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The Impact of Creativity on Alpha Activity

Serena Bruneaux
Eastern Kentucky University, serena_bruneaux@mymail.eku.edu

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The Impact of Creativity on Alpha Activity

Serena Bruneaux

Eastern Kentucky University

Abstract

The current study uses Electroencephalography (EEG) technology to examine the brain activity associated with creative thinking. This study is a within-subjects experiment involving college students recruited from Eastern Kentucky University. Participants will be given a divergent thinking task, an artistic creativity task, and a noncreative task. The modified Alternative Uses Task (Wang et al., 2019) and two tasks from the Modified Cognitive Synthesis Test (Abraham et al., 1987; Razumnikova et al., 2009) will be used. For all three tasks, EEG data will be collected when participants are asked to think or brainstorm. The EEG data between tasks will be compared using spectral analysis. The modulating effects of stress and creative potential will also be examined. This information will be gathered using the State-Trait Anxiety Scale Form Y-1 (Spielberger, 1968/1977) and the Biographical Inventory of Creative Behaviors (Batey, 2007). The current study hypothesizes that participants will exhibit more alpha power during the creative tasks than during the non-creative task, participants who rate their responses as more creative will show more alpha power than participants who rate their responses as less creative, more stressed participants will exhibit lower alpha power than less stressed participants during the creative tasks, and more stressed participants will report lower creativity than less stressed participants.

The Impact of Creativity on Alpha Activity

Creativity is a broad topic that covers a range of activities. The most known creative activities are art-related, such as the creation of a painting or a story. However, creativity is not restricted to only artistic applications. Creativity occurs commonly in everyday life, whenever someone comes up with an idea that is both novel and relevant. This kind of creativity is commonly referred to as divergent thinking, which can be differentiated from artistic creativity (Dietrich & Kanso, 2010). Since creativity is such a wide-ranging concept, it has positive implications in many fields. In the workplace, creativity is shown to improve both employee well-being (Helzer & Kim, 2019) and organizational success (Lapierre & Giroux, 2003). Creativity can also increase academic achievement (Gajda et al., 2017; Pastor & David., 2017). As a result, recent studies have attempted to enhance creativity in workplace (Zhou et al., 2022) and academic (Fakhrou & Ghareeb, 2020) domains. Creativity is also important because it can improve psychological well-being. More specifically, creativity has been shown to relieve stress (Curl, 2008) and increase happiness (Tan et al., 2019). Creative practices have even been implemented as therapeutic measures, such as art therapy (Brandão et al, 2019). Overall, creativity is both prevalent and beneficial.

While the benefits of creativity have been widely established, relatively little is known about the brain mechanisms that underlie creativity. The present study aims to determine how the brain functions while engaging in creative tasks. Electroencephalogram, or EEG, technology will be used to measure brain activity. This technology uses electrodes placed against the scalp to analyze the speed and power of electrical impulses transferred throughout the brain. The frequency of these impulses is used to separate brain waves into five main categories. Delta waves occur from 1– 4 Hz, theta waves occur from 4 – 8 Hz, alpha waves occur from 8 – 13 Hz,

beta waves occur at 13 – 30 Hz, and gamma waves occur at over 30 Hz (Ameera et al., 2019). Lower frequency bands represent an unconscious or highly relaxed participant while higher frequency bands represent a participant that is actively thinking and focused. Delta waves are indicative of deep sleep, while theta waves represent light sleep or drowsiness (Dietrich & Kanso, 2010). Alpha waves appear when a person is awake but relaxed, while beta waves occur when the person is actively concentrating and thinking (Dietrich & Kanso, 2010). Gamma waves occur when a person is doing higher-level thinking and binding information (Dietrich & Kanso, 2010). The present study analyzes brain activity to determine which frequency bands occur during creative tasks.

The current literature on alpha activity and creativity is extensive but contradictory. While many studies suggest a relationship between alpha waves and creativity (Ermakov & Saakyan, 2013; Rominger et al., 2019), other studies have not found this relationship (Benedek et al., 2011). In studies that do find a relationship, the relationship is sometimes positive and sometimes negative. In other words, some studies find more alpha activity during creative tasks while others find less alpha activity and more beta activity (Dietrich & Kanso, 2010). While there are various theories as to why these differences exist, one common explanation is that some studies measure open-ended creativity while others measure closed-ended creativity.

