CAFFEINE'S EFFECT ON CREATIVE PRODUCTION

An Honors Fellows Thesis

by

MARK MATTHEW MIMS

Submitted to the Honors Program Office
Texas A&M University
in partial fulfillment of the requirements for the designation as

HONORS UNDERGRADUATE RESEARCH FELLOW

April 2010

Major: Nutritional Sciences

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Approved by:

Research Advisor:	Robert S. Woodward, Jr.
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ABSTRACT

Caffeine's Effect on Creative Production. (April 2010)

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This study attempted to determine a link between caffeine consumption and an increase in the creative production. Participants, college-aged students at Texas A&M University, completed Form A of the figural portion of the *Torrance Test of Creative Thinking* to establish a baseline score. Participants then received chewing gum containing either 100mg of caffeine or no caffeine (placebo) and completed a survey containing biometric data as well as caffeine consumption habits. After one hour the students took Form B of the figural portion of the *Torrance Test of Creative Thinking*. Scores from these tests were compared among experimental groups and variables reported on the survey were taken into consideration. The experiment showed a statistically significant ($p<0.05$) decrease in the fluency scores of those individuals who received caffeinated gum over their placebo counterparts. Additionally the overall, originality, and elaboration scores trended downwards in the group receiving caffeine. This data shows that caffeine does play a role in the creative thought process, although its effects are complex. Further research is necessary to verify and elucidate the role of caffeine in creative thinking.

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CHAPTER I

INTRODUCTION

In the world today, more and more emphasis is being placed on the ability to be creative. From corporate executives to college students, the ability to be creative is a highly sought after characteristic. Creativity is an elusive trait and while some are more naturally inclined to it than others, practice and exercises in creative thinking can improve creative performance in those not innately gifted in creative thought. This study seeks to explore the idea that there are other ways to enhance creative thought, specifically through the use of caffeine.

Creativity theories

What it means to be creative has proven to be a long standing debate. Many great philosophers and thinkers have attempted to describe what creativity is and why certain people are creative. While many theories share similar characteristics, there has yet to be a consensus among the experts on what it truly means to be creative. Sigmund Freud thought that creativity came from the expression of libido-stimulated thoughts and that those who were deemed "uncreative" simply repressed these natural thoughts (Davis, 2004). Freud also brought forth an important idea to many creative theories: that creative thinking was the result of one regressing to a childlike

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This thesis follows the style of *Creativity Research Journal*.

mindset. This regression involves the suppression of "secondary process thinking," or a more pragmatic approach to thinking, in favor of "primary process thinking," or a more free-form approach to thinking. Another important idea, made popular by Lawrence Kubie, was that of the role of preconscious activity in creative thinking. Kubie believed our mind to consist of a continuum with our conscious mind at one end and our unconscious mind at the other. Creativity, Kubie claimed, was formulated in the area between our conscious and unconscious minds, in that of our *preconscious*. This preconscious mind was free to interplay between the conscious and unconscious to create new ideas, meanings, and connections. More recent theorists such as Robert Sternberg, Mihalhyi Csikszentmihalyi, and Howard Gardner have developed theories of creativity by focusing on the individuals who produce creative ideas (Davis, 2004). These theories show creativity as the result of many different factors, for example the creative person, their domain (or discipline), and field.

Although it has proven to be almost impossible to define, it is common to think of creativity as a culmination of 4 "P's": *person, process, product, place* and the manner in which they interact with each other. The creative person includes all of the factors that have shaped a person, for example a one's history. The creative process is the means by which a creative person develops a creative product. The creative product is the idea, object, or other entity that results from the creative process. Finally, the creative press is the environment into which the creative product is received (Davis, 2004). This experiment will focus on the third P, or the creative *product*. Testing of the creative

product is the most relevant to real-world application because it is rare to find a problem that does not require some sort of tangible response; thus the creative person, process, and press are merely means to an end for most situations.

For the purpose of this research, the author has chosen to define creativity as a complex interrelation between the creative person, process, product, and press which, in combination, yield novel ideas useful to the creative thinker.

