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The Effects of Coloring on Physiological and Behavioral Responses to Stress

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Abstract

Adult coloring books are a popular trend in today's pop culture. Although coloring books are commonly thought to have positive effects on one's anxiety and stress levels, little research exists to support these claims. Muthard and Gilbertson (2016) evaluated the "effectiveness of mandala coloring paired with focused breathing in reducing negative affect, state anxiety, and psychophysiological stress response following a psychosocial stressor" (p16). Findings indicated a modest positive effect on stress after coloring mandalas in combination with mindful breathing. Muthard and Gilbertson suggested several modifications for future research, including having a task for the control group and independently assessing the effects of mindful breathing on participants. The present research replicated the original study, addressing these limitations. Specifically, this pilot study examined how coloring affects one's stress levels using two experimental groups (a coloring group and a mindful breathing group) and one active control group (transcribing a paragraph). Researchers evaluated stress levels through self-reported pre and post behavioral surveys and continuous assessment of physiological responses. Using these results researchers examined the independent effects of coloring on stress as compared to mindful breathing and an active control task.

1. Introduction

Levels of stress among college students are continuing to rise every year. Approximately 30% of U.S. college students have experienced depression that has affected their daily life within the last 12 months and over half have experienced overwhelming anxiety.[1] In addition, students are feeling more pressure to excel in college and are taking on more responsibilities in an effort to make themselves stand out in the competitive job and graduate school markets. As a result, college health and counseling centers are seeing a steady rise in the number of students seeking services and are struggling to keep up with demand.[2] Finding adjunctive ways to support college student wellbeing is essential to improving the overall wellbeing and success of students and may lay the foundation for improved emotional wellbeing even after graduation.

Stress occurs when homeostasis is affected or perceived to be affected and causes an imbalance in areas such as the autonomic nervous system or hypothalamo pituitary-adrenal glands (HPA-axis). The brain is the central organ that determines this stressor.[3] The process of allostasis works to help the body adapt and find balance again and therefore is critical to maintaining stress. However, the allostatic system can become overworked, causing the stress response system to fail to shut down, a process called allostatic load. Allostatic load in turn may cause other systems to overreact and lead to a variety of emotional and physical health problems.[4] Cortisol, epinephrine, and norepinephrine are the primary hormones that affect one's stress systems. Chronic stress can affect one's health and the overproduction of these stress hormones in the body can lead to acute and chronic physical and mental health conditions. Acute stress can also cause or trigger conditions such as migraines, hypotensive and hypertensive attacks, gastrointestinal symptoms, and psychotic episodes.[5,6] Though acute stress can have negative health ramifications, chronic stress is much more detrimental to one's health.[5] Pozos-Radillo et al.[7] found that academic stress was often an indicator of chronic stress, and college students had increased rates of chronic stress compared to older and younger populations not completing higher education.

Effective stress management tools can decrease physiological and psychological responses to stress, decreasing allostatic

load, and therefore improve health conditions stemming from chronic or acute stress. Studies have shown that a decrease in negative stress responses can improve one's health overall, including immune systems health and psychosocial health. [8] There are many different stress management techniques that one may use to manage stress, but researchers question the validity of many of these stress management techniques.[9] Research on the efficacy and comparative efficacy of different stress management techniques is critical.

A new trend among the consumer world is adult coloring books. Adult coloring books are thought to relieve stress for adults. There are many theories as to why these coloring books relieve stress, but little research exists to support these theories. Articles describing art therapy and adult coloring books flood popular news sources, claiming that coloring reduces stress [4]. However, there is little to no evidence to support these claims. According to a popular press article [10] *Colleges turn to coloring books to de-stress students*, colleges are using coloring books to help students de-stress. The efficacy of coloring as a stress management tool needs to be researched, especially when it is targeted towards a population that is vulnerable to stress.

In 2016, Muthard and Gilbertson[11] conducted an experiment to evaluate the effects of mandala coloring in conjunction with focused breathing on decreasing negative affect, state anxiety, and psychophysiological stress response following a psychosocial stressor. The present study will attempt to replicate and expand this original study, addressing noted methodological limitations that confounded the results. [11] The present pilot study analyzed how coloring may affect certain indicators of stress, using the following indicators: state-trait anxiety, positive and negative affect, heart rate, skin conductance, and skin temperature.