Open-ended creative tasks have a wide variety of possible responses and no correct answer, while closed-ended creative tasks have correct answers that participants must think unconventionally to solve. In a study comparing brain activity in open-ended creative tasks to closed-ended creative tasks, it was found that open-ended tasks were more related to alpha activity alone while closed-ended tasks were more related to transformations between alpha waves and beta waves (Li et al., 2016). This suggests that the studies that showed increased

alpha activity were likely more open-ended, while tasks that varied between alpha and beta activity were likely more closed-ended. This theory is also supported by evidence that alpha enhancement training procedures improve performance in only open-ended creative tasks, while alpha transformation training procedures improve performance in both forms of creative tasks (Lin & Shih, 2016). Alpha enhancement training teaches participants to switch to alpha activity at will, while alpha transformation training teaches participants to switch between alpha and beta activity at will. (Lin & Shih, 2016). This further suggests that studies that measure open-ended creativity should show more alpha power than other tasks.

Open-ended creative tasks are commonly operationalized by divergent thinking tasks. In divergent thinking tasks, creativity generally leads to increased alpha power. Participants performing creative divergent thinking tasks usually demonstrate more alpha activity than participants completing noncreative tasks (Fink et al., 2006). Additionally, people that perform more creatively in these tasks tend to have more alpha power than participants with less creative ideas (Grabner et al., 2007). However, not all studies find increased alpha performance in participants completing a divergent thinking task (Benedek et al., 2011). This suggests that differentiating between open-ended creativity and closed-ended creativity can explain much, but not all, of the inconsistencies in the current literature.

The research base for artistic creativity is much smaller than that for divergent thinking, but the preliminary findings suggest that the results are also inconsistent. Most notably, some studies show increased alpha activity while others show decreased alpha activity (Dietrich & Kanso, 2010). One possible explanation for this may be that most studies involving artistic creativity focus on comparing experts and non-experts (Bhattacharya & Petsche, 2005; Fink et al., 2009). These studies have found differences in brain activity of experts and non-experts

completing creative tasks in their specialty (Fink et al., 2009). This may be a covariate that adds to the inconsistencies in artistic creativity research.

Results in EEG studies that have attempted to localize creativity in the brain have been equally inconsistent. However, this is to be expected when taking the poor spatial resolution of the technology into account. Unlike MRI technology, which can generalize activities and functions to very specific brain regions, EEG technology can only generalize to very vague areas of the brain. This is because the technology analyzes electrical activity with relatively little mapping capability. Due to this, it is difficult to generalize results from any one EEG study. While some studies on creativity show increased alpha activity in posterior (Fink et al., 2006) and parietal (Xiong et al., 2015) regions, only frontal areas have been consistently implicated in creativity (Grabner et al., 2007; Rominger et al., 2019). In addition to the localization of creativity to brain regions, some EEG studies have attempted to prove the lateralization of creativity. These studies have found more brain activity in the right hemisphere than the left hemisphere (O'Rourke et al., 2015; Razumnikova et al., 2009), especially in the alpha band (Grabner et al., 2007; Xiong et al., 2015). While these results must be taken with some skepticism, due to the nature of EEG technology, there is some evidence that creativity-related brain activity occurs mainly in frontal areas and the right hemisphere. In these areas, there is commonly more alpha activity associated with creative tasks.

In addition to localization studies, research has also been done into the relationship between stress and creativity. Past research indicates that creative activities can reduce stress (Curl, 2008). Furthermore, there is evidence that stress influences an individual's ability to be creative (Baas et al., 2008). While there is some debate as to whether low levels of stress increase or decrease creativity, it is relatively well established that high levels of stress decrease

creative performance (Byron & Khazanchi, 2010). Since high levels of stress decrease creative performance, it is expected that the corresponding creativity-linked alpha activity will also lessen. Wang et al. (2019) tested this theory by measuring brain activity and creative performance of participants before and after a stress test. While there were alpha power increases in creative participants before the stress test, there was no increase in alpha power after the stress test (Wang et al., 2019). This suggests that stress can decrease alpha activation during a creative task.

Rationale

There are still some unexplained inconsistencies in the literature on creativity and brain activity. Most importantly, not all studies have found alpha power increases in creative tasks. While much of this inconsistency can be explained by open-ended versus closed-ended creative tasks, there may still be some variance that is unaccounted for. This variance may be caused by another divide in the literature as to how creativity should be measured. The most common measuring technique is divergent thinking, but some divergent thinking tasks may measure creativity in a different way than other divergent thinking tasks. Additionally, some studies use artistic activities rather than divergent thinking tasks to measure creativity. While divergent thinking and artistic creativity are commonly generalized to the concept of creativity in the same way, they may measure different types of creativity. This leaves a gap in the literature because there is uncertainty as to how these distinct methods can lead to differences in creative brain activity. The different ways of measuring creativity may have been partially responsible for the inconsistencies in alpha power found in creative tasks.