Torrance Test of Creative Thinking

The test used for this study was the 2006 version of the *Torrance Test of Creative Thinking* (TTCT) – Figural portions. The TTCT is by far the most common measure of creativity. Among the reasons for the popularity of this test is the high interscorer reliability in which through the use of norms and technical manuals the reliability of the scoring is almost always above 0.90. Additionally, and importantly for this study, test/re-test reliabilities range from 0.60-0.80. Perhaps most important was the longitudinal studies which showed scores from the TTCT paralleled creative achievements in the individual's life (Davis, 2004). The figural test asks examinees to respond to three sections in which they must complete a drawing given pieces of shapes. The three sections are: Picture Construction, in which a given form is used as the basis for a creative drawing; Picture Completion, in which ten abstract shapes are given to the examinee who must complete and entitle; and Lines (or Circles), in which the examinee is given a number of parallel lines (or in the other form, circles) to which they must

incorporate in their drawings. The TTCT is scored in five norm-referenced categories and thirteen criterion-referenced categories. The five norm-referenced categories are: fluency, originality, elaboration, abstractness of titles, and resistance to premature closure. Of these five, fluency (the quantity of ideas produced), originality (the production of unique or uncommon ideas), and elaboration (the amount of detail in an idea) parallel most with common accepted ideas of what makes up creative thinking. The other two, abstractness of titles and resistance to premature closure, were more recently added to the scoring guidelines to provide a more comprehensive score. The thirteen criterion-referenced categories represent characteristics that are thought to affect creative thought (Ball, Safter, & Torrance, 2008).

Caffeine's role

Caffeine, classified as a methylxanthine, has numerous physiological effects on the body. One of the effects most relevant to this study is its action as an adenosine receptor antagonist (Chawla, 2006). Adenosine is a compound found in the brain and is known to suppress electrical activity of neurons as well as inhibit synaptic transmission. Through its antagonistic mechanism, caffeine depresses these outcomes caused by adenosine, thereby increasing the brain's ability to communicate through its neurons (Chawla, 2006; Nehlig, 1992).

Recently it has been considered that creative thinking involves a collaboration of many different areas in the brain and a complex level of neural communication (Lanni, 2008).

It was hypothesized by the experimenter that caffeine, which increases the synaptic activity within the brain, may increase the collaboration of the brain and thus increase the ability to be creative. Additionally, by acting as a competitive inhibitor in adenosine receptors, caffeine indirectly causes a release of dopamine into the prefrontal cortex (Nehlig, 1999). The prefrontal cortex is an area of the frontal lobe thought to be important in the formation of creative thought (Lanni, 2008).

Previous studies

Although research has been conducted to observe the different traits and life experiences that influence creative thought, little research has focused on some of the more organic factors that may or may not affect creativity such as diet, exercise, or physical health. At the current time, no studies investigating the role of a compound such as caffeine in creative thinking have taken place. This study may be used as the basis for future studies looking into other lifestyle factors that affect creativity.

Other studies which have involved creativity and transient factors have largely included studies looking at alcohol and creativity. Alcohol, a central nervous system depressant, has been said to aid many people such as authors and painters in their creative works. The disinhibition hypothesis says that a decrease in our real or perceived inhibitions will lead to more creative thinking (Davis, 2004). This is similar to Freud's suppression of secondary processing by means of an external agent, alcohol, to achieve primary processing. Results of experiments studying a link between alcohol and creativity have

shown variable results; however a study which used the *Torrance Tests of Creative Thinking* both Figural and Verbal portions showed that while consuming alcohol did not significantly change scores, the perception of having believed to consumed alcohol resulted in a significant increase in their creativity test scores (Lang, Verret, Watt, 1985). Using caffeine, a central nervous system stimulant, in this study will explore the opposite effect of alcohol on creativity.