There were two experimental groups, one looking at the effects of coloring and one looking at the effects of mindful breathing on psychosocial and physiological stress levels. In Muthard and Gilbertson's [11] study there was only one experimental group that performed mandala coloring in conjunction with mindful breathing. The participants engaged in the activity for seven minutes, however, in the present study participants engaged in the experimental and control activities for 10 minutes. The control group in the present study was also an *active* control group, transcribing the two nursery rhymes "Pop Goes the Weasel" and "Row, Row, Row Your Boat" in Welsh, versus the no-task control group in Muthard and Gilbertson's study. The purpose of transcribing words in a different, non-familiar language is to minimize as much cognition as possible. Welsh was chosen as the language of translation, because the limited amount of cognates in the English language as well as having a similar orthography to the English language.

The researchers hypothesized that participants who were tasked with the coloring independent variable (Experimental Group One) would show the greatest reduction in stress levels by the end of the study, compared to the portions of the study, where the participants were under stressors. Experimental Group Two would show greater stress reductions then the Active Control Group, but not Experimental Group One. In addition to examining between group effects, data was analyzed based on the variability within each participant's physiological and psychological measurements throughout the study.

2. Methods

2.1 Participants

In the present Pilot Study there were a total of 18 participants, 16 female-identified and two male-identified, all of whom were UNC Asheville undergraduate students. Participants were recruited through emails, flyers, word of mouth, and class announcements. Students in UNC Asheville Psychology classes also received PAL (Psychology and Life) credit if they participated in the study. Participants were randomly assigned to one of the three groups: Experimental Group One (coloring); Experimental Group Two (breathing); and Active Control Group (transcribing).

2.2 Materials

2.2.1 demographic survey

The demographic survey was created to understand the participants' backgrounds and determine possible confounding variables among participants. The Demographic Survey contained a total of 17 questions. Questions, such as "Do you regularly participate in mindfulness practices?" and "Rate your level of fluency in comprehending the Welsh language". Previous studies have shown that those who regularly participate in mindfulness practices may derive more immediate benefit from such activities than someone who does not regularly participate mindfulness practices.[13] The question regarding fluency of Welsh was asked to ensure all participants in the active control were unable to comprehend what they were

transcribing. Questions related to physical health, mental health, and prescriptions were asked, as these could possibly impact the various measurements.

2.2.2 psychological measures

Positive Affect Negative Affect Schedule (PANAS)[14] was used to assess the participants' positive and negative mood throughout the study. The assessment consisted of 20 words that the participants were instructed to rank based on how much they felt this emotion in the present moment. High positive scores indicated positive affect and high negative scores indicated negative affect. The PANAS is a commonly used assessment used in the field of psychology and has been proven reliable. Over a 2-month period test-retest reliability coefficients ranged from .47 to .68 for positive affect and .39 to .71 for negative affect. The PANAS was administered at the beginning of the study, following each stressor, and post independent variable. The PANAS was used in Muthard et. al's study to assess positive and negative mood affect as well. Positive and negative affect were dependent variables of the study and analyzed individually, comparing within participant and between groups across the four time periods of the study.

State-Trait Anxiety Inventory (STAI)[15] was used to assess the participants' state anxiety throughout the study. State anxiety was one's perceived stress at the current moment. The STAI for Adults - Short Form will be used, which consists of 10 "I feel…" statements, which participants will rank on a five point Likert-Scale. The STAI is a commonly used assessment in the field of psychology and has been proven reliable. Over a 2-month interval test-retest reliability coefficients have ranged from .65 to .75. The STAI was administered at the beginning of the study, in between stressors, post stressors, and post independent variable. The STAI was used in Muthard et. al's study to assess state anxiety as well. State anxiety was a dependent variable of the study and analyzed individually, comparing within participant and between groups across the four time periods of the study.

2.2.3 physiological measures

Biopac MP36 data collection tool was used to collect Heart Rate, Skin Conductance (EDA), and Skin Temperature. Electrodes were placed on the right Clavicle (-); left Clavicle (+); and left lower rib (Ground) to record throughout the study. Skin conductance electrodes were placed on the middle finger and pointer finger of the non-dominant hand. The skin temperature recorder was placed around the forearm of the non-dominant hand and taped to the ventral distal forearm.