The current literature also highlights other inconsistencies in the field of creativity research. Inconsistencies are present with EEG localization studies, namely that more studies are

needed for EEG localization results to be generalizable in brain regions other than frontal. Also, while differences have been found between experts and laymen completing creative tasks, the mechanisms behind these differences have not been determined. Additionally, while it is established that high levels of stress decrease creative performance, it is unknown whether mid-levels of stress increase or decrease creative performance. These are some inconsistences in the previous literature on this topic.

The current study will address these limitations by using a variety of creative tasks. A divergent thinking task and an artistic task will be used to provide a comparison of how each task measures creativity within the same group of participants. A non-creative task will also be given to provide a control comparison. Localization of creativity to general brain areas, and lateralization to hemispheres, will also be assessed. Participants' creative potential, commonly tested by measuring how often the participant completes creative tasks, will also be measured. This can help determine if creative potential contributes to the brain activity differences found between experts and laymen in creative tasks. Additionally, participants' current stress levels will be evaluated to determine if stress has an impact on alpha activity and performance in a creative task. This study attempts to account for some of the inconsistencies found in the current knowledge base.

It is theoretically important to address these limitations because they can explain the inconsistencies found in previous literature. By comparing different methods of measuring creativity, we may be able to determine if they are measuring creativity in the same way. We can also either support or refute the theory that creativity leads to increased alpha power. Additionally, we can determine how stress influences alpha activity and performance in a creative task.

Hypotheses

1. Participants will exhibit more alpha power during the creative tasks than during the non-creative task.
2. Participants who rate their responses as more creative will show more alpha power than participants who rate their responses as less creative.
3. More stressed participants will exhibit lower alpha power than less stressed participants during the creative tasks.
4. More stressed participants will report lower creativity than less stressed participants.

Method

Participants

Participants will be composed of 150 college students enrolled at Eastern Kentucky University. Participants will be recruited through the online SONA system. The incentive for this study is that 2.0 SONA credits will be given to participants for taking part. A certain number of SONA credits are required for introductory and research methods psychology courses, but this study is not the only way to receive SONA credits.

Measures

Participants will be given three cognitive tasks while wearing an EEG cap to examine their brain activity when completing creative tasks and a non-creative task. Participants will also be given two scales to assess their current level of stress and creative potential.

Creative vs Noncreative Task. The Modified Cognitive Synthesis Test (Abraham et al., 1987; Razumnikova et al., 2009) will be used to ensure participants complete a creative task and a noncreative task that are similar in other regards. The Modified Cognitive Synthesis Test consists of two separate tasks in which participants must combine three seemingly unrelated

objects into a meaningful sentence. In the first task, participants will be asked to create a simple sentence. In the second task, participants will be asked to create the most creative sentence they can and self-rate how creative each sentence is on a three point-Likert scale (1 = *slightly creative*, 3 = *highly creative*). E-Prime software will be used to administer both tasks. An EEG cap will be worn during both tasks so that brain activity data can be collected.

Divergent Thinking Task. A modified version of the Alternative Uses Task (Wang et al., 2019) will be used to assess each participant's divergent thinking ability. In this task, participants are given an object word and asked to think of original uses for that object. A prompt will then be presented asking participants to write down their most creative idea. Participants will also self-rate the creativity of each of their responses on a three-point Likert scale (1 = *slightly creative*, 3 = *highly creative*). This task will be administered using E-Prime software. An EEG cap will be worn during this task so brain activity data can be collected.

Stress. The State-Trait Anxiety Scale Form Y-1 (Spielberger, 1968/1977) will be used to assess the participant's current level of stress. This scale consists of 20 personal statements (e.g., "I am tense") that participants rate their agreement of on a four-point scale (1 = *not at all*, 4 = *very much so*). Participants with more current stress will score higher on the scale than participants with less current stress.

Creative Potential. The Biographical Inventory of Creative Behaviors (Batey, 2007) will be used to assess participants' creative potential. In this survey, participants are given a list of 34 activities (e.g. "written a short story") and asked to mark the ones that they have completed in the last 12 months. Participants with more creative potential will score higher on the scale than participants with less creative potential.

