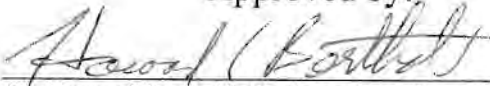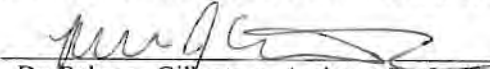The Effect of the Color Red on Test Anxiety
and Academic Achievement

Presented to the faculty of Lycoming College in partial fulfillment
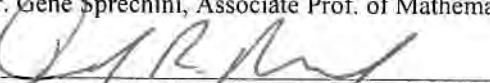of the requirements for Departmental Honors in
Psychology

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The Effect of the Color Red on Test Anxiety

And Academic Achievement

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Abstract

Previous researchers have suggested that the color red might have a detrimental effect on student achievement and test anxiety. My study utilized 4 different measures to examine changes in anxiety measured before and after students received quiz results graded with either red or black ink. Participants were 29 undergraduate Introduction to Psychology students at a small liberal arts college. Results showed that after receiving the graded quizzes, galvanic skin responses increased, blood pressure and scores on the State Trait Anxiety scale decreased, and heart rate remained the same. The only anxiety measurement showing an effect of ink color was the State Trait Anxiety Scale. Students receiving comments and corrections in red ink showed a statistically significant decrease in anxiety on the self report scale compared to students receiving feedback in black ink. Unfortunately, students did not perform better on a second administration of the quiz several days after reviewing their graded quizzes. Thus, an effect on performance caused by a change in anxiety due to ink color could not be determined. Perhaps if the quiz counted toward the students' grades, greater changes in anxiety and performance would have occurred and the relationship between ink color, various measures of anxiety, and performance would have been more apparent.

The Effect of the Color Red on Test Anxiety and Academic Achievement

When a person becomes anxious they usually experience symptoms such as increased heart rate, shortness of breath, perspiration, dry mouth, and muscle tension (Honig, 2010). Students may have a reaction similar to this when they are anticipating results from an exam. This is known as test anxiety. Sometimes the results they receive create an increase in the anxiety that they feel simply from the color of the corrections made to the exam by the professor. The current study focuses on the effect the color red has on anxiety in students through measurement of the galvanic skin response, heart rate, blood pressure and assessment of the State form of the State-Trait Anxiety Inventory, and if that anxiety has an effect on academic achievement in students.

Previous research in this area produced results suggesting that academic achievement in students is affected by the color red (Elliot, Maier, Binser, Friedman, & Pekrun, 2009; Gnambs, Appel, & Batinic, 2010; Lichtenfeld, Maier, Elliot, & Pekrun, 2009; Maier, Elliot, & Lichtenfeld, 2008). As humans, associations are made based on past experiences. For example, the color red may be associated with signs of danger or warning, and also signs of failure, defeat, or mistake. Red is associated with stop signs, emergency exit signs, fire alarms, and in areas that may pose a threat to our safety. These associations may cause the color red to grab our attention due to associations with the color. This may be a reason why teachers often use red pens to correct exams. The teacher wants to draw attention to suggestions that may help students improve their knowledge and work.

A number of researchers have studied the effect of red on academic performance. Gnambs, et al. (2010) gave 131 college psychology and economic majors an online

knowledge test. An experimental group viewed a red progress bar in the upper right hand corner of the page. The control group viewed a green progress bar in the upper right hand corner of the page. The green color group scored higher on the knowledge test than the red color group. Therefore, this study supports the idea that the color red produces a negative effect on achievement in students.

Elliot, et al. (2009) proposed that red created an avoidant behavior in achievement contexts but has no effect on avoidant behavior in non-achievement contexts. The study consisted of two experiments. In the first experiment, participants were assigned to a red or green condition. Participants were then divided into an achievement group or a non-achievement group. The achievement group was given the task of taking an exam. The non-achievement group was given the task of rating the style of an exam. Within each of the two groups, participants were given a folder which contained the task they were given. Half of the achievement group and half of the non-achievement group received a cover page with a red rectangle on the front and half of the achievement group and half of the non-achievement group received a cover page with a green rectangle on the front. Participants were then instructed to go to another room to complete the task. For all participants, the door to the assigned room was locked and the number of times the participants knocked to be let in the room was recorded. In the achievement group of those taking the exam, participants in the red condition knocked fewer times than those in the green condition. This suggests that participants in the achievement group placed in the green condition were more persistent to fulfill the achievement task given than those in the red condition. However, color had no effect on amount of times participants knocked when participants belonged to the non-achievement group. In the second

experiment, male and female students were divided into three different groups; a red condition group, a green condition group, and a gray condition group. In this experiment, participants were set in front of a computer monitor and were told they were going to be taking an IQ test. The cover page of the test was shown. Those in the red condition group were shown a cover page with the title placed on a red rectangle, those in the green condition group were shown the title placed on a green rectangle, and those in the gray condition were shown the title placed on a gray rectangle. Participants did not take the IQ test but movement by the participants after they were exposed to the cover page was analyzed. Results found that participants in the red condition showed avoidant behavior by moving away from the cover page. The overall results of these experiments suggest that the color red produces a negative as well as avoidant effect on achievement (Elliot, et al., 2009).

Lichtenfeld, et al. (2009) suggests that even being exposed to the word "red" has detrimental effects on academic achievement. In this experiment, male and female participants were divided into two groups; an experimental group and a control group. Both groups completed an IQ test. On the test, the copyright label was altered to contain either the word "red" or the word "green." The experimental group completed the IQ test with the copyright label which contained the word "red" and the control group completed the IQ test which contained the word "green." Results found that participants in the red condition performed worse on the IQ examination than those in the green condition. This suggests that even processing the word "red" has a negative impact in academic achievement contexts (Lichtenfeld, et al., 2009).

In four experiments conducted by Elliot, et al. (2007) participants were briefly exposed to the color red before taking a test. Tests consisted of an anagram test, an analogy test, another analogy test, and a number-based task. In all experiments, participants in the red color condition exhibited avoidance (chose easier questions) and performed worse on the tests than those in green, black, white, or gray color conditions.

Maier, et al. (2008) conducted a series of experiments which also supported avoidance and poor academic performance after viewing the color red. In the first experiment, participants were exposed to a red triangle or a gray triangle printed on the cover page of an IQ test. Participants then completed an IQ test. Participants in the red condition answered fewer items correctly than those in the gray condition.

In the second experiment, participants were told that they would be taking an IQ test. A red or gray rectangle was on the front cover of the test. Participants were exposed to the colored rectangle for two seconds and were then told to complete a filler task before the IQ test. The filler task consisted of a 12-item visual matching task. The more limited the participants attentional focus was, the more the participant is likely to choose the local selection. Participants did not have to complete the IQ test. Participants in the red condition made more local selections in the matching task than participants in the gray condition. Therefore, this supports the idea that participants in the red condition had less attentional focus than participants in the gray condition.

