CANNABIS USE FREQUENCY AND MOOD ON CREATIVITY

By

Caitlin A. Clark

A Thesis Presented to

The Faculty of Humboldt State University

In Partial Fulfillment of the Requirements for the Degree

Master of Arts in Psychology: Academic Research

Committee Membership

Dr. Kauyumari Sanchez, Committee Chair

Dr. Gregg Gold, Committee Member

Dr. Ethan Gahtan, Committee Member

Dr. Chris Aberson, Graduate Coordinator

May 2017

Abstract

CANNABIS USE FREQUENCY AND MOOD ON CREATIVITY

Caitlin Clark

This study examines the relationship between cannabis use (infrequent, moderate, and heavy use) and one's mood (neutral, positive, and negative) on creativity. Folk ideas of creativity and the relationships between cannabis use and mood may not reflect the real relationship between these factors (e.g. regarding cannabis use, it is perceived to be linked with higher rates of creativity; regarding mood, negative states [i.e. tortured artist] are thought to fuel creativity). Although both cannabis use and mood have been found to influence creativity independently, the current study is unique in its aims to identify whether cannabis use and mood interact to influence one's creativity.

Participants (n=242) engaged in a creativity task over three different mood blocks (neutral, positive, and negative), where mood was induced via sound stimuli. Creativity was measured by the number of alternative uses for common objects produced by the participants in the alternative use task (AUT). The AUT was followed by a cannabis use survey and the Creative Achievement Questionnaire (CAQ).

Although no significant interaction or main effects of cannabis use frequency and mood was found, post hoc analysis of the survey data suggest self-report creativity and one's education level are linked to higher rates of creativity. Post-hoc analyses also suggest that heavy cannabis users reported a higher CAQ score, thus higher lifetime creativity. Limitations to this study include a failed manipulation check of mood inducement. Future research directions and implication of this study will be discussed.

Acknowledgements

I am deeply thankful to Dr. Mari Sanchez for her consistent guidance and support. Her unique perspective and knowledge helped guide me through my first thesis process from beginning to end. She gave me the freedom to choose this topic while grounding me when I couldn't keep my head on straight. She provided direction and critical insight to this entire project, and for that, I'm forever grateful.

Special thanks goes to the cognition lab members and the professors at HSU for helping me collect participant data for this study.

RAs: Benny Chu, Maria CruzVazquez, Mary De Jerez, Calvin Herman, Kyra Kelly, David Montes, Bailey Swancoat, & Zhelin Wu.

Professors: Chris Aberson, Julia Alderson, Paul Bourdeau, Andre Buchheister, Leena Dallasheh, Amber Gaffney, Ethan Gahtan, Paul Geck, David Greene, Gregg Gold, Brandice Guerra, Patrick LaShell, Melanie McCavour, Bruce O'Gara, Justus Ortega, Tyler Purvis, William Reynolds, Patricia Siering, John Steele, & Claire Till.

Table of Contents

List of Tables

List of Figures

List of Appendices

Introduction

Creativity is important. But how does one become creative? Some may seem more creative while on mind-altering substances, while others use their mood to fuel their creative drives. For example, Steve Jobs once said, "The best way I would describe the effect of the marijuana and the hashish is that it would make me relaxed and creative" (Kowal et al., 2015). This sentiment seems to be shared by many, as half of the reported cannabis users in Europe and the United States believe that they are more creative while under the influence of cannabis (Minor et al., 2014). However, this perceived relationship between cannabis and creativity begs the question as to whether the relationship is real or simply perceived. In addition, previous research has suggested that there is a relationship between a person's mood and how creative they can be (De Dreu, Carsten, Baas, & Nijstad, 2008). This is in line with another common preconception, specifically that emotionally distraught artists are more creative while in the in the wake of their emotional negativity. Everyone knows about the suffering artist, but the link with positive mood and creativity doesn't seem to be present in our culture. Thus we must also ask, is the perceived relationship between mood and creativity real or simply perceived? The aim of this project is to address the relationship between cannabis use and mood on creativity. This paper will first review the literature on creativity.

Literature Review

Creativity

Although creativity can be defined in a multitude of ways, this project will highlight creativity through the production of ideas and thoughts. In fact, one common definition for creativity is through the production of ideas, insights, or problem solutions that are novel and are intended to be useful (De Dreu et al., 2008). This project will focus on the production of ideas. Specifically, this project will operationally define creative thinking in terms of divergent thinking, which is the process of producing multiple ideas or answers for a vague context (Guilford, 1950). Divergent thinking is often tested through the alternative use task (AUT; Guilford, 1967). In the AUT, participants are asked to produce as many possible uses for a common object (i.e. “cup”, “chair”, “brick”). The number of uses produced is a measure of the participants’ fluency of creativity through divergent thinking. Thus, this study will employ the AUT as a means to test creativity through divergent thinking.

In addition to the divergent thinking task of the AUT, creativity has also been measured via questionnaires. For example, the Creative Achievement Questionnaire (CAQ) is a self-report survey that assesses the achievements of the participants across 10 domains of creativity, and 13 different areas of talent (Carson, Peterson, & Higgins, 2005). With undergraduate students, the questionnaire has strong test-retest reliability ($r = .81$, $p < .001$) and internal consistency reliability ($\alpha = .96$). The researchers also found that with divergent thinking tests, the CAQ has strong convergent validity with college students ($r = .47$, $p < .001$). Thus the CAQ is an adequate measure of creative individuals and can be used to assess participants on their perception of their own creative ability.

The CAQ is a good tool for assessing multiple aspects of creativity and may tell us something about the underlying brain mechanisms behind creativity (Silvia, Beaty, Nusbaum, Eddington, & Kwapil, 2014). For example, Zabelina, Colzato, Beeman, and Hommel (2016) found that when using the CAQ with another measure of creativity, the Abbreviated Torrance Test for Adults (ATTA), which is another way to measure divergent thinking (aside from the AUT), the CAQ could predict predispositions related to striatal and frontal cortex dopaminergic processing. Creativity, specifically divergent thinking through the ATTA, is related to dopamine levels for fluency (the number of items produced in the ATTA) and originality when the participants scored high on the CAQ. This result suggests dopamine may play a critical role in creativity. In addition, this result provides support for the validity of the CAQ as a measurement of creative ability.

Past research (Zabelina et al., 2016) suggests that the dopamine levels in the striatal system may play a key role in creativity, insofar as divergent thinking is concerned. Since Guilford's (1950) first research of divergent thinking, researchers (Beaty et al., 2014; Jauk, Neubauer, Dunst, Fink, & Benedek, 2015; Wu et al., 2015) have studied the localization of divergent thinking within the brain. For example, Beaty et al. (2014) examined the default mode network communication with the prefrontal cortex in high and low creative participants. The default mode network is where spontaneous thought production and internal attention occurs. The researchers found few overlapping areas within the brain that are activated during divergent thinking. Specifically, they reported that the striatum and the inferior-prefrontal cortex are positively correlated with internal spontaneous cognition, and both are activated during a divergent thinking task. Thus, these are the physical areas of the brain that are active while engaged in divergent thinking. In addition, the researchers found that the functional connectivity in highly creative participants was greater compared to low creative participants between the inferior parietal lobes (IPL) and inferior frontal gyrus (IFG). This means that highly creative people are more likely to have stronger connectivity within the areas in which creativity occurs within the brain than less creative people. Furthermore, highly creative people were also found to have a higher connection with the default network. Stronger connectivity means an increase of the likelihood of the neurons to receive input from other neurons, resulting in faster pathways for messages to travel within the brain. Thus, this suggests that idea production is physically easier for those who have more creative experience.

Although dopamine seems to play an important role in creativity, the relationship is not simple. The neurochemistry of divergent thinking is related to dopamine levels. For example, Chermahini and Hommel (2010) found an inverse-U shaped relationship between dopamine and divergent thinking. This means that there is an ideal level of dopamine for optimal divergent thinking performance. Interestingly, this also means that too little or too much dopamine are linked with deficits in divergent thinking.

Related to divergent thinking is novelty seeking, which is also associated with dopamine levels in the brain (Flaherty, 2005; Jauk et al., 2015), and creativity (Panksepp

& Biven, 2007). For instance, Jauk et al. (2015) results support novelty-seeking through decreased gating of incoming information, which decreases activation, by the dopaminergic system within the striatum. This makes dopamine a vital component in thought production and the desire to find or experience something new. This supports the notion that dopamine levels are important for idea production and creativity. However dopamine is just one neurotransmitter and creativity can be influenced by much more than just one particular molecule.

