observed and recorded. The three types of recordings are presented in the subsequent sections.

3.3.1 Time-on-Task and Task Success

A maximum of three minutes was allocated to each of the nine tasks that a participant was required to perform in a word processor application. Time-on-task was recorded for each task and when three minutes had elapsed the participant was asked to stop and continue with the next task, even if the current task was incomplete. Table 3 depicts the time-on-task and task success rate for each of the nine tasks.

From Table 3, it can be seen that the last task "Save" was performed in the longest time (average = 2 min, 41s) while the task "Bold" (average = 37s) took the shortest time to complete.

Table 3: Average, minimum and maximum durations of tasks.

Tasks	Time-on-task			Task success (%)
	Average time-on-task (mm:ss)	Minimum time-on-task (mm:ss)	Maximum time-on-task (mm:ss)	
Center	1:13	0:08	3:00	84.2
Change to italic	0:49	0:06	3:00	84.2
Change line spacing	2:01	0:15	3:00	43.9
Cut & Paste	2:16	0:38	3:00	43.9
Change font size	0:39	0:06	3:00	84.2
Bold	0:37	0:06	3:00	93.0
Underline	0:56	0:13	3:00	89.5
Bullet	1:37	0:25	3:00	77.2
Save	2:41	0:29	3:00	10.2

Table 3 also depicts the task success rate. The

task success rate according to each of the nine tasks shows the percentage of participants who completed successfully/correctly each of the tasks. In agreement with the time-on-task, the task success rate shows that the task "Save" had the lowest task success rate (10.2%) while the task "Bold" had the highest rate (93.0%). This means that the majority of participants failed to complete the task "Save" successfully, but executed the task of "Bold" successfully. Considering both time-on-task and task-success, it can be seen that the task that most participants failed to execute successfully was the task that required the longest time to perform.

3.3.2 Observed Behaviours

As mentioned earlier, the participants were observed as they were executing the tasks. Some behaviours exhibited by the participants who were failing or struggling to perform the tasks were: fidgeting in the chair, tapping fingers on the table, moving closer and away from the monitor, exclaiming in bewilderment or disappointment, sighing, shaking head in denial, constant blinking of eyes, trembling hands, uttering words (for example, words that pleaded with computer to do something), staring at the monitor, and holding the face with two hands with elbows on table. It was noted that among the tasks that were performed, almost all the participants struggled with the last task, which was to save the document in a specified location. When they had to complete this task, most participants exhibited some of the above-mentioned behaviours. However, these behaviours were also noticed when participants performed a few of the earlier tasks.

3.4 Findings from Questionnaire Data

The following are the findings made from the data collected from the pre-test and post- test questionnaires where different themes were discovered.

3.4.1 EREC Sensor Glove

Most of the participants described the glove using phrases such as "interesting" and "comfortable." They stated that the glove did not disturb or distract them when performing the tasks on the computer, although they were "conscious" that they were wearing it.

3.4.2 Participants' Reported Emotions

The participants felt excited, afraid, neutral and frustrated while using the computer. However, the majority felt excited when they thought of using a computer, while they were using it, and even after using it.

Regarding the tasks which they performed, the majority of the participants described that they were stressed rather than anxious or afraid. Most participants were stressed by the last task, "Save." The reasons that participants provided for being stressed and/or anxious were classified into eight categories namely: lack of knowledge on how to perform the task; difficulty in performing the task; consciousness of time; exercised caution to avoid mistakes; uncertainty of whether a task was performed correctly; lack of remembrance; first time experience; and lack of confidence to execute the task correctly.

4 DISCUSSION

The following discussion is based on the results regarding the sensor glove, the reported emotions experienced by the participants, the observations and the statistical findings.

4.1 EREC Sensor Glove

Since most participants found the glove to be "interesting" and "comfortable", and not disturbing nor distracting, it can be concluded that the sensor glove, as a measuring tool, is suitable in terms of comfort and can therefore be recommended for other studies. Nonetheless, the size of the sensor glove in relation to the size of the participants' hands should be carefully considered. In this study, the glove was found to be too small for some hands and in some cases the wires were disconnected as a consequence of the glove being stretched. In such instances of discontinuous data, the data was discarded in order to use valid data only.

4.2 Emotions

As stated earlier, the participants reported having experienced various emotions, which included excitement, anxiety (or fear) and frustration, while using the computer. It can be expected that the participants were excited and anxious simultaneously because experiencing something interesting for the first time can be exciting. At the same time one can be somewhat afraid of the unknown. The feeling of frustration can also be expected when one fails to execute tasks, especially

when one "was careful not to do mistakes" or felt that "time was running out and I was not doing it", as some of the participants reported. It is most likely that participants experienced frustration which led to stress as they were performing the last task which most participants failed to complete.