Although these previous studies suggest detrimental effects of the color red on academic achievement situations, there is a study that suggests the color red may enhance performance in academic situations. Mehta and Zhu, (2009) measured participant achievement in a detailed-task. Participants completed the task on a computer with red,

blue, or neutral background color. Participants studied a list of 36 words for 2 minutes

and were asked to recall as many of the words as they could after 20 minutes. Participants

in the red condition group recalled more words than those in the blue condition group.

Most of the research done on the effect the color red has on academic

achievement suggests that the color red has detrimental effects. However, the research

done in this area did not examine students when they are assessed on normal classroom

material. The past research also did not measure the amount of anxiety that is produced

by viewing the color red and how that anxiety effects academic achievement in students.

The current study is interested in measuring the anxiety that is produced when

exposed to the color red. Little research has been done in this area. A study conducted by

Honig (2010) measured anxiety in participants before and after exposure to red light or

blue light. Heart-rate, finger temperature, and respiration were recorded. Anxiety was

measured using the State-Trait Anxiety Inventory (STAI) short form before and after

exposure to the red or blue color. Before the color was shown, the Tellegen Absorption

Scale was administered to participants. The Tellegen Absorption Scale is a paper and

pencil test which contains 34 statements in which the participant rates themselves of how

true the statement is to them on a scale of 0-4 (i.e. 0 being Not At All, 4 being

Completely). The items on the scale assess one's openness to experience, emotional and

cognitive alterations across various situations, and are associated with periods of relaxed

focused attention. Participants exposed to the color red had higher anxiety than

participants exposed to the color blue, although results were not significant. The study

consisted of a small sample size and a large variance among the observed measures

which is believed to be why results were not statistically significant. The lack of research

done in this area demonstrates the need for further research. The current study intends to

further research in this area by measuring the effect of the color red on anxiety in students.

Measures of Anxiety

   Galvanic skin response and heart rate. In the past, several physiological

processes were used to measure anxiety, including galvanic skin response, heart rate, and

blood pressure as measurements of anxiety. With regard to GSR, the Biopac Student Lab

Manual states that:

   the galvanic skin response (GSR) or electrodermal activity is one variable

   traditionally associated with sympathetic nervous system activity. The

   galvanic skin response is affected by sweat gland activity and skin

   responses on the palmar surface of the hand. Unlike the heart, the sweat

   glands are only activated by sympathetic activity. If the sympathetic

   branch of the autonomic nervous system is highly aroused, then sweat

   gland activity increases and consequently, so does GSR. Because of this

   association, the GSR is traditionally used as an index of sympathetic

   activity. When a person is relaxed, then the GSR should be low (Pflanzer,

   Uyehara, & McMullen, 2003. p.2).

The manual also states that:

   GSR is a measure of electrical conductance and the units of the GSR

   recording are given in "mho". In 1885, Oliver Heaviside coined the term

   "mho" to represent the units of electrical conductance. Electrical

   conductance is the reciprocal of electrical resistance, which is measured in

   ohm (Ω). Therefore, the mho unit was adopted by spelling ohm backwards

and is represented by an upside down Greek letter omega. The SI unit of

electrical conductance is the Siemens (S). Therefore, in the current study,

GSR recordings are given in "mho" (Pflanzer, et al., 2003. P.11).

Peretti (1990) provides an example of how GSR has been used to measure anxiety.

The study examined the effect music, sex, and academic discipline had on anxiety. In this

study, anxiety was measured through changes in galvanic skin response (GSR). GSR was

measured first while students performed a pencil-maze task, and again while students

performed the same task while listening to music of the participant's choice.

Chattopadhyay, et al., (1975) recorded GSRs of anxiety state patients and people without

anxiety state. Groups were matched according to age, sex, and socioeconomic level. GSR

measurements were recorded during task-performance and also when participants were at

a rested state. GSR was analyzed through mean level differences, variability, instabilities

trends, amplitude of response, onset and offset angle of response, and recovery time.

Bacow, et al., (2010) measured self-reported anxiety and physiological arousal in

participants before and after treatment for panic disorder. Self-reported anxiety was

measured through subjective units of distress (SUDS). Physiological anxiety was

measured through recordings of heart rate. Average heart rate was calculated during each

task the participants were given and were compared to the average of a 3-minute baseline

heart rate.

Marsh, et al., (2011) which examined psychopathic adolescents and the

physiological responses they have to fearful situations. Participants were asked to recall

situations in which they experienced anger, fear, disgust, happiness, and sadness.

Participants completed a two-page section of questions which asked questions for each

emotion. Self-report checklists were provided which describe numerous physiological changes, including sweat and increased heart rate, which would be related to the GSR and HR measures used in the current study. This study doesn't directly measure GSR as a form of anxiety. However, GSR is measured by changes in skin conductance which is related in this study through self-reports of sweating. Also, this study measured heart beating faster which is another measure (change in HR) used in the current study.

Najström & Högman (2003) measured skin conductance of two groups of soldiers. One group had combat experience and the other group had not experienced any truly disturbing emotional experience within the last 5 years. Participants were shown both emotionally charged and neutral pictures. The soldiers' reactions to the pictures were measured through skin conductance responses. Results did not show any differences in arousal between the two groups.

Hyman and Gale (1973) examined galvanic skin response measurements of females with a phobia of snakes during systematic desensitization. Participants were given tasks in which they had to visualize scenarios in which a snake was present and then rate how they felt using the Fear Survey Schedule (FSS).Galvanic skin response of participants was used to measure anxiety in the participants just before each visualization and scoring response.

Myers (1974) investigated the effect systematic desensitization has on people with speech anxiety. Participants were given a self-reported anxiety pretest. The elements of this pretest were not specified. Participants with the highest self-reported anxiety rating were assigned to the experimental group. Participants in the experimental group received systematic desensitization sessions. GSR measurements were taken during the first and

last days of the sessions. Participants in the control and experimental groups both

received a self-reported anxiety post-test.

The preceding studies found that GSR and HR both increased as anxiety in

participant's increased. These studies demonstrated the frequent use of GSR and HR as a

measure of anxiety in a wide variety of studies.

Blood pressure. Blood Pressure has also been used as a measurement of anxiety

used in numerous studies. In a study by Egloff, Neubauer, Mauss, and Gross (2002),

participants completed the trait form of the STAI (State-Trait Anxiety Inventory).

Participants were then exposed to a threatening word and a neutral word shown at the

same time on a computer screen. One week later, physiological instruments measuring

Heart Rate (HR) and Blood Pressure (BP) were connected to the participant.

Physiological recordings were taken as the participant viewed a 3-minute nature video

and again as the participant performed a 3-minute speech task. Results found that the

physiological measures of anxiety (Heart Rate and Blood Pressure) in the participants'

were increased during the speech task than while watching the nature film.