Creativity and Cannabis

It is a widely held notion that one's creativity can be enhanced with mind altering substances, such as cannabis. In fact, about 50% of cannabis users believe that using cannabis can make them more creative (Minor et al., 2014). Although there are many anecdotes concerning a presumed positive relationship, neuroscience and behavioral studies have sought to scientifically test this idea. However, in order to understand how creativity and cannabis are related, one must understand the relationship between dopamine and cannabis first.

The relationship between dopamine and cannabis is indirect, but distinct. Cannabis works within the endocannabinoid system (ECBS) in humans. Befort (2015) and Makriyannis (2014) define the ECBS as a modulatory system that is in both the central nervous system (CNS) and peripheral nervous system (PNS). Naturally synthesized cannabinoids, anandamide (AEA) and 2-arachidonoylglycerol (2-AG), or delta-9-tetrahydrocannabinol (THC), which is the main psychoactive compound in cannabis, activates presynaptic GABA/glutamate terminals through CB1 and CB2 receptors on the embedded in the presynaptic neuron (Makriyannis, 2014). Through these GABA/glutamate terminals, cannabinoids can influence neuronal dopaminergic release (Kowal et al., 2015). In addition, it has been observed that THC can increase striatal dopamine release (Bossong et al., 2009; Kuepper et al., 2010). This could be the biological connection between cannabis and creativity, since it appears that dopamine is released in the same areas in which creative thought occurs. In relation to the current study, these results explain the underlying mechanisms that can alter dopamine levels when taking cannabis. These are the same areas within the brain that are associated with creativity production (Wu et al., 2015). Understanding the procedure of how dopamine levels can be influenced by the neurobiological modulatory system, that is the ECBS, is crucial to understanding how dopamine can influence creativity.

However, the connection between cannabis and dopamine is not clearly defined. Sami, Rabiner, and Bhattacharyya (2015) conducted a meta-analysis of past experiments (Barkus et al., 2011; Bossong et al., 2009) connecting neuronal dopamine levels to cannabis use. The results of the meta-analysis suggest that acute striatal dopamine release in humans is still largely inconsistent. However, acute striatal dopamine release with animal testing tends to support the increase of dopamine release when given low and high dosages of THC. Overall the research on animals concerning acute striatal dopamine release has found more consistent patterns of results than research in humans. This suggests that the ECBS is more complex in humans than in other mammals. In fact, Sami et al. (2015) also found that heavy use of cannabis in humans can diminish dopamine synthesis and the amount of dopamine released within the brain. This means that heavy users of cannabis may have a deficit in dopamine production. This may also mean that heavy users of cannabis tend to have less dopamine production overall, compared to their healthy non-user counterparts. Thus, this may suggest that the heavy user may be less creative when *not* under the influence of cannabis, due to an insufficient level of dopamine. However, the ingestion of cannabis for the heavy user may counteract this dopamine deficiency, and may lead to an increase in creativity. This outcome would be in line with popular conceptions of the relationship between cannabis and creativity (Minor et al., 2014).

Alternatively, Fernández-Ruiz, Hernández, and Ramos (2010) found that with the use of the activation of TRPV(1) receptors in GABAergic and glutamatergic synapses, endocannabinoids can indirectly influence dopaminergic neurons through those TRPV(1) receptors. This suggests the possibility of another pathway in which cannabis can indirectly increase dopamine levels within the brain. These results add to the complex system that is the ECBS and how dopamine levels can be influenced by cannabis. THC can influence many behaviors and cognitions. The two pathways (CB1 and CB2, and TRPV(1) receptors) are the link between the biological mechanisms, and the perceived psychological and physiological changes in the cannabis user. When cannabis is used, these pathways are activated and can alter dopamine levels within the brain and thus may impact creativity.

Since dopamine also seems to play an important role in creativity, it is thought that THC is indirectly related to divergent thinking. For example, Kowal et al. (2015) studied divergent thinking using the AUT on regular cannabis users. Their research was the first to compare high and low dosages of THC against a placebo, while participants engaged in divergent and convergent thinking tasks. They found high dosages of THC impaired the participant's ability to think creatively on the AUT, compared to the low and placebo dosages. This result is also in line with Chermahini and Hommel's (2010) inverted-U hypothesis. Minor et al. (2014) also found a related pattern of results when investigating people with different levels of THC. They found that THC can increase creativity, but only in low-creative individuals while engaged in a divergent thinking task. Therefore, these two studies support the notion that THC can assist with creativity when the participant's dopamine levels are low, but too much can hinder their higher level cognitive processes, or top-down thinking. Thus, this suggests that the biological mechanisms of the creativity and cannabis relationship is nonlinear.

The relationship between dopamine and creativity seems to follow an inverse U-shaped function (Chermahini & Hommel, 2010). This evidence suggests that those individuals who naturally have lower levels of dopamine will receive a benefit from the addition of low levels of THC, as it would increase dopamine levels within the system. This increase in dopamine may shift those dopamine deficient individuals to an optimal level, leading to improved creativity. However, this evidence also suggests that those individuals who may already be at an optimal level of dopamine may be hindered with an added increase to their dopamine level, leading to an impairment in creativity. This can help explain how Minor et al. (2014) and Kowal et al. (2015) found different patterns of results on the same types of participants engaged in the same task.

Many results investigating the relationship between cannabis and creativity has been inconsistent. This may also be attributed to the tolerance effects of cannabis on heavy cannabis users (Kowal et al., 2015). Frequency of cannabis use and subsequent tolerance effects may account for different patterns of results on cognitive tasks, as there is a difference in cognitive ability between the variation of cannabis use between cannabis users. Tolerance is a biological adaptation to a substance. THC/cannabis tolerance is shown through the downregulation of CB1 receptors, which reduces the pharmacodynamic response of THC (Ramaekers et al, 2011). This tolerance effect is likely to make infrequent and moderate users of cannabis react differently to cannabis ingestion, compared to heavy cannabis users. Thus, overtime and continued use of cannabis, one is no longer affected by the same dose of THC, and possibly no longer negatively affected by the introduction of THC into their system as compared to infrequent or moderate users of cannabis.

For example, Ramaekers, Toennes, Moeller, Kauert, and Theunissen (2009) studied neurocognition in heavy cannabis users (those who used cannabis four times or more a week for the past year) and occasional users (those who used cannabis once a week or less for the last year). They found that THC impaired the performance on executive control tasks for occasional cannabis users but not heavy cannabis users. These results demonstrate different patterns of results for two different groups of cannabis users on the same tasks. This seems to suggest that one’s cannabis use frequency may lead to different patterns of results for people with different tolerance levels of cannabis. Thus, one who consumes cannabis infrequently is not, and should not, be categorized as equivalent to a heavy cannabis user in studies.

In addition, different amounts of THC has been found to influence creativity in different ways. For instance, it has been found that the introduction of low doses of THC can increase creativity for those who have low levels of creativity (Minor et al., 2014). However, too much THC (and thereby too much dopamine) in their system has been found to hinder creativity (Chermahini & Hommel, 2010; Kowal et al., 2015). When looking at the creativity of a cannabis user, cannabis use frequency can change one's level of creativity. This provides rationale for the idea that heavy cannabis users (who have not recently ingested cannabis) will have a larger dopamine deficit because they have a higher tolerance for cannabis. Consequently, this means that the creativity of heavy cannabis users who have not recently ingested THC will likely be less than other groups, because heavy cannabis users will be below the optimal dopamine level (Chermahini & Hommel, 2010). However, heavy cannabis users who have recently ingested low levels of THC, arguably placing them in an optimal dopamine state, are predicted to perform with high rates of creativity.

Further evidence to support the idea that cannabis use frequency should be taken into account when investigating the behaviors of cannabis users is provided by Young, Gullo, Feeney, and Connor's (2012) study. They found that heavy and moderate users of cannabis can differ in more ways than cognitive ability. For example, heavy users of cannabis can have different perspectives of the purpose of using cannabis than those who use cannabis infrequently. Cannabis user type was based on the number of days per week and the quantity of cannabis consumed, at the discretion of the researcher's impression. The researchers found that heavy users of cannabis claim to use cannabis for the purpose of emotional regulation, while casual users of cannabis use it more recreationally, with the aim of pleasure. The rationale provided by heavy users supports the notion that cannabis has an emotional component to users. In addition, Bonn-Miller, Boden, Bucossi, and Babson (2014) asked a sample of legal cannabis users (i.e. users have 215 cards, which allows users to use cannabis for medical purposes) for the purpose of their cannabis use. They found that 61.8% used it for anxiety, 48.6% for stress, and 44.8% for depression. Furthermore, Somanini et al. (2012) found that users of cannabis had significantly higher scores on somatisation, OCD, interpersonal sensitivity, depression, anxiety, anger, hostility, phobic anxiety, paranoid ideation, and psychoticism. This suggests that many users of cannabis may use it for the relief of negative emotional states.