Procedure

Participants will be recruited through the online SONA system (see Appendix A). Participants will be run individually. When participants arrive, they will be greeted and led into the experiment room. They will then be given a consent form and asked if they have any questions (see Appendix B). After they sign the consent form, the experiment will begin. Participants will be run according to the script and materials (see Appendix C; Appendix D).

The first measure given to participants will be the State Trait Anxiety Scale Form Y-1 (Spielberger, 1968/1977). This scale consists of 20 statements that participants rate their agreement of on a scale from one to four. After completing the scale, participants will be connected to the EEG machine. The Modified Cognitive Synthesis Test (Abraham et al., 1987; Razumnikova et al., 2009) will then be administered. This measure consists of two cognitive tasks in which participants must combine three seemingly unrelated words into a meaningful sentence. In the first task, participants are asked to create a simple sentence. In the second task, participants are asked to create the most creative sentence they can and self-rate the creativity of each sentence. After completing these tasks, a modified version of the Alternative Uses Task (Wang et al., 2019) will be administered. In this task, participants are given a conventional object word and asked to think of creative uses for that object. Participants then report their most creative idea and how creative they feel that idea was. Upon completion of this task, the EEG cap will be removed, and participants will be given a rag to clean their hair.

Participants will then be given the Biographical Inventory of Creative Behaviors (Batey, 2007). In this survey, participants are given a list of 34 activities and asked to mark the ones that they have completed in the last 12 months. They will then be given a demographic form asking for their age, birth sex, ethnicity, education level, and whether they are right-handed or left-handed. Participants will be debriefed and thanked for their participation (see Appendix E). It

will take about one hour to complete the study. Participants will not be timed, but the experiment words will be shown for a set amount of time.

Scoring

Creative vs Noncreative Writing Task. This will be scored by comparing the two cognitive tasks included in the Modified Cognitive Synthesis Test (Abraham et al, 1987; Razumnikova et al., 2009). In this test, participants must combine three unrelated items into a sentence. In the first task, the noncreative task, participants are asked to create a simple sentence. In the second task, participants are asked to create a creative sentence. EEG data will be collected while participants are asked to think or brainstorm each sentence. This is a multiple-item measure because participants will create 8 simple sentences and 8 creative sentences. The EEG segments between the 8 simple trials will be averaged together. Likewise, the EEG data segments between the 8 creative trials will be averaged together. Then the overall EEG data between the two tasks will be compared using spectral analysis.

Artistic Creativity vs Divergent Thinking. This involves comparing the brain activity present between a task requiring artistic creative ability (e.g. the creative task of the Modified Cognitive Synthesis Test) and a task requiring divergent thinking (e.g. a modified version of the Alternative Uses Task). The creative task of the Modified Cognitive Synthesis Test (Abraham et al, 1987; Razumnikova et al., 2009) asks participants to create the most creative sentence they can using three given items. The modified version of the Alternative Uses Task (Wang et al., 2019) gives participants an object word and asks them to think of creative uses for that object. This is a multiple-item measure because it is assessed on 8 trials for each task. The trials for each task will be averaged together. The overall amount of alpha power between the two tasks will be compared to determine if brain activity is influenced by the type of creativity being assessed. If

differing amounts of alpha power are found between tasks, it would suggest that creativity type has an influence on brain activity.

Stress. This involves assessing the current state of anxiety that participants have using the State-Trait Anxiety Scale Form Y-1 (Spielberger 1968/1977). This scale includes a list of short statements that participants rate their agreement of on a four-point scale (1 = *not at all,* 2 = *somewhat,* 3 = *moderately so,* 4 = *very much so*.) This is a multiple-item measure because it has 20 statements. The following items for the stress scale will be reverse coded: 1, 2, 5, 8, 10, 11, 15, 16, 19, and 20. The weights of these items are flipped compared to the normally coded items. The sum across all 20 items will be calculated to obtain the stress score.

Self-Rated Creativity. Participants will rate how creative each of their responses were on the creative stage of the Modified Cognitive Synthesis Test (Abraham et al., 1987; Razumnikova et al., 2009) and the modified version of the Alternative Uses Task (Wang et al., 2019). They will rate their creativity on a three-point Likert scale (1 = *slightly creative,* 2 = *moderately creative,* 3 = *highly creative).* This is a multiple-item measure because it will be assessed on all 8 trials of the Alternative Uses Task and all 8 trials of the creative stage of the Modified Cognitive Synthesis Test. The mean across the 8 trials will be calculated to obtain a self-rated creativity score for each task.