In a study done by Hughes and Callinan (2007), undergraduate student

participants were administered the Personality Research Form, the STAI and a

questionnaire which examined expected task difficulty, expected threat, and anticipated

ability to cope from the tasks. The tasks were then explained to the participant and the

blood pressure cuff was applied to the participant's non-dominant arm. Participants were

instructed to relax during a 6 minute baseline period. Participants were then instructed to

complete the two tasks. Blood pressure measurements were taken in 2 minute interims

throughout the procedure. After the two tasks were completed, the blood pressure cuff

was removed and participants were asked to complete the STAI and a questionnaire which assessed the difficulty of each task. The participant was then given a packet containing the Ways of Coping Questionnaire and another questionnaire concerning health information. The participant was advised to take the packet home, complete it, and submit the packet to the experimenter at an agreed time later that week. Results found that blood pressure increased as a result of the anxiety created by the tasks the participants were asked to perform. In general, all of the previously cited studies found increases in GSR, HR, and BP consistent with situations and stimuli that experimenters predicted would increase anxiety.

My study is interested in the average Blood Pressure of the participants. The Mean Arterial Pressure (MAP) is the average arterial pressure during a single cardiac cycle (Wikipedia, 2011). Therefore, the measurement of Blood Pressure in the current study is measured in MAP. The wide-known connection of GSR, HR, and BP to anxiety as mentioned in the cited studies is the motive for use of GSR, HR, and BP as measurements of anxiety in the current study.

STAI. Anxiety is also measured through self-report tests. The State-Trait Anxiety Inventory (STAI) is a self-report measure used in studies to measure anxiety and is known to be valid and reliable. Gunning, et al., (2010) examined maternal anxiety in pregnant women. Participants were given the STAI and were asked to answer an open-ended question asking how they felt about their pregnancy. Results of lower anxiety from the STAI correlated with more "positive" answers to the open-ended question. Onyeizugbo (2010) examined test anxiety and test performance in students. Participants were informed they would be given a test. Before the test, they were given the General

Self-efficacy Scale, State-Trait Anxiety Inventory, and Westside Test Anxiety Scale. A

book by Anderson and Sauser (1995) examined the theory, assessment, and treatment of

test anxiety. In the book, the STAI is used several times as measures of test anxiety. One

of the chapters reviews different anxiety scales and it is stated that "The STAI has

become the most widely used measure of both trait and state anxiety" (Anderson &

Sauser, 1995, P.38). The STAI is a respected self-report anxiety measure was used in the

current study due to its outstanding reputation and use in other studies. The current study

is particularly interested in the state anxiety of the participants. Therefore, only the state

form of the STAI was assessed.

Academic Achievement

　　Previous research in student academic performance suggests that students with

anxiety perform worse on academic achievement tasks than those without anxiety. In a

study by Williams (1996) 103 high school students completed a standardized science

achievement test (Iowa Tests of Basic Skills) followed by an anxiety test (Worry-

Emotionality Scale**).** The results showed that participants who had reported more anxiety

performed worse on the ITBS than participants who reported significantly less anxiety.

　　A study by Elliot & McGregor (1999) assessed the effect of state test anxiety on

academic performance. Participants provided experimenters with SAT score data. In the

second week of the experiment, participant achievement goals were assessed. In the 5th

week, students were given a 50 question multiple choice exam. Immediately following

the exam, participants were given the state version of the STAI to examine anxiety the

students felt at that time. Participants were also administered the Revised Worry-

Emotionality Scale. The results found that participants who reported high levels of

anxiety performed worse on the exam than those who reported low levels of anxiety. These studies only measure "high" anxiety compared to "low" anxiety. Some research has shown that a certain amount of anxiety can have positive effects on academic performance.

This theory that anxiety can enhance performance is supported by the Yerkes-Dodson Law and the Inverted-U Hypothesis. The Yerkes-Dodson Law was founded by Robert M. Yerkes and John D. Dodson in 1908. This law states that a certain amount of anxiety or arousal can enhance performance. Too much arousal or too little arousal impedes performance. Several studies support the Inverted-U Hypothesis. Munz, et al. (1975) administered the Achievement Anxiety Test (AAT) to students which is a two-dimensional self-report anxiety test which measures facilitative anxiety (AAT +) and debilitative anxiety (AAT -). The AD-ACL was administered to students one week later. The AD-ACL is a self-report questionnaire which measures transitory levels of activation. Immediately after students completed the AD-ACL, students were given a 60 multiple choice exam. Results found that students who scored AAT+ on the Achievement Anxiety Test, therefore exhibiting facilitative anxiety, performed better on the exam. Participants who scored AAT- correlated negatively with performance on the exam.

Srivastava (1991) also supports the Inverted-U Hypothesis. Participants consisted of 352 technical workers from a large locomotive industry. Participants completed the Occupational Stress Index which is a 46-item self-report measure of anxiety and stress from 12 dimensions of their job; Role Overload, Role Ambiguity, Role Conflict, Group and Political Pressures, Responsibility for Persons, Under Participation, Powerlessness, Unprofitability, Poor Peer Relations, Intrinsic Impoverishment, Strenuous Working

Conditions, and Low Status. The level of performance in participants was measured by how quickly participants could complete given tasks. The time it took them to complete the work was subtracted from the total amount of time they were given to complete it. The group of participants categorized with "moderate" stress at work performed most efficiently where as high or low stress participants took longer and worked less efficiently. This study supports the Inverted-U Hypothesis in that there was a certain amount of anxiety that allowed people to work to their highest potential, anything below or above that threshold was detrimental to achievement. The Inverted-U Hypothesis demonstrates how a certain amount of anxiety can enhance performance and was therefore incorporated into the theory of the current study. It was hypothesized that the color red creates a certain anxiety or arousal which enhances performance on academic situations.

The current study focuses on the increase in academic performance that may occur when student quizzes are graded with red ink. The previous research has not examined the achievement of students who have taken a test, then been exposed to the color red, and then re-tested on the same material. As more research is collected, extraneous variables can be found that may come in to play which can be controlled for in future experiments. By accomplishing this, better conclusions can be made and data can be interpreted more precisely.

The cited studies demonstrated that the color red appearing somewhere on or around exam books may have had negative effects on students. It would be tempting to generalize these findings to suggest that red ink should not be used in correcting exams and papers. However, students may have sufficient experience with assignments graded

in red to be able to discriminate the difference between situations where red is being used as a warning or an emergency situation and where red is being used to help students differentiate student and teacher writing. Given the presumed prevalence of using red ink to correct papers and the apparent negative effects of red ink in the vicinity of exams before and during their administration, it seems relevant to test the effects of red ink on anxiety and the learning process at the point when exams are returned and students are subsequently asked to utilize the feedback teachers provide. The current study hypothesized that participants exposed to the color red will have a higher galvanic skin response, heart rate, and blood pressure (higher anxiety) than participants exposed to the color black. However, the current study also hypothesized that participants whose quizzes are graded in the color red would perform better on the subsequent quiz than participants whose quizzes were graded in black.