The differences within the frequency of cannabis use also affects responses to emotional stimuli. For example, Somaini et al. (2012) researched how active cannabis users (those who have used cannabis consistently for three years and smoked before the experiment), abstinent cannabis users (those who have used cannabis consistently for three years, but did not smoke before the experiment), and non-users (those who do not use cannabis) responded differently to emotional stimuli. Participants were presented with negative or neutral images and were asked to make pleasantness judgements on the stimuli. After viewing the negative slides, the active and abstinent cannabis users reported higher pleasantness ratings than the control group. This means that cannabis users were not as negatively affected by the negative stimuli. This indicates a suppression of disliking, or in other words, a decrease in negative perception, given that neutral stimuli were not also more positively rated. The results from the negative condition support the theory that there is a relationship between emotional regulation and cannabis use. Specifically, that cannabis use diminishes perceived threats and negativity. After viewing the neutral slides, the active and abstinent cannabis users reported lower pleasantness ratings than the control group. This suggests the baseline mood for cannabis users is lower than those who do not use. With this relationship between cannabis and emotion, the next step is to look at how mood can influence creativity.

Mood and Creativity

One's mood is thought to influence creativity, but under what conditions is it the most beneficial? For example, past research has shown that creativity is enhanced while in a positive mood (Baas, De Dreu, & Nijstad, 2008; Davis, 2009; De Dreu et al., 2008). Two separate meta-analyses (Baas et al., 2008; Davis, 2009) found that people in a positive mood tend to be more creative than those in a neutral or a negative mood. This means people who are in a positive mood, such as being happy, joyous, excited, or thrilled, are likely to be more creative than people who are in a negative or neutral mood when being tested on creativity.

However, the relationship between mood and creativity is mixed. For example, De Dreu et al. (2008) found that activating any enhanced mood (positive or negative), increases creative fluency in relation to divergent thinking. This result suggests that having any strong emotion is related to increased creativity in terms of producing more ideas than someone in a neutral mood. To reiterate, this means that any mood, whether it is positive or negative can increase creativity. This finding supports the common cultural relationship between artistic influence of negative emotional states, like depression, across art history. However, these data also suggests that one should also be more creative when in a positive mood.

Yet, because the image of the suffering artist is so prevalent in society, many fail to acknowledge the happy and creative artist. Relatedly, Kaufmann (2003) argues that it is a bit too soon to claim that positive moods enhance creativity in individuals, as evident by analyzing many past great artists and their mental wellness, or lack thereof. Along these lines, it has been found that mental disorders, such as schizophrenia and bipolar disorder, are associated with higher creativity skills (Cheung et al., 2010). However, the effects of a positive mood on healthy patients are still significant, but mild (Baas et al., 2008). This muddles the connection between mood and creativity, and when studying cannabis users, it becomes even more complex.

Mood and Music

The literature defines mood and emotion differently. A mood is a general state of feelings, whereas an emotion is felt towards someone or something (Davis, 2009). The duration of each is still undecided since a mood can stay for hours, but can be inconsistent when they arise, whereas emotions can reoccur but can only last a few moments. Davis (2009) suggests that moods and emotions can be influenced by each other. For example, when someone is in a negative mood, it can evoke a rash angry emotion. Alternatively, a positive emotion can perpetuate throughout several days as a positive mood. Although moods and emotions are not classified as the same, they do appear to be interchangeable under specific conditions.

Music has been shown to successfully induce or alter moods, but often only under certain conditions (Dunn, 1997; Jolij & Meurs, 2011; Lewis & Lovatt, 2013; Zentner, Grandjean, & Scherer, 2008). For example, Jolij and Meurs (2011) altered participants' moods via music to research changes in the participants' perceptions. They found that participants listening to their own collection of happy music had an increased positive mood. They also found that participants listening to their own collection of sad music had an increased negative mood. These results provide a pathway to induce positive or negative moods via music. This study paired different music types to induce a positive or negative mood whilst simultaneously perceiving faces displaying ambiguous emotions amidst visual static. It was found that one's mood influenced the interpretation or perception of the information. Specifically, the ambiguous faces were interpreted in line with the mood induced by the music. These results are important to consider since mood appears to be a variable in creativity. These results indicate that music is a viable vehicle to successfully induce a certain mood.

Koelsch, Fritz, Cramon, Müller, and Friederici (2006) investigated the neurological underpinnings of mood changes via music. Participants listened to either a pleasant or negative piece of music. The pleasant stimulus was comprised of orchestra dance music. The negative stimulus was the same music but electronically altered by variations in pitch and was thus considered to be dissonant. Under these auditory conditions, participants' brains were scanned in an fMRI machine. The researchers found that the music successfully induced the intended mood. While listening to the pleasant music, the inferior frontal gyrus, the anterior superior insula, the ventral striatum, Heschl's gyrus, and the Rolandic operculum were all activated, while the amygdala was deactivated. It's suggested that these areas are related to auditory perception and vocal production while listening to the positive music. While listening to the unpleasant music, emotional regulators within the brain (amygdala, hippocampus, and the temporal poles) were activated. The contrast between the areas of the brain while listening to the positive and negative music suggests a difference in processing the stimuli. This suggests a more emotional and memory based perception of the negative music that was presented compared to the positive. This illustrates the biological changes while listening to different emotional auditory stimuli.

Statement of Problem

The aim of this project is to address the role of cannabis use frequency (infrequent, moderate, and heavy) and the relationship between different moods (i.e. neutral, positive, and negative) on creativity.

Hypothesis 1: Interaction of Cannabis use frequency and Mood

Different levels of cannabis use frequency (infrequent, moderate, and heavy) will result in a creativity pattern that follows an inverse U-shaped curve when taking into account one's current mood condition (e.g. neutral, positive, and negative). The predicted differences are presented below, sorted via the mood condition.

H1a: Cannabis use frequency and positive mood. When in a positive mood, it is expected that heavy cannabis users will produce the highest rates of creativity, compared to moderate users and infrequent users.

Rationale for this hypothesis is supported by the work of Chermahini and Hommel (2010), who found that heavy cannabis users had increased rates of creativity while in a positive mood. This result is attributed to an underlying inverse U-shaped relationship between dopamine and creativity. Being in a positive mood can produce more dopamine (Mitchell & Phillips, 2007). Thus, we predict that the positive mood stimuli will increase cannabis user's dopamine level to their ideal dopamine and creativity level (Chermahini & Hommel, 2010). This increase in dopamine is important because we believe that cannabis users will be at a dopamine deficit while participating in this experiment, while infrequent users will not be (Sami et al., 2015). The dopamine boost given from the positive mood will enhance the cannabis user's dopamine levels greater than in infrequent users, and closer to their optimal level of dopamine for creativity (Kowal et al., 2015). Whereas infrequent users will not be as strongly benefited by this increase of dopamine due to their assumed dopamine level being already at their optimal level. With this reasoning, we expect heavy cannabis users to be more creative than moderate and non users when in the positive mood condition.

Moderate users of cannabis will demonstrate a higher rate of creativity compared to the infrequent users, which is supported by the same rationale of having a dopamine boost, bringing them to a more optimal dopamine/creativity level from their dopamine deficit (Chermahini & Hommel, 2010; Sami et al., 2015). Infrequent users of cannabis are predicted to begin the experiment at their optimal dopamine level, so that the increase in dopamine they experience due to the positive music will place them in a state that is beyond the optimal range, leading to poor creativity performance.

The positive mood condition for all cannabis use frequencies will result in the highest rates of creativity compared to the negative and neutral mood conditions, thus serving as the peak of the inverse U.

H1b: Cannabis use frequency and negative mood. When in a negative mood, it is expected that infrequent cannabis users will produce the highest rates of creativity, compared to moderate users and heavy users.