2.2.4 materials for dependent variables

Experimental Group One was asked to choose a coloring page from one of the following coloring books: *Everyone Loves Coloring- Flowers* or *Everyone Loves Coloring-Animals* produced by Bendon.[16,17] Experimental Group Two was electronically guided through the following guided breathing exercise: *Breath: Mindfulness of Breathing* (10 Minutes) by C. Wolf.[18] The active control group transcribed the following nursery rhymes in Welsh: *Pop Goes the Weasel* and *Row Row Row Your Boat*.

2.3 Procedure

Following IRB approval, participants were recruited and scheduled into one-hour time slots to complete the study. Upon first meeting with the participant, consent was explained and all participants were told that participation was completely voluntary and they could discontinue at any time. Once researchers were given consent, the study began. Participants remained anonymous throughout the study, each receiving a coded number (i.e. 001,002). All participants completed the demographic survey and were randomly assigned to one of the three groups: Experimental Group One (coloring); Experimental Group Two (breathing); or Active Control Group (transcribing). Participants were then be prepared for ECG, EDA, and Skin Conductance readings. Alcohol swabs were used to clean the areas of skin needed for the three ECG electrodes. Isotonic gel was placed on the middle and pointer fingers of the nondominant hand. Once all electrodes were placed on the participants, each were asked to sit for three minutes while baseline measurements were recorded. Participants then completed the first round of PANAS and STAI assessments.

The Trier Social Stress Test [15] was then conducted, starting with the speech portion of the protocol first. Researchers stated the following: *"This is the speech preparation portion of the task; you are to mentally prepare a five-minute speech describing why you would be a good candidate for your ideal job. Your speech will be videotaped and reviewed by a panel of judges trained in public speaking. You have 5 minutes to prepare and your time begins now."* The researcher then

indicated the start of a stressor on the Biopac device and waited as the participant prepared for speech. There was a video camera placed in the room, where the participant was able to see the device, but it was never recording. After the 7 minute preparation period, the researcher walked back into room with the research assistant, who was dressed in a white lab coat. The researcher then stated the following: *"Your preparation time is up. This is the speech portion of the task. You are to deliver a speech describing why you would be a good candidate for your ideal job. You should speak for the entire the five-minute time period. Your time begins now."* If the participant stopped talking during the speech, the researcher allowed the participant to remain silent for 20 seconds. If the participant did not resume speaking, the researcher prompted the participant to continue speaking by instructing them: "You still have time remaining." During the speech the research assistant will appear to be taking notes on a clipboard. After the speech was complete, the researcher indicated the end of the speech stressor on the Biopac device. The researcher then administered the second round of PANAS and STAI assessments. For the second part of the Trier Social Stress Test [15], participant completed a mental arithmetic problem. The researcher indicated the start of a new stressor on Biopac and then stated the following: *"During the final five-minute math portion of this task you will be asked to sequentially subtract the number 13 from 1,022. You will verbally report your answers aloud, and be asked to start over from 1,022 if a mistake is made. Your time begins now."* If the participant made a mistake, the researcher prompted them with: *"That is incorrect, please start over from 1,022."* The research assistant again appeared as though they were taking notes during this task. Once the 5 minute period was complete the researcher informed the participant that their time was up and indicated the completion of the stressor on the Biopac device. The researcher then administered the third round of PANAS and STAI assessments. The researcher informed the participant that the first portion of the study was complete and the research assistant left the room.

For the second portion of the study the researcher instructed the participant to complete the task associated with the group to which they were randomly assigned. Participants in Group One were asked to color a coloring sheet of their choosing, and they were given gel pens and colored pencils. Participants in Group Two were asked to listen to the mindful breathing exercise and followed along to an audio recording. Participants in Group Three were asked to transcribe the documents presented to them (Welsh Nursery Rhymes). After instructing the participant on the relevant activity, the researcher indicated the beginning of the independent variable on the Biopac device. After the 10 minute intervention, the researcher informed the participant that their time was up and the researcher administered the final PANAS and STAI assessments. The researcher then assisted the participant in taking the physiological measurement electrodes off and completed the debriefing process.

During debriefing, the researcher informed the participants of their heart rate and skin temperature at the start and end of the study, and what they mean, including how the independent variable affected them. The researcher ensured the participant that the stressor was only to increase stress and no notes or videos were taken. The researcher provided the participant with a resource packet including: a mindful breathing link, coloring page, research hypothesis, counseling services information, and the researcher's contact information. The researcher ensured the participant had no other questions and then thanked the participant for completing the study and escorted the participant out of the room.