Alpha Power. EEG data will be recorded during all three cognitive tasks. This includes the noncreative task of the Modified Cognitive Uses Test, the creative task of the Modified Cognitive Uses Test, and the modified version of the Alternative Uses Task (Abraham et al., 1987; Razumnikova et al., 2009; Wang et al., 2019). EEG segments will be obtained 8 times for each of the three tasks, which makes this a multiple-item measure. EEG segments from the 8 respective trials will be averaged into a total for each task. Spectral analysis will be done to

compare the EEG data between tasks. Frequency bands between 8 – 13 Hz will be considered alpha waves. If there are more frequency bands in this range, there is increased alpha power.

Creative Potential. This involves assessing participants' creative potential using the Biographical Inventory of Creative Behaviors (Batey, 2007). On this scale, participants are given a list of activities and asked to put an x in the box next to the activities they have done in the last 12 months. This is a multiple-item measure because there are 34 possible activities. The number of activities that the participant has done will be summed together into a total number of past creative activities. Participants who have completed more creative activities are considered to have more creative potential.

Analysis Plan and Expected Results

To test the hypothesis that participants will exhibit more alpha power during the creative tasks than during the non-creative task, I will conduct a repeated t-test. The two variables being analyzed are the creative alpha score and the noncreative alpha score. For the hypothesis to be confirmed, I expect to find a statistically significant t-statistic. The creative tasks will have a higher mean than the noncreative task.

To test the hypothesis that self-ratings of creativity will be positively correlated with alpha power, I will conduct a bivariate correlation test. The two variables entered for this test will be self-rated creativity and alpha power. For the hypothesis to be confirmed, I expect to find a statistically significant Pearson's r and positive coefficient.

To test the hypothesis that stress will be negatively correlated with alpha power during the creative tasks, I will conduct a bivariate correlation test. The two variables entered for this test will be stress and alpha power. For the hypothesis to be confirmed, I expect to find a statistically significant Pearson's r and negative coefficient.

To test the hypothesis that stress will be negatively correlated with self-rated creativity, I will conduct a bivariate correlation test. The two variables entered for this test will be stress and self-rated creativity. For the hypothesis to be confirmed, I expect to find a statistically significant Pearson's r and negative coefficient.

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Appendix A.

Recruitment Statement.

For this experiment, you will be asked to complete cognitive tasks on a computer. You will also be asked to complete brief surveys about yourself and your current emotional state. You will be connected to Electroencephalography (EEG) technology during this study. This involves placing an elastic cap on your head and inserting saltwater gel into that cap. It is a painless procedure, but the gel will get in your hair so you may want to bring a hat. You should also wash your hair later that day. You can stop the procedure at any point without penalty. This study will take approximately one hour to complete. You must be at least 18 years old to participate in this study.

Appendix B.

Consent Form.

The Impact of Creativity on Alpha Activity

Consent to Participate in a Research Study

Upon approval of your study, the IRB will place a stamp with a protocol number here. You are required to use only the stamped version when enrolling participants in your study.

Key Information

You are being invited to participate in a research study. This document includes important information you should know about the study. Before providing your consent to participate, please read this entire document and ask any questions you have.

Do I have to participate?

If you decide to take part in the study, it should be because you really want to volunteer. You will not lose any benefits or rights you would normally have if you choose not to volunteer. You can stop at any time during the study and still keep the benefits and rights you had before volunteering. If you decide to participate, you will be one of about 150 people in the study.

What is the purpose of the study?

The purpose of the study is to determine the underlying brain activity of creative processes. You are eligible for this study if you are over eighteen years of age.

Where is the study going to take place and how long will it last?

The research procedures will be conducted at Eastern Kentucky University. You will need to come to Cammack 107 one time during the study. This visit will take about an hour.

What will I be asked to do?

You will be given a short assessment to determine your current feelings. Afterwards, you will be connected to EEG technology. This involves placing an elastic cap on your head and putting saltwater gel into that cap. The EEG can be worn for long periods without discomfort, and all materials touching the skin are hypoallergenic, nonlatex, and electrically shielded. The gel will get into your hair, so you will want to wash your hair at a later point. After the cap has been secured, you will then complete cognitive tasks on a computer. The cap will then be removed, and you will be given a rag to clean your hair. You will then be asked to answer some additional questions about yourself.

Are there reasons why I should not take part in this study?