This prediction is based on results where cannabis users have been shown to have a dopamine deficit (Sami et al., 2015), meaning that moderate and heavy cannabis users are expected to have a negative affect and will therefore be at a disadvantage for divergent thinking, compared to infrequent users. Infrequent users are not expected to be at a dopamine deficit, and in accordance to the inverse U-shaped relationship between dopamine and divergent thinking (Chermahini & Hommel, 2010), will be more creative. Moderate users are expected to have higher rates of creativity than heavy users, for their dopamine deficit would less than heavy users.

However, if heavy cannabis users have active cannabis in their system during the experiment (due to having recently ingested cannabis), they are expected to outperform infrequent and moderate users while in the negative mood. Rationale for this prediction stems from research suggesting that cannabis use is associated with a decrease in disliking effect, meaning that participants will not be as negatively affected by the negative stimuli (Somaini et al., 2012). This suggests that heavy cannabis users with active cannabis in their system will reduce their dopamine deficit, leading to both an increase in positive affect and a reduction of negative influence of negative stimuli. The positive benefit in mood and the protective factor against negative information, as a consequence of recently ingesting cannabis, is only predicted for heavy users. Moderate and infrequent users would be expected to have too much dopamine in their system if they recently ingested cannabis.

H1c: Cannabis use frequency and neutral mood. When in a neutral mood, it is expected that infrequent cannabis users will produce the highest rates of creativity, compared to heavy and moderate users of cannabis.

Support of this prediction stems from research concerning the participant's assumed dopamine level (Kowal et al., 2015; Sami et al., 2015; Zabelina et al., 2016). Infrequent users of cannabis are assumed to be at an optimal level of dopamine while heavy and moderate users of cannabis will have a deficit in dopamine (Ramaekers et al., 2009). This means that due to the lower levels of dopamine in cannabis users, their creativity will be hindered. This is in relation to the inverted U-shape relationship between dopamine and divergent thinking (Chermahini & Hommel, 2010). Mood and creativity research suggests that the neutral mood condition will be the worst for all three groups (Baas et al., 2008; Davis, 2009; Kauffman, 2003; Mitchell, 2007). If heavy users have a dopamine deficit (Ramaekers et al., 2009), then they should be less creative than infrequent and moderate users in the neutral mood condition (Kowal et al., 2015). In this prediction we assume that the cannabis users are at a dopamine deficient state.

In addition, it is predicted that moderate users of cannabis will demonstrate a higher rate of creativity compared to the heavy cannabis users. This prediction is supported by a lesser dopamine deficit than heavy users, thus more creative than heavy users (Ramaekers et al., 2009).

However, if moderate and heavy users voluntarily consumed cannabis before participating in the experiment, then they should have a higher creativity score than infrequent users in the negative mood condition. This prediction is expected because high dopamine levels are associated with a decrease in disliking (Somaini et al., 2012). This means that those with high dopamine levels have a more positive mood and thus a boost in their creativity. However, it is not in the scope of this study to vary the last time of consumption of cannabis to influence one’s current dopamine level, though this information will be assessed through a questionnaire.

Hypothesis 2: Main effect of Cannabis Users

If cannabis use affects creativity, then different rates of cannabis use frequency will cause people to perform differently in the AUT. It is predicted that due to the dopamine deficit in cannabis users (Sami et al., 2015), infrequent users of cannabis will produce more instances of creativity than heavy and moderate cannabis users. This is in relation to the inverted U-shape relationship between dopamine and divergent thinking (Chermahini & Hommel, 2010). We predict that heavy and moderate users of cannabis will be below their optimal level of dopamine, compared to infrequent users.

Hypothesis 3: Main effect of Mood

If mood affects creativity, then participants will show different amounts of creativity in the AUT when in different moods. It is predicted that all participants will have the highest rates of creativity when in the positive mood condition, compared to the negative and neutral mood conditions. This is supported by the research done by Baas et al. (2008) and Davis (2009) who found that participants in a positive mood had higher rates of creativity compared to a neutral mood.

It is also predicted that those in the negative mood condition will have higher rates of creativity than those in the neutral mood condition. Research by De Dreu et al. (2008) supports the prediction that positive and negative moods will lead to higher rates of creativity than those who are in a neutral mood, as they found that being in any enhanced mood can lead to increased rates of creativity. It is predicted that participants will be the least creative while in the neutral mood condition.

This research can help provide a clearer insight between the relationship within the levels of cannabis use with creative thinking. This study can also assist further research in harm reduction and therapeutic effects of cannabis. Creative therapy could be helpful for patients who are chronic users of cannabis. Knowing how cannabis users respond to different mood conditions can assist with the user's dependency with cannabis and may help inform practices of alleviating emotional strain and dependency on the user by acknowledging their emotional crutch. Additionally, this research may serve to change the common perception of a negative mood being necessary for creativity in society.

Method

Design

This study employed a 3 cannabis use frequency (infrequent, moderate, and heavy user) X 3 mood (positive, negative, neutral) mixed subjects design. The variable of cannabis use frequency was between subjects. Heavy cannabis use is defined as those reporting use cannabis nearly every day or several times a day. Moderate use is defined as those reporting cannabis use once a week or couple of times a week. Infrequent users is defined as those reporting using cannabis couple of times a month or less, including those who report never or almost never. The mood (positive, negative, or neutral) variable was experienced within subjects, induced via music.

The dependent variables in this study are AUT scores and CAQ scores. The AUT is a measure of divergent thinking and will consist of the number of alternative uses listed in an alternative use task. The CAQ is a measure of lifetime creative achievements and is used as a generalized creativity score.

Participants

242 (141 females) Humboldt State University students, (Mean age = 20.78 years) participated in the study for course credit (IRB#: 16-021). The distribution of participants with respect to cannabis use frequency, is as follows: 104 infrequent users, 48 moderate users, and 67 heavy users. See Table 1 for a detailed depiction of the demographics of the participants.

Table 1

Demographic of AUT Sum

n= 219	AUT Sum Mean	SD	Significance Value	*p*	η^2
Sex: Male	3.83	1.07		.21	.00
Sex: Female	4.06	1.43	F (1, 217) = 1.58		
Age	20.78 Age	0.23	t (217) = 1.99	.05	.02
GPA	3.20 GPA	0.55	t (196) = 2.53	.01	.03
College Standing: Freshmen	3.56	1.03			
College Standing: Sophomore	3.84	1.27	F (5, 213) = 2.85	.02	.06
College Standing: Juniors	4.14	1.43			
College Standing: Seniors	4.36	1.41			
Family Income	$55,742	1.8	F (9, 209) = 1.04	.41	.04
Creative Identity	3.46	0.46	t (215) = 1.31	.25	.00
Age of First Use	12.96	0.45	t (181) = -1.38	.17	.01
Cannabis increases creativity? Yes	4.01	1.26	t (217) = 0.41	.68	.00
Cannabis increases creativity? No	3.94	1.37			
Use cannabis to regulate emotions? Yes	4.08	1.19	t (217) = 1.02	.31	.00
Use cannabis to regulate emotions? No	3.9	1.41			

Note. The values represent the only the confidence interval around the AUT sum mean. Significance in the full model is not represented in this table. Variables are individually predicting the AUT sum.

Instruments and Measurements

Alternative use task stimuli. Creativity was tested through the alternative use task. 15 alternative task items (from Guilford, 1967) were used in this experiment and was presented to all participants. The 15 AUT items are as follows: rock, shoe, newspaper, brick, cup, chair, pencil, plastic bag, candle, pillow, plate, printer paper, paper clip, a plank of wood, glass soda bottle. The number of alternative uses produced is defined as the participants' creativity.

Music stimuli. Mood changes were induced via music presentations. The music used in this study is from Koelsch et al. (2006). The original music itself are short clips of joyful instrumental dance-tunes. The positive mood condition was instrumental major-toned music. The negative mood condition used the same music but was digitally altered to be inconsistent and dissonant. Specifically, the negative music's pitch was changed to one octave above and one below the original music at inconsistent time intervals. The neutral mood condition served as a control condition, where white noise was presented. The music that was presented for each mood condition combined the music clips to make a 10 minute song for the two mood conditions. Music played only in the appropriate mood condition until the participant had completed the task. Mood induction was done during the time of the experiment to address time constraint issues.

Scales and surveys. This study used six scales and one survey. They are detailed below.

The Brief Mood Introspection Scale. The Brief Mood Introspection Scale (BMIS) is a survey that asks participants how they generally feel (Mayer & Gaschke, 1988). Its purpose was to assess participants' mood outside of the experimental mood manipulation (Appendix A).