Method

Participants

Participants consisted of 29 undergraduate male and female students. Participants were recruited from three undergraduate Introduction to Psychology classes at Lycoming College. The Ishihara color blindness test was administered at the end of the experiment; it confirmed that all participants had normal color vision.

Materials and Apparatus

Paper and pencils were used for the participants to complete two quizzes on information they were learning in the psychology course and to complete the State form of the State-Trait Anxiety Inventory. The first quiz students completed was graded and used as the anxiety stimulus. Corrections to the quizzes were made in red and black

colored pens. The Biopac device used was an MP36 system. The lesson used was the Pre-Loaded Biofeedback, Lesson 14. The Biopac device (Biopac, Inc.) was used to measure the galvanic skin response and heart rate of the participants before and after they received the exams. A blood pressure monitor was used to measure the blood pressure of the participants. A stopwatch was used to identify start and stop times of GSR and HR recordings.

Procedure

Participants were assigned a number which was used for every part of the experiment to ensure confidentiality. Participants then completed a 20 question multiple choice quiz on introductory level material they were likely to have seen in class. A completely randomized design was used to assign participants to each group. The experimenter collected and graded the quizzes. One group was assigned to the experimental group and the other was assigned to the control group. The experimenter graded the quizzes with Zebra® Z-Grip Max Bold Retractable Ballpoint Pens in Red or Black. The independent variable of the study was the color ink used to grade the quizzes.

Participants were scheduled a time to individually meet with the experimenter through a sign-up sheet and e-mail. Figure 1 is a diagram of the time line of the procedure. The participants were run one at a time. When the participant entered the room, the experimenter asked the participant to sit comfortably on the laboratory stool. The experimenter instructed the participant to relax for 20 minutes. After the 20 minute period, the experimenter administered the State Anxiety form of the STAI. After the participant completed the self-report measure, the experimenter connected the participant to the blood pressure monitor and measured the participant's baseline blood pressure. Then, the

experimenter connected the participant to the Biopac device to measure anxiety. Anxiety

is defined in this experiment as a physiological arousal in galvanic skin response, heart

rate, and blood pressure. Anxiety is one of the dependent variables of the experiment. To

connect the participant to the Biopac device, the experimenter placed electrode gel into

each cavity of the GSR transducer. The experimenter placed the GSR transducer

(SS3L/SS3LA) on the index and middle finger of the participant's left hand. The

experimenter placed three disposable electrodes on the participant; one on the

participant's right forearm (just above the wrist), one on the inside right leg (just above

the ankle bone), and one on inside of left leg (just above the ankle bone). The

experimenter attached the electrode lead set (SS2L) to the electrodes; the white lead was

attached to the right forearm electrode, the black lead was attached to the right leg

electrode, the red lead was attached to the left leg electrode. The experimenter then

measured the baseline galvanic skin response and heart rate of the participant by

recording the participant for 3 minutes. Next, the experimenter exposed the participant to

the graded multiple choice quiz. The participant did not know the grade they received on

the exam until that time. The questions the students had answered wrong were marked in

either black or red ink depending on the group the student was assigned to. Next to the

correct answer, the experimenter wrote "The correct answer is__" filling the blank with

the correct letter choice. The participant was then given 3 minutes to review the exam as

thoroughly as possible. The participant was asked to use the entire 3 minutes to review

the exam. During the 3 minute period, the experimenter measured the participant's GSR

and HR. At the end of the 3 minutes, the experimenter took away the exam. The

participant was administered the State Anxiety form of the STAI again. The State form of

the STAI was also a dependent variable. After that, the experimenter took another blood

pressure reading. Next, the experimenter measured the participant's GSR and HR for 5

minutes to acquire a post reading. The experimenter then measured the participant's

blood pressure for a third time. The experimenter removed the electrode lead set (SS2L).

The participant was asked to remove the three electrodes, GSR transducer, and blood

pressure cuff from their body. At a later date, the participants re-took the multiple choice

quiz after a regular class period. The second quiz the participants took was another

dependent variable of the study. The experimenter collected the quizzes. Participants

were given the Ishihara Test for Color Blindness. All participants were debriefed via e-

mail.

Results

The data on all participants on all measures are shown in Tables 1, 2, and 3. The

results will be presented in terms of the five dependent variables that were measured. The

pre and post measurements of participants' reactions to corrections involving either red or

black ink are listed. SPSS was used to analyze the results of the 2x2 unbalanced repeated

measures design. Separate ANOVAS were conducted for each of the 5 dependent

variables: Galvanic Skin Response (GSR); Heart Rate (HR); Blood Pressure (BP); State

Anxiety; and Quiz Score. In the analyses, the within-subjects main effect compared the

mean of the red and black pre measurements to the mean of the red and black post

measurements (main effect of pre vs. post). ANOVA results across all measures are

shown in Table 4.The between-subjects main effect compared the mean of the pre and

post measurements of the black ink group to the mean of the pre and post measurements

of the red ink group (main effect of ink color). The interaction indicated whether the

pattern of results for the ink color variable differed across the pre vs. post variable. In the discussion that follows, I will use the term the main effect of ink color and the main effect of pre to post to describe the two main effects, and the term interaction to describe whether the pattern of results for the ink color variable differed across the pre vs. post variable.

Galvanic Skin Response

As seen in Figure 2, the mean pre GSR was higher for the red group (-0.59 Mho) than the black group (-1.34 Mho). The mean post GSR was higher for the red group (2.07 Mho) than the black group (1.31 Mho). ANOVA analysis indicated that the main effect of pre vs. post was statistically significant, $F(1,27)=47.22$, $p=.000$. The main effect of ink color was not statistically significant, $F(1,27)=.425$, $p=.520$. The interaction between pre and post GSR and ink color was not statistically significant, $F(1,27)=.000$, $p=.998$.

Heart Rate

The results for Heart Rate are shown in Figure 3. The mean pre heart rate measurement was higher for the red group (90.94 BPM) than the black group (83.06 BPM). The mean post heart rate was higher in the red group (89.24 BPM) than the black group (83.28 BPM). The ANOVA analysis indicated that the main effect of pre vs. post was not statistically significant, $F(1,27)=.115$, $p=.737$. The main effect of ink color indicated a trend toward statistical significance, $F(1,27)=3.088$, $p=.090$. The interaction between pre and post HR and ink color was not statistically significant, $F(1,27)=.195$, $p=.662$.