You should not take part in this study if you are under eighteen years of age.

What are the possible risks and discomforts?

To the best of our knowledge, the things you will be doing have no more risk of harm than you would experience in everyday life. The EEG is hypoallergenic, nonlatex, and electrically shielded to protect you from harm. While the EEG can be worn for long periods without discomfort, the initial application may be

slightly uncomfortable if you are tender headed. If you experience any discomfort, please tell the researcher and adjustments will be made or the experiment will be stopped.

What are the benefits of taking part in this study?

You are not likely to get any personal benefit from taking part in this study. Your participation is expected to provide benefits to others by helping to explain the underlying brain activity associated with creativity. With better knowledge of the brain functions of creativity, further research can be done to help individuals increase their creative ability.

If I don't take part in this study, are there other choices?

You will be given SONA credit for taking part in this study. If you do not want to take part in the study, there are other choices to gain your SONA credits. Other than this study, you can earn SONA credits by taking part in different research studies or completing other assignments unrelated to research participation.

Now that you have some key information about the study, please continue reading if you are interested in participating. Other important details about the study are provided below.

Other Important Details

Who is doing the study?

The person in charge of this study is Serena Bruneaux at Eastern Kentucky University. She is being guided in this research by Dr. Adam Lawson. There may be other people on the research team assisting at different times during the study.

What will it cost me to participate?

There are no costs associated with taking part in this study.

Will I receive any payment or rewards for taking part in the study?

You will receive 2.0 SONA credits for taking part in this study, which can aid you in getting the credits required for certain psychology courses. If you should have to quit before the study is finished, you will still receive the full reward.

Who will see the information I give?

Your information will be combined with information from other people taking part in the study. When we write up the study to share it with other researchers, we will write about this combined information. You will not be identified in these written materials. Your responses will be kept confidential. We will collect your information under a unique numerical code rather than your name. We will make every effort to prevent anyone who is not on the research team from knowing that you gave us information, or what that information is. However, there are some circumstances in which we may have to show your information to other people. For example, the law may require us to show your information to a court. Also, we may be required to show information that identifies you for audit purposes.

Can my taking part in the study end early?

If you decide to take part in the study, you still have the right to decide at any time that you no longer want to participate. You will not be treated differently if you decide to stop taking part in the study.

The individuals conducting the study may need to end your participation in the study. They may do this if you are not able to follow the directions they give you, if they find that your being in the study is more risk than benefit to you, or if the University or agency funding the study decides to stop the study early for a variety of reasons.

What happens if I get hurt or sick during the study?
If you believe you are hurt or get sick because of something that is done during the study, you should call Serena Bruneaux at 502-604-1718 immediately. It is important for you to understand that Eastern Kentucky University will not pay for the cost of any care or treatment that might be necessary because you get hurt or sick while taking part in this study. Also, Eastern Kentucky University will not pay for any wages you may lose if you are harmed by this study. These costs will be your responsibility.

Usually, medical costs that result from research-related harm cannot be included as regular medical costs. Therefore, the costs related to your care and treatment because of something that is done during the study will be your responsibility. You should ask your insurer if you have any questions about your insurer's willingness to pay under these circumstances.

What else do I need to know?
You will be told if any new information is learned which may affect your condition or influence your willingness to continue taking part in this study.

We will give you a copy of this consent form to take with you.

Consent

Before you decide whether to accept this invitation to take part in the study, please ask any questions that come to mind now. Later, if you have questions about the study, you can contact the investigator, Serena Bruneaux at serena_bruneaux@mymail.eku.edu. If you have any questions about your rights as a research volunteer, you can contact the staff in the Division of Sponsored Programs at Eastern Kentucky University at 859-622-3636.

If you would like to participate, please read the statement below, sign, and print your name.

I am at least 18 years of age, have thoroughly read this document, understand its contents, have been given an opportunity to have my questions answered, and voluntarily agree to participate in this research study.

Signature of person agreeing to take part in the study Date

_____ _____

Printed name of person taking part in the study

_____

Name of person providing information to subject

_____

Appendix C.

Script.