Mood manipulation check. A mood manipulation check was used to measure the participants' mood with the mood condition (instilled via music). If their moods changed in accordance to the correct mood condition, than we could conclude the mood manipulation worked. A mood manipulation check question was presented before and after each mood condition. The question was based on an item from the BMIS that was modified to address how the participant currently feels. The scale is a 20-point response scale (-10 = very unpleasant, 10 = very pleasant; Appendix A), sourced from Mayer and Gaschke (1988).

Creative Achievement Questionnaire. The Creative Achievement Questionnaire (Carson et al., 2005; Appendix B) is a lifetime achievement questionnaire that scores participants' creativity over 10 different domains of creativity, and is used as a general creativity score. Its purpose was to assess participants' general creativity outside of the divergent thinking AUT score.

Creative identity scale. This scale measures the personal importance of identifying as a creative person or a musical person (Appendix C) and was created by the author. Its purpose was to score the participant's self-identity of being a creative individual, along with their relationship with music. This is meant to see if there is a difference between creativity in those who identify strongly with being a creative individual than those who do not.

Substance use scale. The substance use and history scale is a combination of Reynold's (2016; Appendix D) cannabis use frequency scale and the author's substance use questionnaire, with an emphasis on cannabis (Appendix E). The survey was used to identify if participants currently feel the effects of cannabis or other substances, age of cannabis first use, their beliefs of cannabis impacting creativity, their beliefs of cannabis impacting happiness, and if they use cannabis to influence their emotional regulation.

Demographic scale. The demographic questions (Appendix F) were created by the author. The questionnaire contained questions concerning age, sex, gender, ethnicity, income, GPA, college standing, major, and family education.

Procedure

Participants were recruited in three ways. First, we informed potential participants of the study by visiting classes at Humboldt State (with approval from the instructors). We verbally informed them of the study as well as provided them with flyers for the study. Participants recruited from classroom visits were given extra credit (at the discretion of the class instructor). Second, we used the psychology research participant pool (SONA) and listed the study on the psychology department's experimental sign-up system. Participants recruited from the psychology research participant pool were also given course credit. Lastly, flyers were displayed in the two local medical cannabis dispensaries in Arcata, CA. Compensation for the participants were snacks, and extra credit for the course they signed up through (with the professor's approval).

Due to the sensitive nature of this experiment, in asking questions concerning drug use, it was emphasized that all data collected would be confidential and anonymous to eliminate the risk of connecting any responses to any particular individual.

The study was conducted on the HSU campus. Each participant was directed into an individual experimental room. The AUT and manipulation check portion of the experiment was presented on a computer running E-Prime software (Psychology Software Tools, 2002). Participants were provided with verbal instructions before commencing the experiment. The instructions provided a cover story (Davis, 2009). Participants were told that we were studying the differences in creativity between cannabis use frequency, but there was no mention of mood or music.

The experiment had two parts, the creativity task and the survey. The creativity task always occurred first in the experiment. In it, participants were asked to produce as many possible alternative uses for 15 different objects for the AUT by entering their responses on the keyboard. The items listed in the AUT were randomly selected (without replacement) from the full list of AUT items by the computer program. Throughout the creativity portion, participants were instructed to wear headphones while completing the task.

The creativity task was comprised of three blocks, to induce the different mood conditions. The first mood condition was the neutral (white noise) condition, to establish a baseline for their creativity. The second and third block served to induce the positive and negative moods via music presentation (counterbalanced). Before and after each block, a mood survey was administered as a manipulation check for the mood condition.

The final part of the experiment consisted of a detailed background survey. This consisted of the following questionnaires in the following order: Brief Mood Introspection Scale (BMIS), Creative Achievement Questionnaire (Carson, Peterson, Higgins, & Daniel, 2005), creative identity scale, substance use and history (Reynolds, 2016), and demographic questions.

Results

From the 242 participants that participated in the experiment, data from 219 participants were used in the analysis. Those who responded to 10 or less of the 15 AUT items were excluded from the study. Inferential statistics are presented separately accordingly to the DV used. See Table 2 for a comparison of means and significance for cannabis use frequency (CUF) and mood on creativity.

Table 2

Main Effects between Cannabis Use Frequency and Mood on Creativity Scores

DV	IV Cannabis Use Frequency					
Value	Infrequent	Moderate	Heavy	*F*	*p*	η^2
AUT Median	0.57 (0.21)	0.57 (0.26)	0.61 (0.19)	0.85	.43	.01
AUT Sum	3.89 (1.41)	3.93 (1.32)	4.14 (1.16)	0.78	.46	.01
CAQ Score	3.63 (0.88)	3.96 (0.87)	4.09 (0.84)	6.24	< .001	.05
DV	IV: Mood					
Value	Neutral	Positive	Negative	*F*	*p*	η^2
AUT Median	0.6 (0.22)	0.56 (0.23)	0.56 (0.22)	2.52	.08	.01
AUT Sum	4.15 (1.27)	3.97 (1.33)	3.86 (1.32)	2.74	.06	.01
CAQ Score	3.65 (0.81)	3.82 (0.92)	3.99 (0.85)	1.15	.32	.01

Note. Table 2 illustrates the means and standard deviations between cannabis use frequency and mood on the three dependent variables of AUT median, AUT sum, and CAQ score. The only significant main effect is CUF on CAQ score.

DV: Scoring and Transformation of the AUT

The AUT has traditionally been scored based on four separate parameters: fluency (total number of responses, flexibility (the number of different categories), originality (responses compared to other participant responses), and elaboration (the amount of detail used to describe the alternative use). It usually scored by at least three individuals. Due to time constraints and scheduling difficulties, fluency was the only parameter chosen to score the AUT.

Participant responses of alternative uses for the items in the AUT were recorded and served as a measure for creativity productions. Specifically, responses to each item were scored based on the total number of responses generated by a participant, subtracting uses that were repeated (e.g. throwing and tossing), initial (the original purpose to use that object), and impossible uses of the object. For example, if the stimulus word was "pencil", and the participant responded with: "writing, drawing, sketching, hat, drumsticks, making a tiny fort, playing darts, and making noise with a beat", the corrected count sum would represent three valid responses, because "writing, drawing, and sketching" are initial uses, while "making noise with a beat" is considered the same as using a pencil as a "drumstick", and further, it is impossible to use a pencil as a hat realistically. All AUT scoring was done by the author, and based responses on the realistic ability to use that item for that alternative use. For example, many individuals said to use a cup as a hat as an alternative use, however since the initial purpose of a hat is to keep one's head warm or for shade, a hat is an unrealistic use for a cup. All AUT scoring was done blinded to the mood condition, and completed prior to the survey scoring. For the list of unacceptable uses, based on the author's judgement, see Appendix G. The correct counts were used in two different measures of creativity, the AUT median and AUT sum scores.

AUT median. The median number of responses is used instead of mean because it is less susceptible to outliers. The total correct responses reflect the sum of the scores of all 15 items in the AUT. The raw corrected data of AUT median did not meet standard analysis assumptions for skew and kurtosis. Thus, the median number of correct AUT responses were log transformed.

AUT sum. The summed number of responses were used as another dependent variable. The distribution of the AUT sum scores were not normal and were transformed. The total sum of correct AUT responses were square rooted to meet the assumptions needed for linear regression and ANOVA analysis.

DV: Creative Achievement Score

The CAQ survey provided a self-report score of creativity. The CAQ score reflected the total sum of the participant's score on the CAQ (range 1-45) where each question was worth one point. The raw CAQ data did not meet standard analysis assumptions. Thus, a square root transformation was used on the CAQ total score.

The Brief Mood Introspection Scale

The BMIS is a questionnaire about the moods participants generally feel and the frequency of feeling them. It was scored using reverse coding, producing a numeric mood score (Mayer & Gaschke 1988). The mood score was then categorized into three different mood levels (negative, neutral, and positive). Scores that were ≤ -2 was coded as negative, -1 to 1 was neutral, and ≥ 2 was positive.

Mood Manipulation Check

The mood manipulation check was presented before and after each mood condition of the experiment. Between each block, participants were asked to rate their current mood on a -10 to 10 scale. A one-way ANONA was conducted on mood score based on condition, and found no significant differences between levels of mood ($F(2, 586) = 0.15$, $p = .86$, $\eta^2 = .00$). Thus, we conclude that the mood manipulation (moods induced via music) failed to evoke different moods.