Many studies have been done documenting the effects of caffeine on the human body. One particular experiment relevant to this study explored the link between caffeine and the preterm infant brain. This study found that caffeine injected intravenously into preterm infants increased the infant's cortical activity as seen in the increase of their amplitude-integrated electroencephalography (Kutz, Pielemeier, Roll, & Supcun, 2010). This increase in cortical activity shows that the human brain does increase electrical activity in response to caffeine doses which may have implications for creative thinking.

CHAPTER II

METHODS

Participants

The study was performed as a randomized, single-blind, placebo controlled experiment. Participants for this study were comprised of college-aged (18-24) students from Texas A&M University who were enrolled in an Educational Psychology class. These students were offered credit for one class assignment if they participated in the study. The experiment was held on a Saturday morning with the hopes of minimizing external distractions such as classes or fatigue from a day's activities. Additionally, the tests were held in a room selected to minimize distractions and allow adequate comfort.

Procedure

Prior to the beginning of the experiment, participants were asked to abstain from caffeine and caffeine containing products for the twenty-four hour period preceding the study in hopes of clearing at least 75% of the dietary caffeine stored in the body. The period of abstinence from caffeine is based on research which found the half life of caffeine in the body to be approximately three to six hours (Lab Corp, 2007; Statland 1980). This is done in attempt to minimize the difference in baseline caffeine levels of participants without having to resort to measures such as a blood test for variable adjustment.

On the testing day, students were assigned an experimental number which was used to identify their testing materials throughout the experiment. This was done so as to ensure anonymity and protect the confidentiality of the participants. Upon commencement of testing, subjects took a TTCT in order to establish a baseline creativity score (pre-treatment). After the pre-treatment test, participants received a piece of unlabeled gum randomly assigned to them according to their experimental number and began chewing. The gum received was either the treatment group, a piece of Stay Alert spearmint gum containing 100mg of caffeine, or a placebo control group, consisting of a similar tasting, non-caffeinated piece of gum. This level of caffeine is approximately equivalent to that of a cup of coffee (Chawla, 2006). Stay Alert chewing gum was chosen for this experiment due to its previous clinical testing. According to a previous study, 85% of the caffeine load of Stay Alert gum is released within 5 minutes of chewing (Kamimori, 2002). Based on these results, subjects were asked to chew the gum for 10 minutes and then remove the gum. This allowed the participants enough time to obtain most of the caffeine present in the gum. Another study on Stay Alert gum showed that the time for maximum caffeine absorption for the gum is approximately one hour (Kamimori, 2002). Therefore subjects were asked to wait for one hour from the commencement of chewing before retaking a TTCT (post-treatment).

During this waiting time, subjects filled out a questionnaire to collect data on basic biometric information including height, weight, gender, information on basic diet, exercise, and health patterns as well as specific questions related to caffeine use such as

frequency, quantity, and form of caffeine intake (See Appendix for a copy of the survey used). Since studies involving humans are often complicated from the wide variety of factors influencing human behavior, and especially the human thought process, questions regarding factors other than caffeine intake were used for comparisons between groups to ensure that any significant factors that may affect data were adjusted for. During this period, participants were instructed not to discuss the experiment in any respect for the duration of the hour.

One hour after the commencement of chewing the gum, participants completed a second TTCT in order to obtain post-treatment data. This test was the opposite form of the one previously given, or Figural Form B. Both tests were scored by the experimenter to increase the reliability of the scores. This data was used to determine if there is a correlation between caffeine intake and creativity through statistical analysis. Paired sample t-tests and analysis of variance (ANOVA) were used to determine any statistical significance. TTCT data was then analyzed with regard to the personal information collected from all the participants.