1. Greeting
    a. “Welcome to the experiment. Please take as much time as you need to read this consent form. You may ask any questions that you have. Once you feel you understand the information, please sign and date the form.”
2. State-Trait Anxiety Scale Form Y-1 (Spielberger, 1968/1977)
    a. “Before we set up the EEG, I would like for you to complete this survey. No one else is going to see your responses, so please answer truthfully. You may take as much time as you need.”
    b. Directions on the official form: A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you feel right now, that is, at this moment. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.
3. EEG Set-up
    a. “I will now set up the EEG technology. First, I will place this cap on your head. Then I will insert gel into the electrodes in the cap using a blunt needle. It will not hurt, but it may be uncomfortable if you are tender headed. Please let me know if you experience any discomfort.”
4. Modified Cognitive Synthesis Test (Abraham et al., 1987; Razumnikova et al., 2009)
    a. “You will now complete three tasks on this computer. It will give you directions. Try not to move your head during the tasks because it can affect the results.”
    b. General Directions: Welcome to the experiment! For the following task, you will be given three words. You will use the given words to create a sentence. You will be prompted to create either a simple sentence or a creative sentence. Press the spacebar to see an example.
    c. Example Item: Water, Streetlight, Tape. Create a SIMPLE sentence: There was water on the streetlight so the tape didn’t work. Create a CREATIVE sentence: The cars riding down the street splashed water on people and made the streetlight wet so tape couldn’t be used to attach the missing flyer to it. Press the spacebar to begin.
    d. Task 1 Directions: When the words appear, think of a SIMPLE sentence. Do not write anything until prompted.
    e. Task 2 Directions: When the words appear, begin brainstorming a CREATIVE sentence. Do not write anything until prompted.
    f. Writing Prompt: You may now write down your sentence on the paper provided. When you are finished, press the spacebar to continue.

   g. Rate Creativity Directions: How creative would you rate that response? 1 - Slightly creative 2 - Moderately creative 3 - Highly creative. Please type a 1, 2, or 3 in response.

5. Alternative Uses Task (Wang et al., 2019)
   a. Directions: The name of an object will be presented. Think of as many possible creative uses for the given object as possible. Do not write anything down until prompted. Press the spacebar to begin.
   b. Writing Prompt: Use the paper provided to write down your MOST creative idea.
   c. Rate Creativity Directions: How creative would you rate that response? 1 - Slightly creative 2 - Moderately creative 3 - Highly creative. Please type a 1, 2, or 3 in response.
   d. End Directions: This section of the experiment is now complete. Thank you for participating.
6. Remove EEG
   a. "Alright we can remove the EEG cap now. Here is a rag you can use to clean your hair."
7. Biographical Inventory of Creative Behaviors (Batey, 2008)
   a. "There are two short surveys left. Here is the first survey. You can give it to me once you have completed it."
   b. Directions on the official form: "Please answer as truthfully as you can. Place a cross (X) in the box next to the activities you have been actively involved in. In the past 12 months have you…"
8. Demographic Form
   a. "Here is the last survey. Please give it to me when you are finished."
9. Ending Experiment
   a. "Thank you for your participation! Here is a simple sheet that describes the purpose of the study that you have participated in. Feel free to read it and ask any questions you may have. You may take the sheet with you when you leave."

Appendix D.

Materials (State-Trait Anxiety Scale Form Y-1)

"The Impact of Creativity on Alpha Activity"
State-Trait Anxiety Inventory Form Y-1

DIRECTIONS:

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you feel right now, that is, at this moment. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

	NOT AT ALL	SOMEWHAT	MODERATELY SO	VERY MUCH SO
1. I feel calm	1	2	3	4
2. I feel secure	1	2	3	4
3. I am tense	1	2	3	4
4. I feel strained	1	2	3	4
5. I feel at ease	1	2	3	4
6. I feel upset	1	2	3	4
7. I am presently worrying over possible misfortunes	1	2	3	4
8. I feel satisfied	1	2	3	4
9. I feel frightened	1	2	3	4
10. I feel comfortable	1	2	3	4
11. I feel self-confident	1	2	3	4
12. I feel nervous	1	2	3	4
13. I am jittery	1	2	3	4
14. I feel indecisive	1	2	3	4
15. I am relaxed	1	2	3	4
16. I feel content	1	2	3	4
17. I am worried	1	2	3	4
18. I feel confused	1	2	3	4
19. I feel steady	1	2	3	4
20. I feel pleasant	1	2	3	4

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Appendix D (cont.)

Materials (Biographical Inventory of Creative Behaviors)

"The Impact of Creativity on Alpha Activity"

Biographical Inventory of Creative Behaviors

Please answer as truthfully as you can. Place a cross (X) in the box next to the activities you have been actively involved in.