3. Results

3.1. Demographics

In a sample size of 18 participant, there were 16 female and 2 males. One additional participant began the study but chose to discontinue participation after they began struggling with the mental math portion of the Trier stress test.
All of the participants identified as "White" and the average age of the participants was 21.667. All participants were UNC Asheville undergraduate students, with 61% reporting that they were Psychology majors. The other represented majors are identified in Figure 1. At the time of the study 47.1% of participants currently implemented mindfulness, meditation, and other stress reduction methods into their weekly routine. Participants varied greatly in activity level, with 29.4% indicating they were active for 30+ minutes a day, 4-6 days a week.

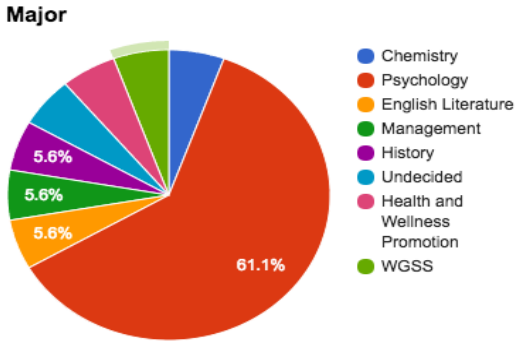

Figure 1. Participants majors of study

3.2. Behavioral Measures Reliability

Although the baseline measure of the negative affect subscale of the PANAS measure yielded a cronbach's alpha of alpha = 0.73, repeated administrations demonstrated strong internal consistency. Reliability was consistent with previously reported values. All other scales administered throughout the experiment yielded strong Cronbach's alpha. Please see Table.1 below for a summary of Cronbach alpha values.

Table 1. Reliability of scales- Cronbach's Alpha

	Cronbach's Alpha	N of Items
PANAS_1_Post	0.870	10
PANAS_1_Neg	0.726	10
PANAS_2_Post	0.931	10
PANAS_2_Neg	0.936	10
PANAS_3_Post	0.867	10
PANAS_3_Neg	0.894	10
PANAS_4_Post	0.869	10
PANAS_4_Neg	0.818	10
STAI_1	0.930	10
STAI_2	0.907	10
STAI_3	0.775	10
STAI_4	0.875	10

3.3. Baseline

ANOVAS were conducted on baseline state anxiety inventories. Analyses confirmed there were no statistically significant differences in mean state anxiety between the three groups at the onset of the research, $F(2,15)=1.076$, $p=0.366$. ANOVAs also were conducted on negative affect across all three groups during the baseline measurements, with similar nonsignificant results, $F(2,15)=0.983$, $p=0.397$. Upon running an analysis of variance comparing positive affect across all three groups during the baseline measurements, it was determined that the assumption of homogeneity of variance was violated $t(2,15)=5.176$, $p=0.020$. Running a robust test of equality of means yielded a nonsignificant Welch test for positive affect at the start of the research, $Fw(2,8.572)=1.383$, $p=0.302$.

Physiological

ANOVAS were conducted on average heart rate before stressors, ensuring no significant differences between the three groups. Analyses confirmed no statistically significant differences in average heart rate during the baseline between the three groups F(2,15)=0.11, p=0.90. ANOVAS were also conducted on average temperature of participants during baseline measurements, ensuring no difference between the three groups. Analyses confirmed there was no statistically significant difference of mean temperature between groups F(2,15)=0.51, p=0.61.

3.3.1. stressor 1

ANOVAs were conducted after the speech stressor on state anxiety inventories, in addition to positive and negative affect. Analyses confirmed there were no statistically significant differences in mean state anxiety between the three groups after the first stressor $F(2,15)=0.339$, $p=0.718$. Similarly, analyses also confirmed there was no significant difference in positive affect between the three groups after the first stressor, $F(2,15)=0.1.220$, $p=0.323$, as well as negative affect, $F(2,15)=0.307$, $p=0.740$.

ANOVAS also were conducted on average heart rate after the first stressor. Analyses confirmed no statistically significant differences in average heart rate after the first stressor between the three groups F(2,15)=0.735, p=0.496. ANOVAS were also conducted on average temperature of participants during baseline measurements, ensuring no difference between the three groups. Analyses confirmed there was no statistically significant difference of mean temperature between groups F(2,15)=1.189, p=0.332.