CHAPTER III

RESULTS

Survey results

The study consisted of 37 participants, of which 35 were female and 2 were male. 35 participants reported consuming caffeine on a regular basis with the majority (78%) receiving caffeine in the form of coffee or sodas. Most participants reported consuming caffeine one to two times a day and reported having consumed caffeine regularly for at least one year. Using the caffeine content listed in the 2009 USDA Nutrient Database for Standard Reference, the average participant consumed anywhere from 35mg to 160mg of caffeine daily (USDA, 2009). This confirms that the caffeine content in the experimental group was within the normal range of caffeine consumption for most participants. Additionally, reports have shown that negative side effects and the development of a tolerance to effects of caffeine occurs after regular consumption of 200mg or more daily (Johns Hopkins, 2003). The majority of participants reported consuming between 100-150mg of caffeine a day and thus the effect of caffeine tolerance as a variable could be removed from analysis. This report also shows that the sample population consumes less caffeine daily than the average adult America, approximately 280mg daily (Johns Hopkins, 2003).

Statistical analysis

Mean scores from the pre-treatment test (Form A) and post-treatment test (Form B) were 27.4 and 25.8, respectively with a standard deviation of 5.6. Mean fluency scores were

20.4 for Form A and 24.7 for Form B with a standard deviation of 6.8. Originality decreased from a mean of 16.0 from Form A to 13.9 on Form B with a standard deviation of 5.9 and mean elaboration scores also decreased from 7.2 to 6.1 with a standard deviation of 1.8. Figure 1 shows these relationships below.

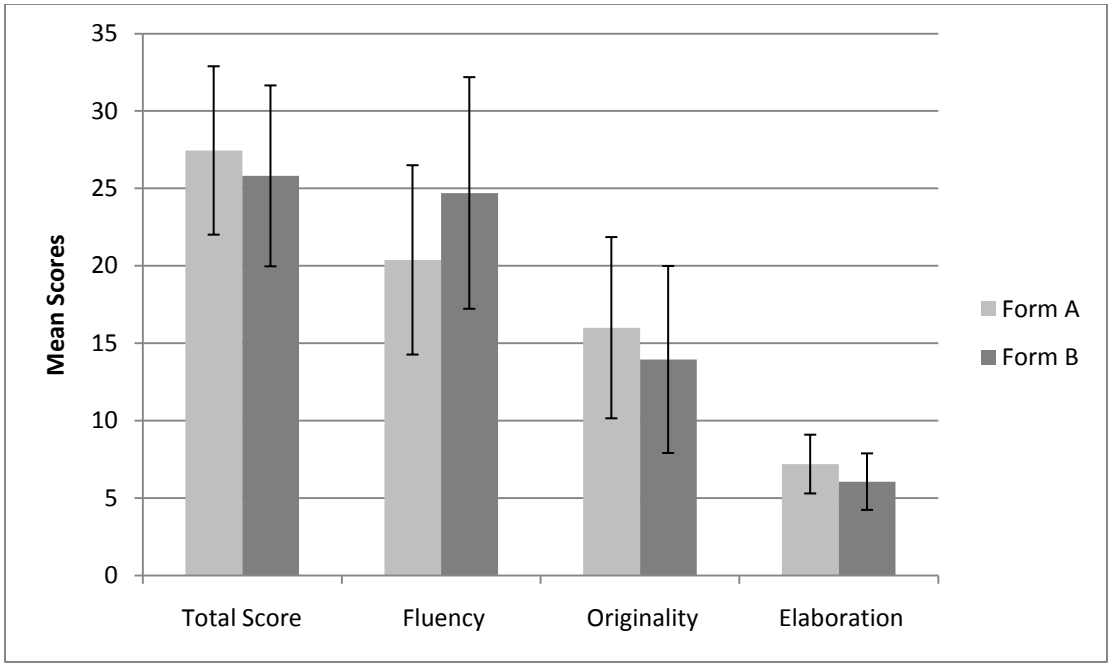

FIGURE 1 Mean scores between Form A and Form B

Data from the experiment was analyzed using two different statistical methods: the Student's paired-sample t-test as well as an analysis of variance (ANOVA). Results of the paired-sample t-test show the difference between the total scores of the pre-treatment and post-treatment tests to have a significance (p-value) of 0.09. Additionally, the three main components, fluency, elaboration, and originality, were also tested individually to see if there was a significance among them. Fluency was significant at the α=0.05 level

with a p-value of 0.003. Originality was also significant at the α=0.05 level with a reported p-value of 0.033. Finally, elaboration showed the most statistically significant difference with a p-value of 0.001. These values are summarized in Table 1.