Analysis

Analyses were conducted with RStudio, with the R packages: lme4, language R, multcomp, lsr, Matrix, rgl, lattice, and ggplot2 (RStudio Team, 2015). Linear mixed effect models used random variable intercepts of Subject. The predictor variables were creativity, measured as the transformed AUT median and sum, and CAQ. The fixed effects variables were the between subject variable of cannabis use frequency (CUF), and the within subject variable of mood condition. These variables were allowed to interact.

DV: AUT Median

Interaction. A 3 CUF by 3 mood mixed model regression was conducted on AUT median scores. Differences around median scores of the AUT between was non-significant between cannabis use frequency and mood, 95% CI [-2.89, 2.56], $p = .70$, $R^2 = .85$. (Figure 1)

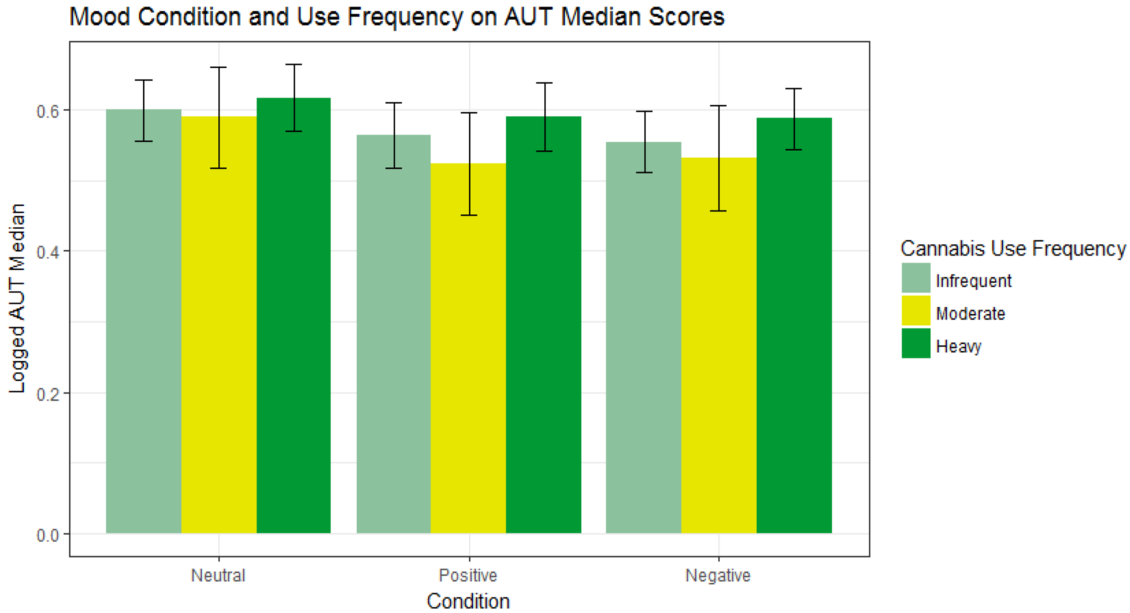

Figure 1. This bar graph illustrates confidence intervals around the AUT median between mood conditions and cannabis use frequency on the AUT median scores.

Main effect of cannabis use frequency. A one-way ANOVA was conducted on the factor of cannabis use frequency and revealed no significant difference between use frequency on the AUT median score (Heavy: $M = 0.61$, $SD = 0.19$; Moderate: $M = 0.57$, $SD = 0.26$; Infrequent: $M = 0.57$, $SD = 0.21$), $F(2, 216) = 0.85$, $p = .43$, $\eta^2 = .01$.

Main effect of mood condition. A one-way ANOVA was conducted on the factor of mood condition and revealed no significant difference of AUT median scores between neutral ($M = 0.60$, $SD = 0.22$), positive ($M = 0.56$, $SD = 0.23$), or negative conditions ($M = 0.56$, $SD = 0.22$), $F(2, 657) = 2.51$, $p = .08$, $\eta^2 = .01$.

DV: AUT Sum

Interaction. A 3 CUF by 3 mood condition mixed model regression was conducted on the variables of cannabis use frequency and mood. Differences around the AUT sum scores was non-significant between cannabis use frequency and mood, 95% CI [-2.96, 3.04], $p = .73$, $R^2 = .88$. (Figure 2).

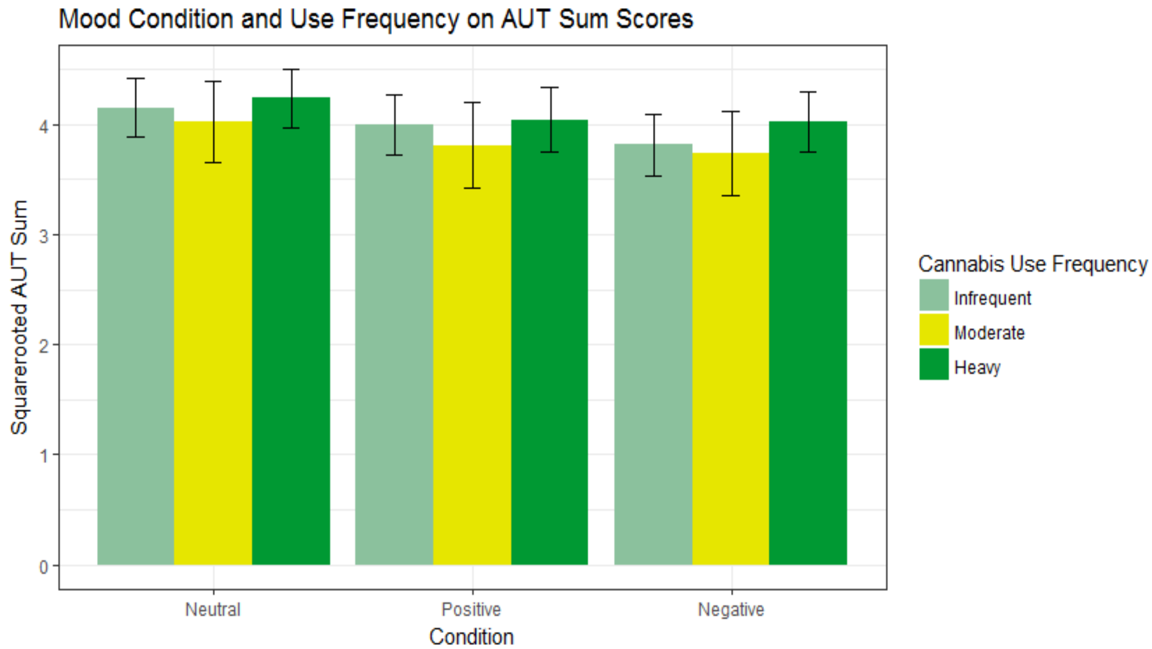

Figure 2. This bar graph illustrates confidence intervals around the mean of AUT sum between mood conditions and cannabis use frequency.

Main effect of cannabis use frequency. A one-way ANOVA was conducted on the factor of cannabis use frequency and found no significant difference between on the AUT total sum between heavy (M = 4.14, SD = 1.16), moderate (M = 3.93, SD = 1.32), and infrequent users (M = 3.89, SD = 1.41), $F(2, 216) = 0.78$, $p = .46$, $\eta^2 = .01$.

Main effect of mood condition. A one-way ANOVA was conducted on the factor of mood condition and found no significant difference of AUT sum scores between neutral (M = 4.15, SD = 1.27), positive (M = 3.97, SD = 1.33), or negative condition (M = 3.86, SD = 1.32), $F(2, 657) = 2.74$, $p = .06$, $\eta^2 = .01$.

DV: CAQ

Interaction. A 3 CUF by 3 mood (BMIS) multi-way ANOVA was conducted on CAQ scores. Differences around CAQ sum scores was non-significant between cannabis use frequency and BMIS mood, 95% CI [-2.20, 3.17], $\eta^2 = .00$.

Main effect of cannabis use frequency. A one-way ANOVA was conducted on the factor of cannabis use frequency and found a significant difference of CAQ score between heavy (M = 4.09, SD = 0.84), moderate (M = 3.96, SD = 0.87), and infrequent users (M = 3.63, SD = 0.88), $F(2, 216) = 6.24$, $p < .001$, $\eta^2 = .05$. A Tukey test was conducted as a multiple comparisons test. Infrequent users reported less creativity than heavy users, $t(216) = 3.37$, $p < .001$. All other comparisons were non-significant, $p > .05$. Table 3 illustrates the means and standard deviations of the CAQ scores on cannabis use frequency, and Figure 3 graphically represents the confidence intervals around the means of CAQ scores.