Repeated measure ANOVAs were performed to assess change between participants' measurements at baseline and after the first stressor. Using the within-subject analyses, state anxiety increased between the baseline and after the stressor, $F(1,15)=22.500$, $p=0.000$, with an effect size of 0.600. Similarly, there were significant changes in the following measurements: negative affect increased, positive affect decreased, and average heart rate increased, data can be found in

Table 2. Tests of Within Subject Contrasts, looking at the change within subjects from baseline to after stressor one.

Source	Measure	B_S1	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Baseline to Stressor 1	STAI	Linear	441.000	1	441.000	22.500	.000	.600	22.500	.993
	HR	Linear	1100.287	1	1100.287	47.527	.000	.760	47.527	1.000
	PANAS_POST	Linear	230.028	1	230.028	6.809	.020	.312	6.809	.684
	PANAS_NEG	Linear	484.000	1	484.000	27.728	.000	.649	27.728	.998

3.3.2. Stressor 2

Upon running an analysis of variance comparing state anxiety across all three groups following the math stressor, it was determined that the assumption of homogeneity of variance was violated $t(2,15)=0.792$, $p=0.236$. Running a robust test of equality of means yielded a nonsignificant Welch test, $Fw(2,9.854)=1.044$, $p=0.388$. As such, no significant differences exist across the three groups on state anxiety following the math stressor.

ANOVAs were conducted on positive affect, after the math stressor. Analyses confirmed there was no significant difference in positive affect between the three groups after the math stressor, $F(1,15)=0.317$, $p=0.733$. Similarly, there was no significant difference in negative affect between the three groups, $F(1,15)=1.557$, $p=0.243$. ANOVAS were conducted on average heart rate after math stressor. Analyses confirmed no statistically significant differences in average heart rate after the math stressor between the three groups, $F(2,15)=1.076$, $p=0.366$.

Table 3. Test of Within Subjects- Greenhouse-Geisser, looking at change between stressor one and stressor two

Greenhouse-Geisser	Measure	df	F	Sig.	Partial Eta Squared	Observed Power
S1_S2	STAI	1	0.023	0.881	0.002	0.052
	PANAS_Pos	1	2.525	0.133	0.144	0.319
	PANAS_Neg	1	0.03	0.865	0.002	0.053
	HR	1	9.538	0.007	0.389	0.823
	Temp	1	2.664	0.123	0.151	0.333
S1_S2 * Group	STAI	2	1.541	0.246	0.17	0.276
	PANAS_Pos	2	3.443	0.059	0.315	0.555
	PANAS_Neg	2	0.906	0.425	0.108	0.177
	HR	2	0.33	0.724	0.042	0.093
	Temp	2	2.558	0.111	0.254	0.432
Error(S1_S2)	STAI	15				
	PANAS_Pos	15				
	PANAS_Neg	15				
	HR	15				
	Temp	15				
Computed using alpha = .05						

3.3.3. Intervention

Given that no significant differences existed between groups on any of the reported psychological or physiological variables at baseline or following stressor two, the effect of the independent variable was determined using a repeated measures design, examining changes from, after math stressor to after intervention (time three to time four), as well as all four time points. Positive affect and negative affect violated assumed sphericity when analyzing data throughout the study.

Table 4. Test of Within Subjects- Greenhouse-Geisser, throughout the study

	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power
Temp	11.241	1.8	6.245	4.564	0.023	0.233	8.217	0.697
Temp*Group	5.385	3.6	1.496	1.093	0.376	0.127	3.936	0.283
Error(Temp)	36.94	27.001	1.368					
PANAS_Pos	525.153	2.144	244.894	8.006	0.001	0.348	17.168	0.948
PANAS_Pos*Group	136.639	4.289	31.859	1.041	0.404	0.122	4.467	0.3
Error(PANAS_Pos)	983.958	32.166	30.59					
PANAS_Neg	1084.375	2.098	516.795	17.86	0.00	0.544	37.476	1
PANAS_Neg*Group	166.667	4.197	39.715	1.373	0.265	0.155	5.76	0.385
Error(PANAS_Neg)	910.708	31.474	28.935					

State anxiety inventories and heart rate were analyzed using repeated measure ANOVAs to look at the change in state anxiety and heart rate over the period of the study.