TABLE 1 Paired sample t-test results between forms

		Paired-sample t-test	
	df	t	p-value
Total Score A Total Score B	36	1.740	.090
Fluency A Fluency B	36	-3.172	.003
Originality A Originality B	36	2.217	.033
Elaboration A Elaboration B	36	3.809	.001

These p-values allow us to determine whether differences observed between two experimental parts (in this case between different scoring categories in the different forms) can be explained by chance or random fluctuations. The smaller the p-value, the less likely it is that the difference can be explained by chance. Most analyses use an α level of 0.10 or 0.05 which means that if a p-value is less than 0.10 or 0.05, the study determines that difference to be statistically significant, or rather, that the probability of that difference being cause by random chance is low enough to assume that another factor was present driving the change. As there were three statistically significant variables in the paired sample t-test (fluency and elaboration at the α=0.05 and total score at the α=0.10), an ANOVA was used to attempt to determine what might be driving this difference.

Table 2 shows the ANOVA test revealed that the differences among the separate categories (total score, fluency, etc) were not statistically significant in Form A of the test results. However in the results for Form B, it was observed that fluency was significant at the α=0.05 level with a p-value of 0.005. Total score had a p-value of 0.726, elaboration a p-value of 0.372 and finally originality showed a p-value of 0.176.

TABLE 2 ANOVA results between forms

	ANOVA	
	F	p-value
Total Score A	0.053	0.818
Total Score B	0.124	0.726
Fluency A	0.022	0.882
Fluency B	8.969	0.005
Originality A	0.012	0.912
Originality B	1.903	0.176
Elaboration A	0.01	0.92
Elaboration B	0.817	0.372

To analyze the statistically significant differences in Form B, a closer look was taken at the data given by the two treatment groups to determine if caffeine could be an explanation for the observed differences.