Blood Pressure

The results for Blood Pressure are shown in Figure 4. The mean pre blood pressure measurement was higher for the black group (92.64 mm/Hg) than the red group (85.02 mm/Hg). The mean post blood pressure was higher for the black group (90.11 mm/Hg) than the red group (82.71 mm/Hg). The ANOVA analysis indicated that the main effect of pre vs post approached statistical significance, $F(1,27)=3.925$, $p=.058$. The main effect of ink color was statistically significant, $F(1,27)=7.139$, $p=.013$. The interaction between pre and post BP and ink color was not statistically significant, $F(1,27)=.008$, $p=.928$.

State Anxiety

The results for State Anxiety are shown in Figure 5. The mean pre state anxiety score was higher for the red group (59.71) than the black group (58.87). The mean post state anxiety score was higher for the black group (58.60) than the red group (57.00). The ANOVA analysis indicated that the main effect of pre vs. post was statistically significant, $F(1,27)=4.967$, $p=.034$. The main effect of ink color was not statistically significant, $F(1,27)=.039$, $p=.846$. The interaction between pre and post state anxiety indicated a trend toward statistical significance, $F(1,27)=3.349$ $p=.078$. As a matter of interest to the hypothesis, secondary comparisons were done to confirm the relationships suggested by the ANOVA. No statistically significant difference existed between the red and black ink groups on the State Anxiety Inventory during pre-testing, $t(27)=1.56$, $p>.10$. However, the mean score for the red ink group was lower than the mean score for the black ink group during post-testing (after the participants received their scores) and that difference was statistically significant, $t(27)=2.77$, $p<.01$. A statistically significant drop in State

Anxiety Inventory scores occurred for the red ink group, t(13)=2.87,p<.02, but not the black ink group, t(14)=.30,p.>.10.

Quiz Score

The quiz score results are shown in Figure 6. The mean quiz 1 results were higher for the black group (11.93) than the red group (11.57). The mean quiz 2 score was higher for the black group (12.80) than the red group (12.36). The ANOVA analysis indicated that the main effect of pre vs. post was not statistically significant, F(1,27)=2.242, p=.146. The main effect of ink color was not statistically significant, F(1,27)=.105, p=.748. The interaction between pre and post quiz score and ink color was not statistically significant, F(1,27)=.005 p=.942.

<center>**Discussion**</center>

The discussion will be organized in the same order as the results section.

Galvanic Skin Response

Figure 2 shows that a change in GSR occurred between pre and post recordings. The GSR recordings for both groups increased significantly after the quiz results were shown to the participants. The main effect of pre vs. post was statistically significant. The main effect of ink color and the interaction with pre vs. post GSR readings were not statistically significant. This suggests that student GSR increases after receiving feedback from a quiz. This is consistent with other studies showing increases in GSR to possibly anxiety producing events. For example, Hyman et al. (1973) found that GSR readings increased as desensitization therapy to participant snake phobia began. The current study is the first to show that GSR levels do increase when a quiz is returned. However, there was no evidence indicating that GSR was affected by the color of the corrections made to

the quiz. It may be that since the quiz did not have an impact on the students' grade in the

class, a factor like ink color may not raise anxiety beyond what is normally felt when a

quiz is returned.

Heart Rate

Figure 3 shows that the pre and post recordings of HR were very similar. The

main effect of pre vs. post was not statistically significant. The main effect of ink color

indicated a trend toward statistical significance; however the interaction between ink

color and pre vs. post HR readings was not statistically significant. This suggests that

there was no evidence indicating that HR was affected by ink color. HR measures have

been used as a measure of anxiety in class settings. For example, Egloff, Neubauer, and

Gross (2002) found that HR increased as students carried out a speech task. In the present

study however, the HR measurements were recorded after receiving feedback rather than

during a task. This might account for the lack of change shown in the present study. It is

also possible that giving a speech arouses more anxiety, at least as measured by HR

changes, than different colored corrections on a quiz.

Blood Pressure

Figure 4 shows that BP in participants decreased from pre to post recordings. The

BP analysis indicated that the main effect of pre vs. post approached statistical

significance. The main effect of ink color was statistically significant. The interaction

with pre vs. post BP readings was not statistically significant. The main effect of ink

color but the absence of an interaction suggests that the difference in BP was due to a

vargary in random assignment to color groups that presented itself in both pre and post

measurements, and not to changes occuring with exposure to post test corrections in

different ink colors. There was no evidence that BP was affected by ink color. BP

measures have been used as a measure of anxiety in class settings. As stated previously,

Egloff, et al. (2002) found that HR and BP increased as students performed a speech task.

The present study recorded BP measurements after receiving feedback on a quiz rather

than while performing a stressful task. This may account for the lack of change shown in

the present study. It is also possible that performing a speech task arouses more anxiety,

in terms of BP changes, than different colored corrections on a quiz.

State Anxiety

Figure 5 shows that state anxiety scores decreased after participants viewed the

quiz results. The state anxiety analysis indicated that the main effect of pre vs. post was

statistically significant. The main effect of ink color was not statistically significant. The

interaction of pre vs. post state anxiety indicated a trend toward statistical significance.

Follow-up t-test results showed a significant decrease in state anxiety scores for the red

ink group but not the black ink group. This suggests that when students quizzes are

graded in the color red, they self-report less anxiety than students whose quizzes are

graded in black.The State-Trait Anxiety Inventory has been used as a measure of test

anxiety in students. Onyeizugbo (2010) examined test anxiety in students through self-

report measures of the STAI. In this study, test anxiety correlated positively with trait

anxiety. The current study measured student state anxiety before and after viewing results

from a quiz. It may be that prior to taking a quiz, test anxiety is at an increased level and

after seeing the results of the quiz, anxiety decreases.

Quiz Score

Figure 6 shows that the quiz 1 and quiz 2 scores were very similar. The quiz score

analyses indicated that neither the main effects of pre vs. post and ink color or and the

interaction were statistically significant. Student quiz scores may not have improved

significantly between quiz 1 and quiz 2 since the quizzes used in the experiment did not

count toward the students' grades in the class. The Yerkes-Dodson Law suggests that a

certain amount of anxiety can enhance performance. Munz et al., (1975) found that

students who had reported experiencing facilitative anxiety through self-report of the

Achievement Anxiety Test (AAT) performed better on an exam than students who

reported debilitative anxiety. Without a change in performance on a quiz as a result of

feedback, it is impossible to to test the differential effects of anxiety as described by the

Yerkes-Dodson Law.

The current study addresses three major issues, all of which seem to be frequently

discussed by teachers and students, but none of which have been extensively studied in

an empirical way.

The first is the issue of anxiety accompanying the return of exams. GSR and

STAI both showed statistically significant change upon the return of exams, and BP

approached significance. Interestingly, GSR increased while both BP and STAI

decreased. HR did not appear useful in studying this issue.