4.3 Findings from Observations and Questionnaires

Considering the results from the observations, it is apparent that the last task caused the participants anxiety or stress. The participants took the longest time to perform it and struggled the most to execute it (see Section 3.3.1). Moreover, the participants reported that they felt stressed when performing it (see Section 3.4.2). Moreover, most of the behaviours which were exhibited by the struggling participants (see Section 3.3.2) were observed when the last task was executed. These behaviours exhibited by the participants who were failing or struggling to perform tasks (for example, sighing, shaking head in denial, and constant blinking of the eyes) were observed, as mentioned in Section 3.3.2 The behaviours (for example, trembling) were mentioned in literature (Mayo Clinic, 2012; Rogge, 2011) as behaviours common to individuals experiencing computer anxiety or stress. It was therefore evident that at some point the participants experienced anxiety, taking into consideration that stress and anxiety are difficult to differentiate as mentioned in Section 1.1.

4.4 Computer Anxiety and Performance

Statistically significant negative correlations were found between anxiety and performance, suggesting that a relationship between performance and anxiety probably exist; the higher a person's levels of anxiety, the poorer he/she performed on the assessment. Since this relationship was found from the results of both the CARS questionnaire and the sensor glove, we conclude that computer anxiety possibly has an effect on the performance of the users performing tasks on the computer.

4.5 Reviewing the Goals of the Study

The first goal of this study was to establish whether using a sensor glove provided complementary knowledge to an existing computer anxiety questionnaire. No significant correlations were found between the measurements of anxiety using respectively the sensor glove and the CARS questionnaire (see Table 1). One possible interpretation of this finding is that the sensor glove does not measure the same variable as the CARS anxiety questionnaire, and thus potentially provides different information on anxiety than the CARS questionnaire. Of course, the absence of significant correlations would also be explained by either one of the instruments, or both, not being suitable measures of anxiety. However, both measurements were significantly correlated with performance, which suggests that both instruments return a signal, and not just noise. The CARS questionnaire has been validated as a measurement of anxiety whereas the sensor glove has not been validated for that specific measurement. The sensor glove measures skin conductance or GSR which, according to literature (Lin and Hu, 2005; Picard, 1997), has been used successfully to measure stress. What remains to be investigated is the relationship (or a distinction) between computer anxiety and stress because it is evident that anxiety and stress, though different, are closely related.

The second goal of this study was to relate computer anxiety of participants, as measured by a sensor glove and an anxiety questionnaire, respectively, to performance. Our findings suggest that a relationship between anxiety and performance probably exists, namely the higher an individual's levels of anxiety, the poorer he/she performed on the assessment. This finding was also reported by Glaister (2007) and Parayitam et al., (2010), but contradicts the finding of Olufemi and Oluwatayo (2014) who found no significant differences in performance scores in subjects with high, moderate and low computer anxiety. Again we can note that it is difficult to distinguish between stress and anxiety. The task that the participants failed to complete was the one reported to cause the highest stress. In effect, the majority of the participants indicated that they experienced stress rather than anxiety as they were performing the tasks.

4.6 Recommendations for Further Research

The present study that investigated computer anxiety using physiological measures is amongst the first of its nature in a third world country. Recommendations for further research are therefore presented. Firstly, skin conductance readings of one minute before and after interaction with the computer may not have been optimal. This design could have influenced the correlation between the

sensor glove and the CARS. No literature references have been found on the optimal duration for reading conductance. It is suggested that a research study be conducted to establish the optimal timing of conductance measurements using the sensor glove.

Secondly, it is noted that the measurements using the sensor glove and the anxiety questionnaire, respectively, had similar correlations with performance, yet the two types of measurements of anxiety were not significantly correlated. These findings call for deeper investigation of objective and subjective measures of computer anxiety in the context of third world countries.

Thirdly, the participants were directly observed while performing tasks in this study. Since the participants were aware that they were being observed, there is a possibility that the measurements could have been influenced by this awareness. Perhaps a study conducted with participants who are oblivious of being watched would produce different results.

Fourthly, since the start of this study, improved versions of the sensor glove have appeared on the market. Furthermore, the glove used in the present study was small and volatile. Using the improved version of the glove in similar investigations might provide interesting results.

Fifthly, a study which includes another instrument, such as a heart rate monitor could give more understanding about computer anxiety. In this study heart rate was not measured because the heart rate monitor packaged in the EREC malfunctioned and due to time constraints it could not be fixed.

The final recommendation for follow-up studies is to establish the relationship between anxiety and stress. Perhaps a study could be conducted where both anxiety and stress questionnaires are employed. The data from the two questionnaires could be related to conductance data from the sensor glove. The findings of such a study could provide more insight about anxiety and stress when interacting with a computer. A study that utilised a stress questionnaire and conductance data (Lin and Hu, 2005) has already been performed. However, in that study an anxiety questionnaire was not included.

5 CONCLUSIONS

This study investigated computer anxiety using subjective (scores from an anxiety questionnaire) and objective (conductance data from the sensor glove) measures. The correlations between apparent computer anxiety and performance were similar using the two measures of anxiety. The study findings confirmed the literature where it has been stated that the higher the anxiety levels of an individual, the poorer they are likely to perform. Additionally, this study is amongst the first research studies conducted in a third world country where computer anxiety was measured using an objective physiological instrument.

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