Table 5. Test of Within Subjects- Sphericity assumed throughout the experiment

	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power
HR	1492.512	3	570.289	21.983	0.000	0.594	57.531	1.000
HR*Group	343.345	5.234	65.405	2.521	.043	.252	13.196	.738
Error(HR)	1018.428	39.257	25.943					
STAI	932.375	3	310.792	8.006	0.001	0.348	17.168	0.948
STAI*Group	337.083	6	56.181	1.041	0.006	.320	21.133	.918
Error(STAI)	717.792	45	15.951					

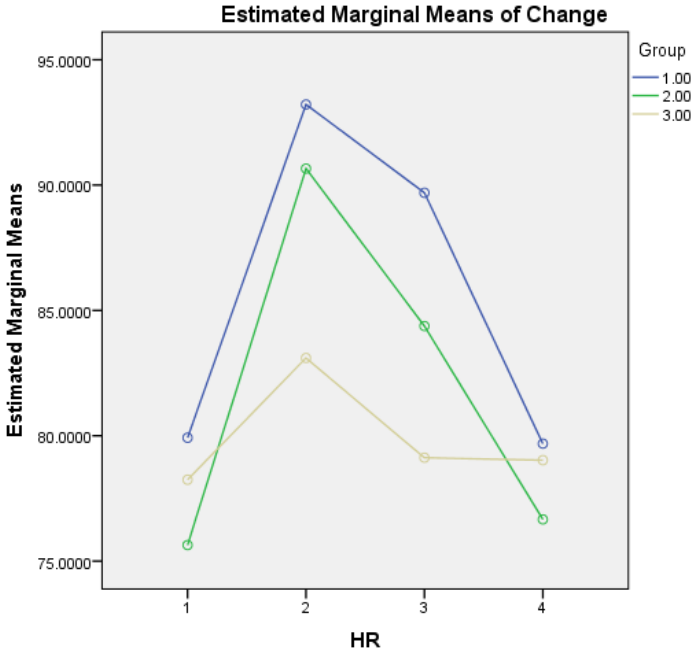

Figure 3. Change in heart rate over the period of the study between groups

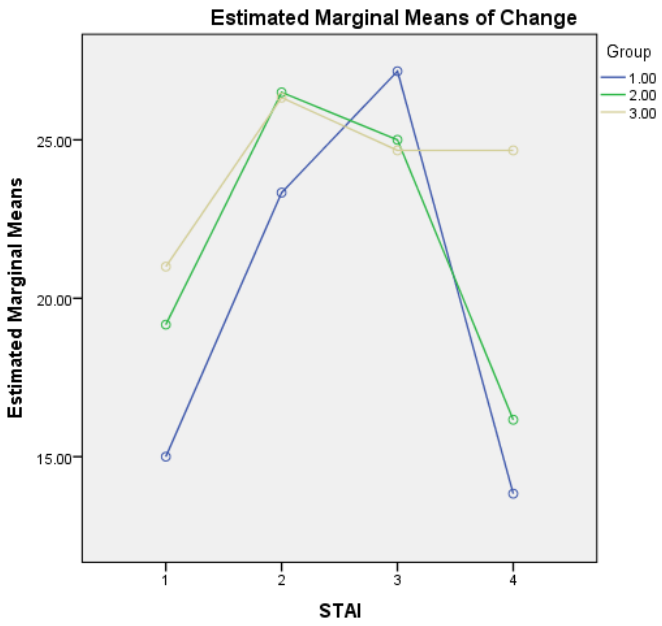

Figure 4. Change in state anxiety over the period of the study between groups is displayed in Graph 2.

4. Conclusions

The key findings of this pilot study suggest that there are statistically significant differences between coloring, mindful breathing, and transcribing in state anxiety levels and heart rate from baseline, stressor one, stressor two, and the interventions. These findings suggest that coloring alone can positively affect one's state anxiety and heart rate levels in response to a stressor. Despite these findings, there does not seem to be a significant difference in temperature, positive affect, and negative affect in response to coloring alone with the sample size drawn for the present pilot study.

Research question one explored how coloring, as compared with mindful breathing, and an active control, impact state anxiety, following a psychological stressor. Levene's test of Homogeneity of Variance was confirmed, ensuring no statistically significant differences between the three groups baseline state anxiety levels. Sphericity Assumed indicates a significant difference in the change of the participants' state anxiety, between the two experimental groups and the control group, when looking at the repeated measures over the period of the study. Graph 2 demonstrates this change in state anxiety over the duration of the study. Group three, the transcribing group, appears to maintain the same level of state anxiety between stressor two and post intervention, when looking at the graph. Group one and two appear to have a decrease in state anxiety between stressor two and post intervention. Assumed Sphericity was violated when looking at state anxiety after stressor two and the intervention. This may be due to variance in anxiety levels that stressor two elicited. A larger sample size may influence this variance in reported state anxiety after stressor two.