Table 3

Comparison of Cannabis Use Frequency on CAQ Scores

Cannabis Use Frequency	Heavy	Moderate	Infrequent
CAQ Total Means	$4.14(1.16)_{a}$	$3.93(1.32)_{ab}$	$3.89(1.41)_{b}$

Note. Values represent means of the squared scores for each cannabis use frequency level. Within a row, values that do not share a subscript differ significantly at *p* <.05 (Tukey's HSD).

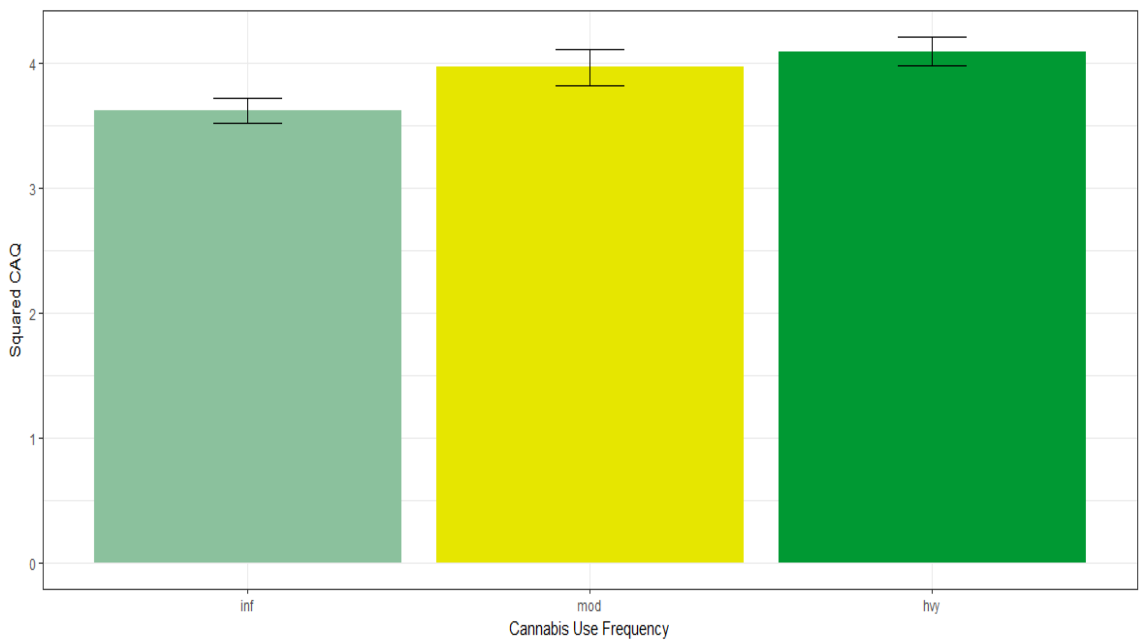

Figure 3. This bar graph illustrates the significant differences between cannabis use frequencies on the lifetime creative achievement.

Main effect of survey mood score. A one-way ANOVA was conducted on the factor of mood condition and found no significant difference of CAQ total between neutral (M = 3.65, SD = 0.81), positive (M = 3.82, SD = 0.81), or negative moods (M = 3.99, SD = 0.85), $F(2, 209) = 1.15$, $p = .32$, $\eta^2 = .01$.

Post Hoc analyses

Post hoc analyses added predictor variables that were included into analysis models. See Table 3 for a comparison of participant demographics. The motivation for each post-hoc analysis and the relevant factors investigated, is detailed below.

Active cannabis participants. The substance use survey inquired if the participant had active cannabis in their system. Thus, in this study, active cannabis users were those participants who indicated that they voluntarily consumed cannabis before participating in the study and claimed to feel the effects of cannabis. There were 29 active cannabis users in total, with 23 of them being heavy users, five moderate users, and one infrequent user. The role of having active cannabis was investigated because research has found that being under the influence of cannabis can influence creativity (Kowal et al., 2015). A 2 (active cannabis user or not) X 3 (CUF) ANOVA was conducted on the AUT median and sum scores, separately.

DV: AUT median. No significant interactions or main effects were found on AUT median, $F(2, 213) = 1.27$, $p = .28$, adj. $R^2 = .01$.

DV: AUT sum. *N*o significant interactions or main effects were found on AUT sum, $F(2, 213) = 1.53$, $p = .22$, adj. $R^2 = .01$.

It would not have made sense to test CAQ, because being actively under the influence of cannabis should not influence one's previous creative achievements.

Demographics. Demographic information concerning the participants' sex, gender, age, ethnicity, college standing, GPA, family income, and high family educational degree were collected. In addition, responses concerning the personal importance of identifying as a creative individual, age of first use of cannabis, along with questions concerning the belief that cannabis can increase creativity, the belief that cannabis can increase happiness, or used to regulate emotions were also collected. These factors may influence creativity. To this end, a multivariate linear regression was conducted on the relationship between the variables above and creativity. A stepwise model selection process was selected for each dependent variable (AUT Median, AUT Sum, and CAQ score) with the predictor variables above. The reduced models showed different patterns of results for the different dependent variables and are presented below.

AUT median. The reduced model of AUT median found GPA, college standing, and creative identity score to be the best predictors of AUT median, $F(7, 188) = 3.29$, $p < .001$, adj. $R^2 = .08$.

AUT sum. The reduced model of AUT sum found college standing was shown to be the best predictor of AUT sum, $F(5, 213) = 2.85$, $p = .02$, adj. $R^2 = .04$.

CAQ score. The reduced linear model of CAQ score found two main effects. Creative identity score, and the belief that cannabis can increase creativity were significant predictors of CAQ score, $F(2, 214) = 32.82$, $p < .001$, adj. $\mathrm{R}^2 = .23$. As creativity identity score increased, CAQ score increased ($t(214) = 6.95$, $p < .001$).

Additionally, those who believed cannabis can increase creativity (*M* = 4.07, *SD* = 0.80) had a higher CAQ score than those who did not (*M* = 3.62, *SD* = 0.92), $t(214) = 2.32$, $p = .02$.

College standing and creativity. Given that the reduced models of concerning AUT median and AUT sum both found college standing as a good predictor, college standing was investigated further. A one-way ANOVA was conducted on college standing (freshmen, sophomores, juniors, and seniors) with respect to AUT median, $F(5, 213) = 2.30$, $p = .05$, $\eta^2 = .05$, and sum, $F(5, 213) = 2.85$, $p = .02$, $\eta^2 = .06$, and found significant differences. A Tukey test was conducted to find the simple effect differences between the levels of college standing. The results found seniors were more creative than freshman for both the AUT median ($t(213) = 3.22$, $p = .01$), and AUT sum ($t(213) = 3.43$, $p < .01$; Table 4).

Table 4

Comparison of College Status on Creativity Scores

College Status	Freshmen	Sophomore	Juniors	Seniors
Logged AUT Median	$0.51(0.20)_{a}$	$0.57(0.20)_{ab}$	$0.60(0.23)_{ab}$	$0.64(0.22)_{b}$
Square Root AUT Sum	$3.56(1.03)_{a}$	$3.85(1.21)_{ab}$	$4.11(1.48)_{ab}$	$4.42(1.35)_{b}$

Note. Values represent means of the transformed creativity scores for each college status level. Within a row, values that do not share a subscript differ significantly at $p < .05$ (Tukey's HSD).

A one-way ANOVA found no significance differences between college standing and CAQ score, $F(5, 213) = 0.71$, $p = .61$, $\eta^2 = .02$.

DV: Cannabis use frequency. In this set of analyses, CUF served as the dependent variable and was treated as a continuous variable. Rationale for this set of analyses stem from research that has indicated that the frequency of cannabis use may be attributed to differences in the user's rationale for using (Young et al., 2012). The research suggests that heavy users tend to use cannabis to alleviate emotional and mental distress, while casual users tend to use it with the aim of recreation and pleasure. Thus, when investigating cannabis use, it is important to look at the variables that might influence who is likely to be a cannabis user. The following served as predictor variables for cannabis use frequency: age of cannabis first use, the perception that cannabis use can increase creativity, the perception that cannabis use can increase happiness, whether cannabis is used to regulate one's emotions, and demographic information.