The second issue is whether or not corrections made in red ink cause more anxiety

than those made in black ink. An article in an educational journal by Wilson (1987)

entitled "Opinion: Massacre by Red Iink," demonstrates the intensity of feelings some

educators have toward this issue. In the current study, the only measure that demonstrated

an effect of ink color on returned papers was the STAI, which showed a statistically

significant <u>decrease</u> in anxiety in participants receiving feedback in red ink compared to

those with black ink.

The third issue was whether corrections in red or black ink might lead to better

learning. Most teachers who correct papers and tests in red ink probably don't do so to

produce anxiety in their students, but rather to insure that their corrections stand out from

students' responses thereby increasing the chances of the feedback being read and

retained. The Yerkes-Dodson Law in conjunction with anxiety measurements might also

have relevance to such results. Unfortunately, students did not demonstrate statistically

significant improvement on the second administration of the quiz several days after

receiving feedback on their initial performance. This was an unexpected result. Future

research needs to insure that there is sufficient incentive to remember material on a

corrected test so that differences in the relative effectiveness of feedback can be

ascertained.

While the results of this experiment did not provide unequivocal answers to the

three primary issues being studied, they did provide information that would be helpful in

planning future research. The study shows that HR may be the least useful of the

measures, that corrections made in red ink may actually result in less anxiety than

corrections made in black, and that one shouldn't assume that students will learn from

feedback on their work unless there are incentives for doing so.

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Table 1
Red Group Raw Data

Participant	GSR pre	GSR post	HR pre	HR post	BP pre	BP post	State Anxiety pre	State Anxiety post	Quiz 1	Quiz 2
1	6.06	7.98	85.95	69.30	77.67	75.00	43	42	13	16
2	1.33	3.20	73.11	70.44	78.67	80.67	57	54	12	15
3	-1.34	-1.28	85.25	83.48	79.33	75.33	65	57	16	17
4	-1.53	-0.76	86.49	88.54	90.67	88.33	60	61	13	11
5	-0.85	5.70	79.56	71.83	84.67	81.67	63	62	13	10
6	1.12	5.66	95.67	105.11	85.33	81.00	63	63	12	13
7	-3.00	0.44	102.37	102.77	94.00	89.00	63	60	5	5
8	-1.63	0.77	109.63	104.62	85.00	80.67	60	48	4	10
9	-0.68	0.41	85.82	92.26	76.33	77.00	63	59	18	15
10	1.19	1.03	94.66	103.78	97.00	88.33	59	59	13	15
11	-4.63	-1.82	78.94	92.92	90.33	87.33	60	60	16	12
12	-5.33	-1.69	105.30	75.47	86.67	87.00	55	54	9	10
13	-0.57	3.14	102.42	94.19	87.00	88.67	62	59	10	16
14	1.64	6.19	87.97	94.58	77.67	78.00	63	60	8	8

Table 2
Black Group Raw Data

Participant	GSR pre	GSR post	HR pre	HR post	BP pre	BP post	State Anxiety pre	State Anxiety post	Quiz 1	Quiz 2
1	-1.90	1.11	59.57	64.66	89.67	100.33	62	64	16	13
2	0.68	2.62	80.75	77.79	98.00	93.67	57	64	14	16
3	-1.48	-0.68	86.60	86.73	98.67	95.33	59	51	16	20
4	2.03	6.86	101.17	105.37	94.00	96.00	54	53	11	7
5	-1.78	5.82	99.10	75.87	69.67	71.00	58	57	9	13
6	0.37	0.89	67.49	72.75	96.00	84.00	63	63	10	11
7	-1.81	2.44	68.65	100.52	93.33	88.33	58	63	12	11
8	2.23	8.88	80.85	83.76	109.67	101.67	67	65	15	18
9	-0.39	1.24	79.99	78.63	71.00	81.00	66	61	14	12
10	-2.65	-0.98	89.38	92.99	89.33	90.00	49	47	11	9
11	-6.88	-5.04	75.24	72.43	86.00	88.33	54	54	13	18
12	-6.04	-4.17	87.21	90.12	97.33	78.67	62	62	8	8
13	-1.70	-0.91	99.75	90.11	102.00	97.33	62	60	13	16
14	0.66	2.99	98.21	83.65	88.33	95.00	54	54	10	13
15	-1.50	-1.42	71.95	73.89	106.67	91.00	58	61	7	7

Table 3
Combined Averages

Group	GSR pre	GSR post	HR pre	HR post	BP pre	BP post	State Anxiety pre	State Anxiety post	Quiz 1	Quiz 2
Red	-0.59	2.07	90.94	89.24	85.02	82.71	59.71	57.00	11.57	12.36
Black	-1.34	1.31	83.06	83.28	92.64	90.11	58.87	58.60	11.93	12.80

Table 4
Analysis of Variance

Effect	df	F	p
GSR			
Pre-Post	1	47.22	.000**
Color	1	.466	.501
Pre-Post x Group	1	.000	.998
HR			
Pre-Post	1	.115	.737
Color	1	3.088	.090
Pre-Post x Group	1	.195	.662
BP			
Pre-Post	1	3.925	.058
Color	1	7.139	.013*
Pre-Post x Group	1	.008	.928
State Anxiety			
Pre-Post	1	4.967	.034*
Color	1	.039	.846
Pre-Post x Group	1	3.349	.078
Quiz Score			
Pre-Post	1	2.242	.146
Color	1	.039	.748
Pre-Post x Group	1	.005	.942