Research question two explored how coloring, as compared with mindful breathing and an active control, impact positive and negative affect, following a psychological stressor. When analyzing negative affect, Levene's test of Homogeneity of Variance was confirmed. Homogeneity of Variance was violated when analyzing positive affect. The Welch test revealed an insignificant p-value when computing a robust test of equality of means on positive affect. As such, no significant differences exist across the three groups on positive affect and negative affect. There were no statistically significant changes of positive or negative affect throughout the study, between groups.

Research question three explored how coloring, as compared with mindful breathing and an active control, impact physiological responses following a psychological stressor. Levene's test of Homogeneity of Variance was confirmed, ensuring there was no statistically significant difference of mean temperature or mean heart rate between groups, at baseline. Sphericity assumed indicates a significant difference in the change of the participants' heart rate, between the two experimental groups and the control group, when looking at the repeated measures over the entirety of the study. Graph 1 displays the changes in heart rate over this period of the study, between groups. Because group three's heart rate was

already fairly low, after stressor two, this could account for group three's consistent heart rate between stressor two and the intervention. Nevertheless, there is a significant difference in variance of heart rate overall, between groups.

A key limitation to this pilot study is the small sample size. A larger sample size could account for the variance in measurements at times. Along with a small sample size, the demographics of the participants were not diverse in regards to gender, major, and race/ethnicity. This lack of diversity reflects student demographics at UNC Asheville, but needs to be addressed in some way. Researchers did not control for any demographic variables such as medications, medical conditions, and mental illness. These variables can greatly affect a participant's responses to stress, and should be accounted for in future studies. Researchers also found that stressor one and stressor two varied greatly. Many of the participants' physiological and psychological indications of stress decreased greatly during stressor two. Researchers believe the stressors would be more effective if they were both speech stressors.

The location of the electrodes is also something that should be considered in the full study. The placement of the ECG electrodes on the left and right clavicle allows for a great deal of noise in the ECG readings, especially when a participant is talking and moving. The physiological measurements in the present pilot study were not cleaned for disturbances in the readings, which is also a limitation of the study. Heart rate measurements were averaged during the four different phases of the study, rather than analyzing variability of the participants' heart rates. A meta-analysis of heart rate variability found that heart rate variability was effective in evaluating stress levels.[12] In Muthard and Gilbertson's [11] study, as well as the present study, heart rate was measured and analyzed, rather than heart rate variability. Heart rate variability is a more accurate tool for measuring one's Autonomic Nervous System, because it determines the changes in each heartbeat, rather than the average number of heartbeats per minute. Assessing heart rate variability will allow researchers to closely examine the participants autonomic nervous system over the entire span of the study and see the effects of the independent variables.[12]

There were also limitations in biases of the participants. Many of the participants knew the researcher and the research assistant. This can vary the participants responses to stress, compared to other participants who do not know researchers. Many people assume that coloring reduces stress, as such, some participants may have walked into the study with this assumption in mind, influencing the results of the study. This could be addressed by informing the participants that each of the three interventions were known to decrease stress, eliminating some of the participant bias.

In the full study, considerations will be made in regards to sample size, ensuring a larger more diverse group of participants. Researchers will also evaluate the placement of the ECG electrodes, in the hopes of collecting cleaner ECG readings. In addition, researchers plan to clean physiological data, noting participants' actions that could affect readings and heart rate variability will be analyzed. Medications, medical conditions, mental illnesses, mindfulness experience, and physical activity levels will also be controlled for, ensuring that the previously mentioned activities and conditions do not influence behavioral and psychological measurements.

Despite these limitations there was a great deal of valuable information gained from this pilot study. This is the first study to demonstrate significant changes in stress related variables in response to coloring alone. In addition, as the researchers recruit a larger sample and use finding from this pilot to address methodological considerations, a stronger study will be conducted to better inform how adult coloring books influence our physiological and behavioral indices of stress. With a better understanding of adult coloring books effects on stress, college students, universities, and college health centers can make more informed decisions on what activities to implement to help college students reduce stress levels.

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