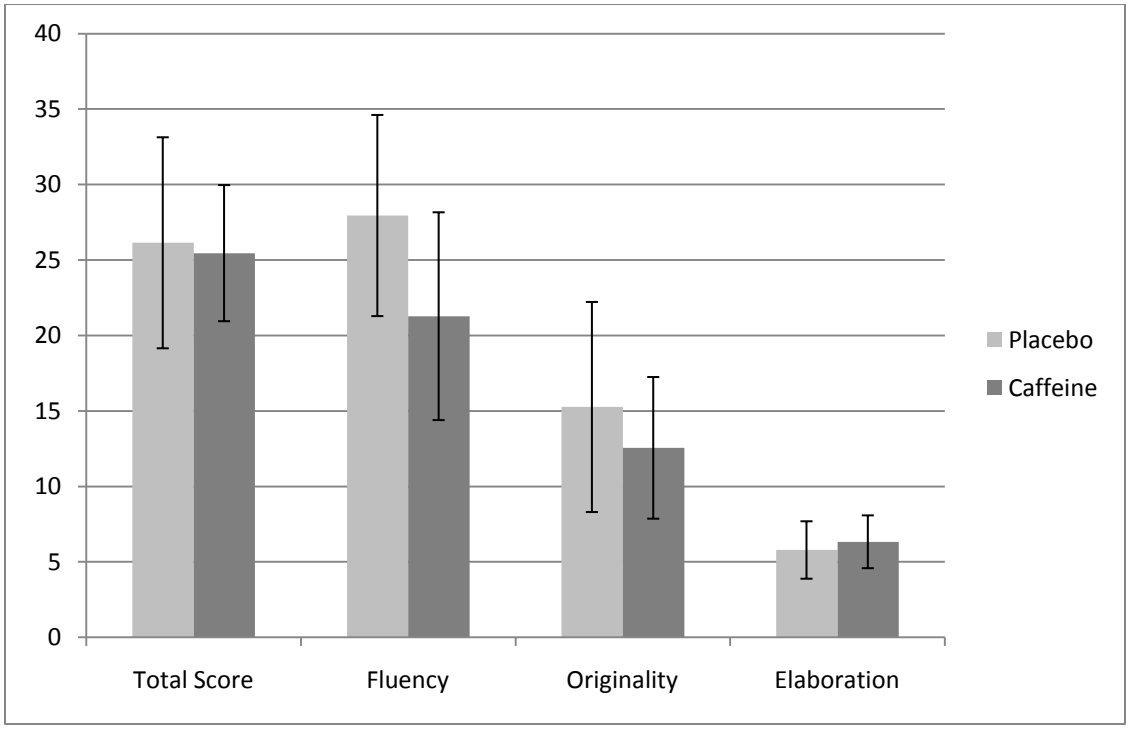

FIGURE 2 Post-treatment means between treatment groups

Differences among the two post-treatment groups, placebo and caffeine, were then compared using ANOVA for the post-treatment test. Figure 2 shows the results of this analysis in graphic form. The scores for those who received the placebo were a mean total score of 26.14 with a standard deviation of 6.99, mean fluency was 27.95 with a standard deviation of 6.66, mean originality was 15.26 with a standard deviation of 6.96, and mean elaboration was 5.79 with a 1.9 standard deviation. The experimental, or caffeine group, showed a total score mean of 25.46 with a standard deviation of 4.51, fluency mean score of 21.28 with a standard deviation of 6.88, originality mean score of 4.69 with a standard deviation of 4.69, and an elaboration mean score of 6.33 with a standard deviation of 1.75. These results are summarized in Table 3.

TABLE 3 Post-treatment means between treatment groups

	Placebo		Caffeine	
	Mean	Std. Dev.	Mean	Std. Dev.
Total Score	26.14	6.99	25.46	4.51
Fluency	27.95	6.66	21.28	6.88
Originality	15.26	6.96	12.56	4.69
Elaboration	5.79	1.9	6.33	1.75

CHAPTER IV

CONCLUSIONS

The findings from this experiment demonstrate that caffeine does play a role in creative thinking, however its effect and the extent of this effect is complex. In the statistical analysis, the difference in total score between the pre-test and post-test was not statistically significant; however, upon breaking down the scoring into categories, it was found that one reason for this was that the scoring categories did not have a uniform direction of change. While fluency increased between the pre-test and post-test, originality and elaboration both decreased by a similar amount, causing the total score between forms to appear statistically irrelevant. Therefore it was important to break down the scores into the different categories and evaluate each of these on their own.

In the analysis, fluency was the only component tested that showed statistical significance in both the paired-sample t-test as well as the ANOVA. It was significantly higher in the post-treatment test than in the pre-treatment test. In comparing the means of the post-treatment test between the two post-treatment groups, it was found that fluency was significantly lower in the experimental group than in the placebo group. This difference shows that caffeine may actually depress one's ability to generate creative ideas.

One possible explanation of this difference is what is known as item-specific practice. In this scenario, subjects exposed to a repeated procedure, or test, tend to develop better

test-taking strategies on subsequent tests. However the effect from repeated testing can be mitigated using alternate test forms, as in the case of the TTCT (Benedict & Zgaljardic, 1998). Another explanation may be the novelty effect. This effect states that a subject will produce their strongest response to a stimulus the first time they encounter it (Corsini, 1999). In this study the novelty effect would artificially inflate the pre-test scores. This may account for some of the decreases seen in the post-test, however it would not account for the significance of the fluency scores. Fatigue from the testing procedure may also have resulted in lower post-test scores, although like the novelty effect, it likely would not account for the difference in fluency scores. A final factor that must be considered is caffeine consumption. While caffeine may or may not explain the difference between fluency scores between the pre-test and post-test means, there is a largely significant difference between the caffeinated and non-caffeinated fluency scores on the post-test. This may show that caffeine inhibits the brain's ability to generate creative ideas due to an overstimulation. Fluency is an important component of creative thinking and knowing that a negative correlation between fluency and caffeine consumption may exist would be beneficial to those who must think creatively.