In the past <u>12 months</u> have you…

1	Written a short story	
2	Written a novel	
3	Organized an event, show, performance or activity	
4	Produced a TV/Play script	
5	Designed and produced a textile product (e.g. made an item of clothing or household object)	
6	Redesigned and redecorated a bedroom, kitchen, personal space, etc.,	
7	Invented and made a product that can be used	
8	Drawn a cartoon	
9	Started a club, association or group	
10	Produced a picture, i.e. NOT a doodle (using paint, pencils, charcoal, acrylic, etc.,)	
11	Had an article published	
12	Formed a sculpture using any suitable materials	
13	Recognized where an accepted scientific theory/approach does not explain what it purports to	
14	Produced your own food recipes	
15	Produced a short film	
16	Produced your own website	
17	Produced a theory to explain a phenomenon	
18	Invented a game or other form of entertainment	
19	Selected to lead/manage others	
2	Made someone a present	

0		
21	Composed a poem	
22	Adapted an item and used it in a way that it was not designed to be, in what you consider to be an ingenious way	
23	Published research	
24	Choreographed a dance	
25	Designed and planted a garden	
26	Produced a portfolio of photographs (NOT photographs of a holiday, party, etc.,)	
27	Acted in a dramatic production	
28	Delivered a speech	
29	Mentored/Coached someone else to improve their performance	
30	Devised an experiment to help understand something	
31	Made up a joke	
32	Been made a leader/captain of a team/group (e.g. Debating society chairperson, Captain of the Hockey team, etc.,)	
33	Composed a piece of music	
34	Made a collage	

Appendix D (cont.)

Materials (Demographic Form)

"The Impact of Creativity on Alpha Activity"

Demographic Form

1. What is your birth sex?
    a. Male
    b. Female

2. What is your age (years old)?

    _____

3. What is your ethnicity?

    _____

4. What is your level of education?
    a. Undergraduate Freshman
    b. Undergraduate Sophomore
    c. Undergraduate Junior
    d. Undergraduate Senior
    e. Graduate student

5. Are you right-handed or left-handed?
    a. Right-handed
    b. Left-handed

Appendix E.

Debriefing Form.

"The Impact of Creativity on Alpha Activity"

Debriefing Form

Thank you for participating in this experiment! The purpose of this study was to investigate the underlying brain activity that occurs during the creative processes. Electroencephalogram (EEG) technology was used to measure brain activity. This technology uses electrodes to measure the electrical activity occurring in the brain. Alpha waves are one type of electrical brain activity commonly associated with creativity.

This study tests several hypotheses. The first hypothesis is that participants will exhibit more alpha power during the creative tasks than during the non-creative task. The second hypothesis is that participants who rate their responses as more creative will show more alpha power than participants who rate their responses as less creative. This study also examines how a person's current level of stress can influence how their brain functions during a creative task. It is hypothesized that more stressed participants will exhibit lower alpha power than less stressed participants during the creative tasks. Also, more stressed participants will report lower creativity than less stressed participants. The independent variables in this experiment were different writing tasks (simple sentence vs creative sentence), different types of creativity (verbal artistic creativity vs divergent thinking), and current levels of stress (high vs low). The dependent variables were self-rated creativity (high vs low) and alpha power (high vs low).

With this information, we hope to gain a better understanding of how creativity affects brain activity. With better knowledge of this concept, further research can be done to help individuals increase their creative ability. We hope that participating in this study made you think about the influence of creativity in your own life. Please contact us if you have any questions. Serena Bruneaux, the Principal Investigator responsible for this project, can be reached at serena_bruneaux@mymail.eku.edu. Adam Lawson, the faculty advisor, can be reached at adam_lawson@eku.edu. If you would like to learn more about the concepts of this study, you can read the following articles:

Benedek, M., Bergner, S., Konen, T., Fink, A., & Neubauer, A. C. (2011). EEG alpha synchronization is related to top-down processing in convergent and divergent thinking. *Neuropsychologia, 49*(12), 3505-3511.

Dietrich, A., & Kanso, R. (2010). A review of EEG, ERP, and neuroimaging studies of creativity and insight. *Psychological Bulletin, 136*(5), 822–848. https://doi-org.libproxy.eku.edu/10.1037/a0019749

Wang, X., Duan, H., Kan, Y., Wang, B., Qi, S., & Hu, W. (2019). The creative thinking cognitive process influenced by acute stress in humans: An electroencephalography study. *Stress: The International Journal on the Biology of Stress, 22*(4), 472–481. https://doi-org.libproxy.eku.edu/10.1080/10253890.2019.1604665