*p<.05, **p<.01

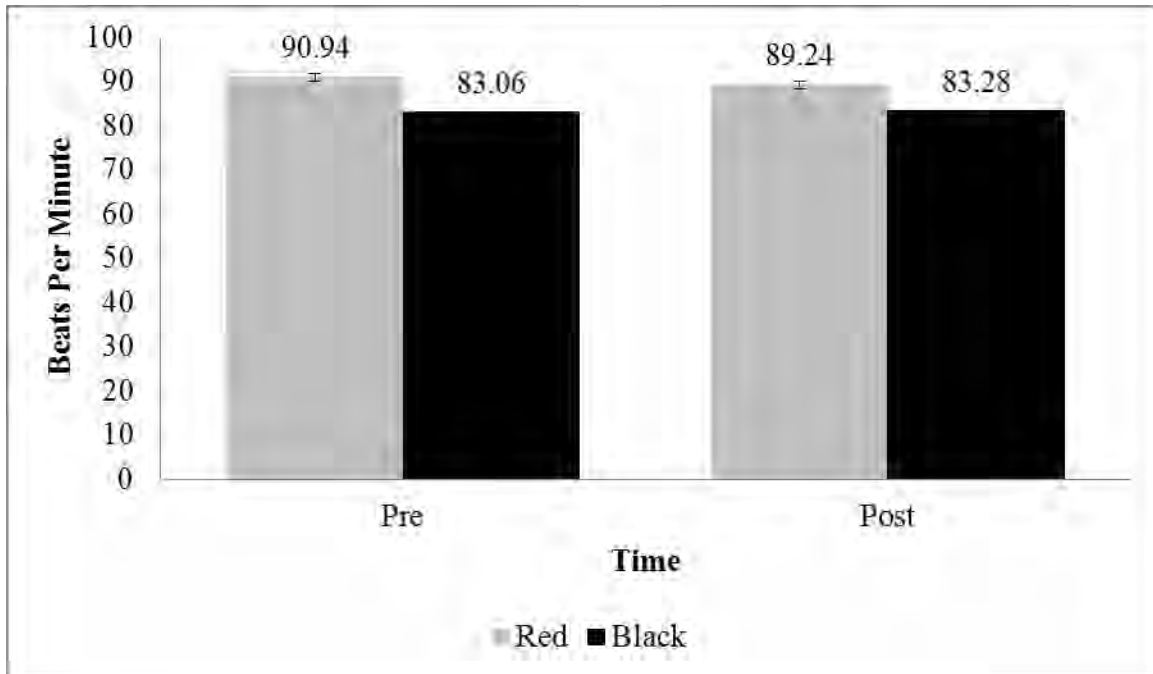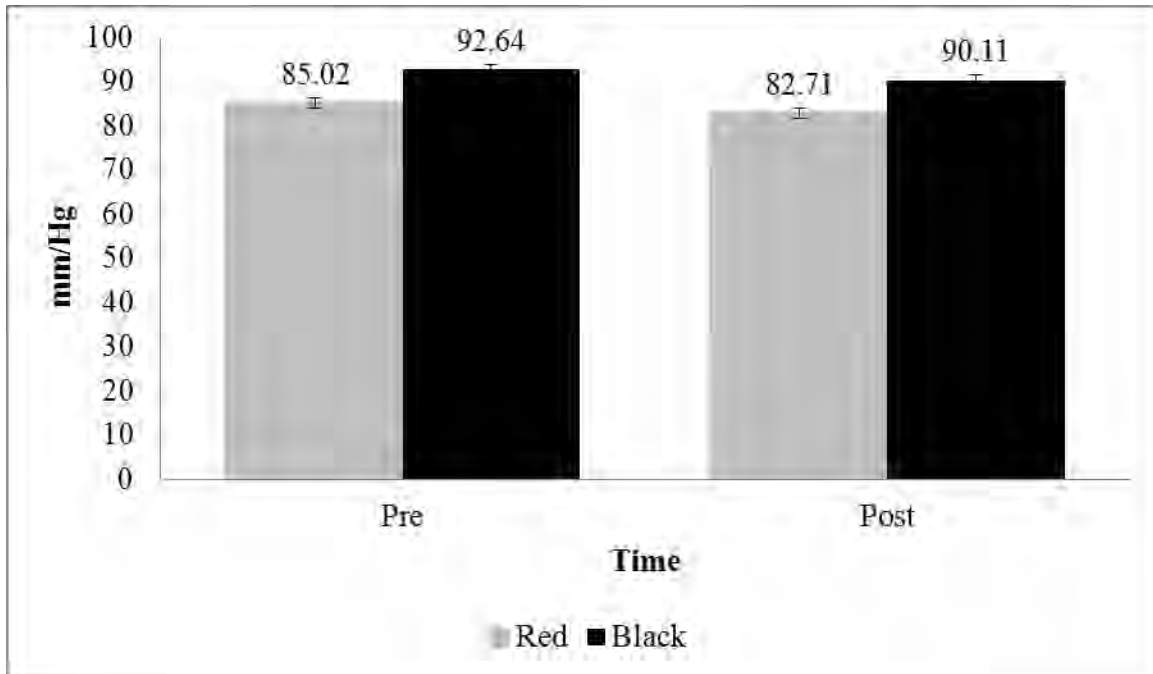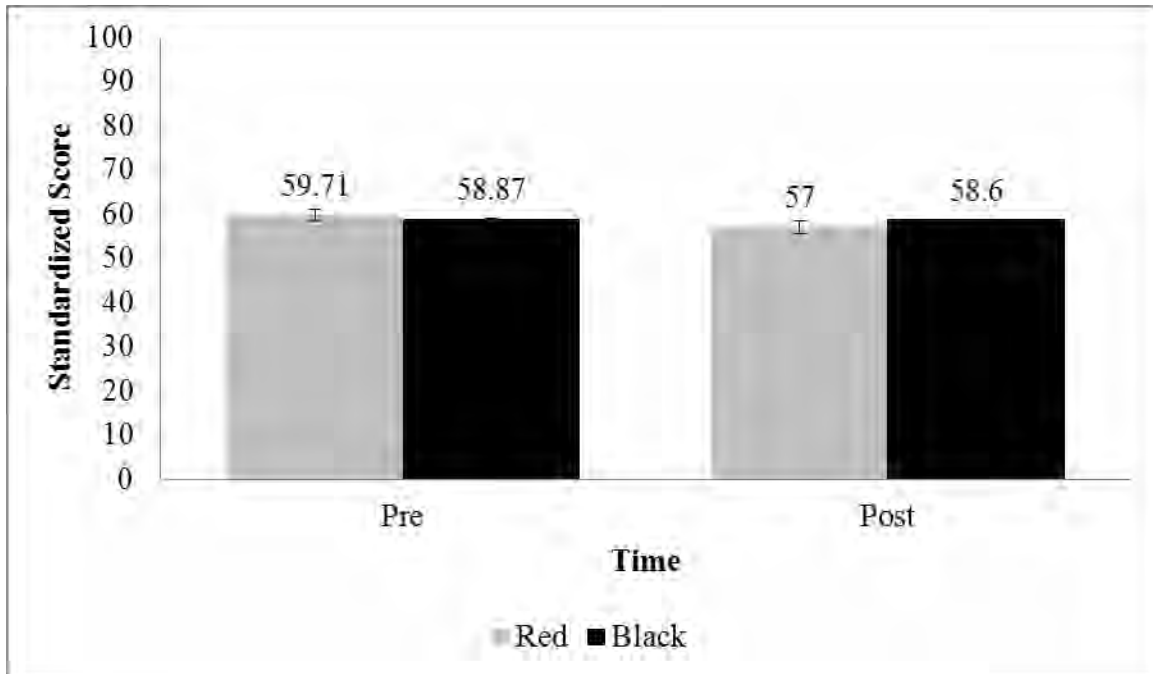# Timeline
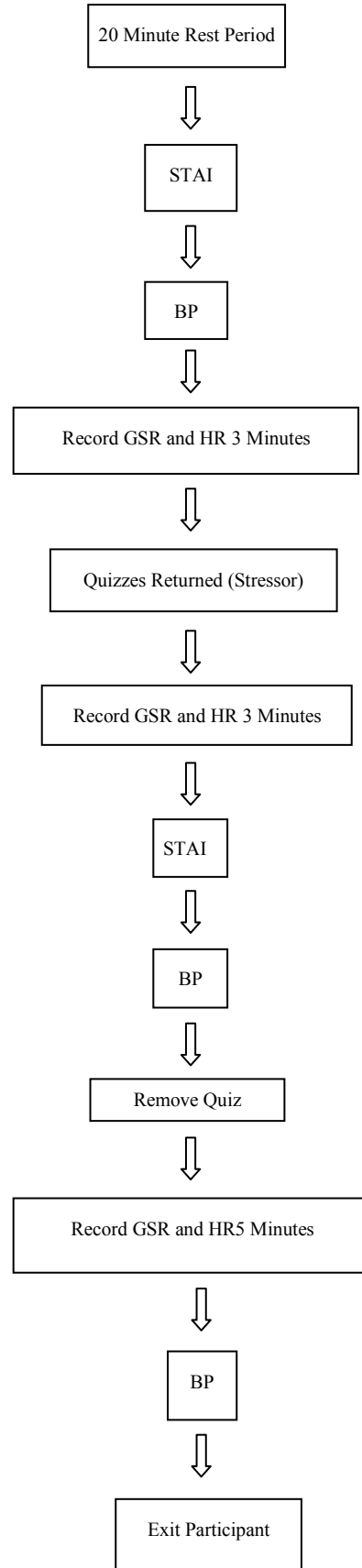
Figure 1. Procedure Timeline
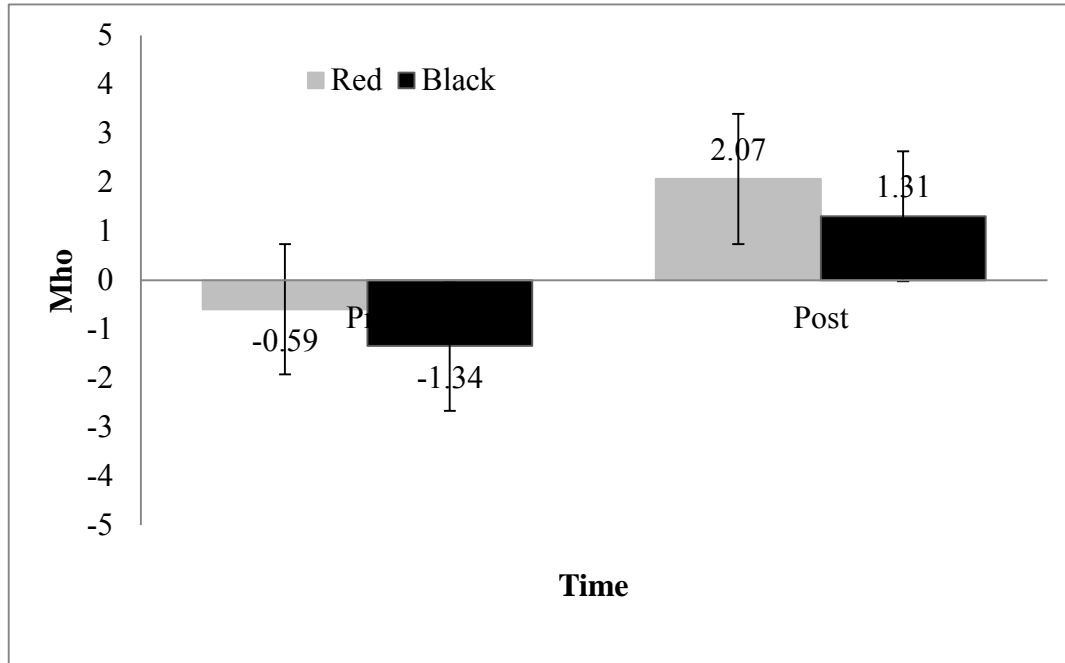
Figure 2. Mean GSR for red and black ink groups before and after receiving the quiz.