While the other components tested did not reach statistical significance in both analyses, the trends shown in the statistical analysis of these scores are worth considering. Originality demonstrated statistical significance in the paired-samples t-test but did not reach statistical significance in the ANOVA. However, the p-value of originality in the ANOVA from Form A scores was $p=0.912$ and in Form B, the p-value dropped

dramatically to p=0.176. Similarly, elaboration reached significance in the paired-samples t-test but not in the ANOVA. Elaboration also showed a large difference in p-values between Form A and Form B (from p=0.920 to p=0.372). These decreases may be the result of a number of factors, caffeine consumption among them. Additionally, fatigue from the testing procedure may have played a role in the overall decrease in the mean scores of these two components. Further research with a larger sample population and perhaps a revised testing procedure may be able to better define the role of caffeine in these two components.

These variables also did not show significant difference between the treatment groups in the ANOVA computations. Total score and elaboration scores were very similar between groups and while originality showed a large difference, it was still not statistically significant. And while not statistically significant, the data shows a decrease in three of the four scoring categories and only a slight increase in the fourth category, lending itself to the thought that caffeine may decrease creative thinking in general.

Scores were compared to the *Torrance Tests of Creative Thinking* Norms-Technical Manual which confirmed that the participants of this study scored well within the averages listed for their age group. The majority of participants scored within the 40-60 percentile group of the nation. As expected, fluency scores for the post-treatment test were slightly above average, but not by a statistically significant amount (Torrance, 1998).

Reported answers in the surveys did not reveal any significant variables that may have skewed the data and thus did not need to be accounted for in the statistical analysis.

Limitations

Limitations of this study include a sample group containing only college aged students, the large majority of whom were of one gender. This is not indicative of the general population and may lack utility in some situations. The sample size is also a concern, and while statistical analysis may compensate for having a smaller sample group, further research with a larger, more diverse, sample population would be beneficial in exploring the relationships between caffeine and creative thinking.

Another important criticism that may be found is that the TTCT is not an accurate representation of creative ability. While the TTCT is generally accepted as a good measure of creative product, this is just one portion of creativity. Additionally, these tests do not take into account factors such as personality and personal history, important components of one's overall creativity. However, any increase in a component of creativity will result in the subsequent increase in one's overall creativity; therefore an increase in the creative production of an individual will lead to an increase in the overall creativity of an individual, which accomplishes the purpose of the study.

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APPENDIX

Testing Number_____

Age: _____ Height (ft, in): _____ Weight (lbs): _____ Gender: O M O F
Major: _____ I work: O I don't work O 1-20 hrs/wk O 21-40+/wk
Ethnicity: O Caucasian O African American O Hispanic O Asian O Decline
Other_____
Have you taken a Torrance test before? O Y O N If so, when? _____

Answer the following questions to the best of your abilities, choosing the closest matching answer.

My primary source of caffeine is (bubble only one):
O Coffee O Tea O Energy Drinks O Soda O Pain Relievers With Caffeine
O Caffeine Pills Other_____

On average, I consume caffeine containing products:
O I don't consume caffeine O Once a day O Twice a day O Three times a day O Four or more times a day

I have consumed caffeine regularly for:
O I don't consume it regularly O 1-3 months O 4-6 months O 7-12 months O 1-3 years O 4-6+ years

On average, I sleep about (hours per night):
O 4 or less O 5 O 6 O 7 O 8 O 9 O 10 or more

On average, I exercise for at least 20 minutes:
O Less than 1 time a week O 1 time a week O 2-3 times a week O 4-5 times a week O 6+ times a week

What form(s) of exercise do you primarily do? _____

I last consumed caffeine (date, time and in what form): _____

If I consume caffeine, it makes me feel:
_____

If I don't have caffeine for an extended period, I feel:
_____

How does caffeine affect you?
_____

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