Figure 3. Mean Heart Rate for red and black ink groups before and after receiving the quiz.
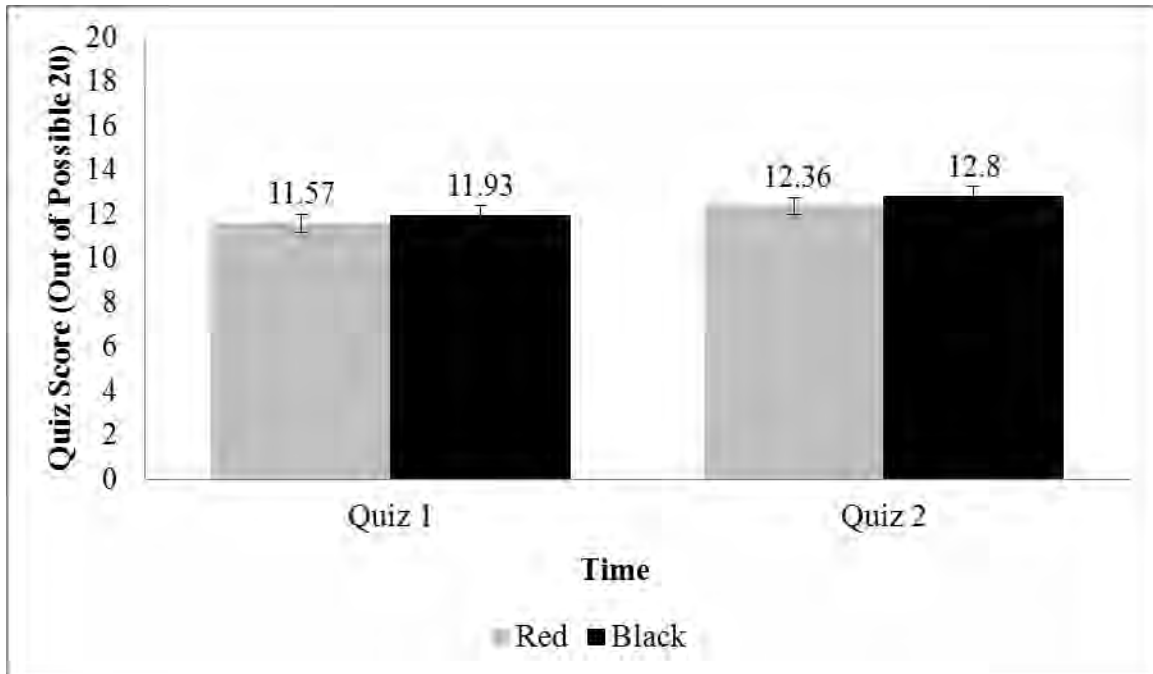
Figure 4. Mean Blood Pressure for red and black ink groups before and after receiving the quiz.

Figure 5. Mean State Anxiety for red and black ink groups before and after receiving the quiz.

Figure 6. Mean Quiz Scores for red and black ink groups before and after receiving the

quiz.