A multivariate linear regression was conducted predicting cannabis use frequency. Two significant main effects were observed, indicating that those who thought cannabis can increase creativity, and thought that cannabis can increase happiness were more likely to be cannabis users, $F(2, 216) = 107.2$, $p < .001$, adj. $R^2 = .49$. Participants who thought cannabis increases creativity were more likely to have higher cannabis use frequencies than those who did not, $t\ (216) = 7.37$, $p < .001$, adj. $R^2 = .04$. Participants who thought cannabis makes them a happier person were more likely to be a higher use frequency than those who did not, $t\ (216) = 5.56$, $p < .001$, adj. $R^2 = .04$.

CAQ. Previous literature suggests that the CAQ is a reliable predictor of momentary creativity, in addition to measuring one's lifetime creative achievements (Carson et al., 2005). If an individual has a higher lifetime creative achievement, then it is suggested that the individual will also have a higher creative ability on our experimental creativity task (AUT). A one-way linear regression was conducted on CAQ predicting AUT. CAQ was a significant predictor variable for both AUT median, t (217) = 3.46, $p < .001$, $R^2 = .04$, and sum, t (217) = 3.46, $p < .001$, $R^2 = .04$ via linear regression. This is supported with a significant correlation between CAQ and the AUT median, r (217) = 0.27, $p < .001$, and sum, r (217) = 0.22, $p < .001$.

Discussion

Interaction of CUF and Mood

This study investigated the relationship between cannabis use frequency and mood on creativity (via divergent thinking). Our hypotheses predicted an interaction between cannabis use frequency (CUF) (infrequent, moderate, and heavy) and mood (neutral, positive, and negative) on creativity. Our results failed to support all of our hypotheses. There was no interaction between CUF and mood condition on AUT median, AUT sum, or CAQ. This means that both cannabis use frequency and the mood condition phases had no influence on participants' divergent thinking scores. Previous research suggest a relationship between dopamine (Sami et al., 2015), mood (Mitchell & Phillips, 2007), and cannabis (Kowal et al., 2015) on creativity (Chermahini & Hommel, 2010). However, the current investigation did not support the pattern of results expected from the literature. Explanations for the discrepancy between our results and the literature are detailed in the limitations section and include discussions of the absences of a dopamine measure and a failed mood manipulation.

Main Effect of CUF

A main effect of cannabis use frequency was predicted for creativity. It was predicted that infrequent users would have higher rates of creativity than moderate or heavy users. Rationale for this hypothesis stems from the dopamine deficit that is produced from consistent cannabis use (Sami et al., 2015). This dopamine deficit would consequently leave heavy and moderate users of cannabis below the optimal dopamine range. The inverted U-shaped relationship of dopamine and divergent thinking, when combined with dopamine deficits of cannabis use, suggest infrequent users would have higher creativity scores than moderate or heavy users. However, our hypothesis was not supported. There was no significant main effect of CUF on AUT median and AUT sum.

However, in addition to measuring immediate creativity in a divergent thinking task, this experiment also measured past creative achievements through the global measure of creativity, CAQ. Using this measure, we do find evidence to support that heavy users had higher rates of creativity over their lifetime. Specifically, it was found that heavy cannabis users reported more creative achievements than infrequent users on the CAQ. This does supports our hypothesis of different levels of creativity based on cannabis use frequency because we expected infrequent users to be more creative. This prediction was based on the idea that infrequent users have an optimal dopamine state most often than heavy users. This would arguably mean that they should therefore benefit from their frequent optimal dopamine state in their creative endeavors. However, the data reflect that the heavy cannabis user has produced more creative outputs over their lifetime than infrequent users.

Although dopamine levels were not measured, it is possible that these creative outputs were produced while in an optimal dopamine state. Since heavy users use at least once a day, this increased the likelihood that they will be in that optimal state more often while in acts of creativity. This supports the research of Kowal et al. (2015), and Chermahini and Hommel (2010) who find dopamine levels influence creativity, but only in the optimal level for the participant.

The literature suggests CUF can influence cognitive tasks (Ramaekers et al., 2009; Young et al., 2012), including creativity (Kowal et al., 2015; Chermahini & Hommel, 2010), especially while under the influence of cannabis. Our results found no significant interaction or main effects of CUF and being under the influence of cannabis on AUT median and sum. However, our results did find a difference between CUF on the CAQ. If heavy users use nearly every day, then there is an increased chance of them being at their optimal level of dopamine. If this is the case, then this supports our hypothesis of a main effect of CUF on creativity.

Main Effect of Mood

A main effect of mood was predicted for creativity. It was hypothesised that the positive mood condition would have the highest AUT scores, when compared to the negative and neutral mood condition. Our hypothesis was not supported. There was no main effect of mood condition on AUT median or AUT sum. This suggests no differences between mood conditions on the divergent thinking task. This result is contrary to the literature. Previous research suggests a significant difference in creativity, favoring a positive mood (Baas et al., 2008; Davis, 2009). Although there is evidence to suggest any heightened mood can increase creativity, due to an increase of attention (De Dreu et al., 2008). The limitations of this study may explain the differences in our results compared to those from the literature. However, in addition to measuring immediate mood, this experiment also measured participants' general and pervasive mood state with the BMIS.

Using the BMIS score, we investigated the relationship between general mood states on lifetime creative achievement (CAQ). There was no significant differences of mood scores on the CAQ. This is contrary to our hypotheses and previous literature, which suggest positive moods can increase creativity (Davis, 2009). If there is no difference between those who have generally negative moods, compared to those who have generally positive moods and neutral mood, on lifetime creativity, than one cannot claim that depressed artists are more creative. Our results suggest no differences in one's general mood in relation to their lifetime creativity.

Main Effect of CAQ

The CAQ is an additional measure of creativity over one's lifetime. The CAQ was found to be a significant predictor of AUT median and sum, meaning there was a positive linear relationship of lifetime creativity on momentary creativity. This suggests that those who have achieved more creative experiences (as evidenced by the CAQ), also have higher rates of divergent thinking in the AUT. The explanation for this result is related to past experiences. If one has a high rate of creative experiences, to the point of reaching domain specific achievement milestones, then they would be expected to have more background knowledge and experiences to assist when presented with a momentary creative task. This is supported by previous literature, which also suggests those who have a higher CAQ, have an increased divergent thinking score (Zabelina et al., 2016).

Post Hocs

Post hoc analyses looked at the additional information that was provided in the survey.

Active Cannabis Users. Previous literature suggests differences among CUF while being under the influence of cannabis (Somaini et al., 2012). Active cannabis users are likely to have a decrease in the cognitive defects of cannabis (Ramaekers et al., 2009). Our results found no difference between active cannabis participants and CUF on creativity, which may suggest that all participants were at their optimal dopamine level. If active users were no different from infrequent users, than their baseline creativity is similar. This suggests those who voluntarily use cannabis before a task, are likely to be similar to infrequent users.

Demographics: AUT Median and AUT Sum. As part of the post hoc analyses, we aimed to find a model that explained the most amount of variance for the AUT scores. The AUT median and sum were analyzed with the additional information provided by the demographic survey.

AUT Median. The fully reduced model found that the demographic predictor variables for AUT median scores resulted in main effects for GPA, college standing and creative identity score with no interaction.

The main effect of GPA suggests that as GPA increases, AUT median score increases as well. This means that the better your performance in college classes, the more divergent creativity you can produce. It is possible that creative thinking can help one devise strategies to perform better in classes, but this data is not in line with the results from previous research (Taylor & Mckean, 1967). In fact, Taylor and Mckean did not find a relationship between divergent thinking and GPA.

The main effect college standing suggests that as one gains more knowledge by progressing in college standing, their cognitive abilities and knowledge increases. Seniors were more creative than freshmen, which suggests experience and a more diverse knowledge background increases creativity. This knowledge serves as a boost in the application of their wealth of knowledge to novel contexts, including those that are abstract. This is supported by previous literature (Liu, Chiu, & Chiu, 2010; Reisberg, 2012) that suggests that increases of creativity are attributed to gains in knowledge.

Additionally, the main effect of creative identity suggests that those who have a higher creative identity score are more creative. This suggests that individuals who see themselves as creative, may actively reaffirm that trait, especially in a task designed to measure creativity. It was expected that those who strongly identify as creative, would produce more creative outputs in the AUT, than those who do not have a strong creative identity. These findings are supported by the research done by Liu et al. (2010). The researchers found that those who had higher rates of personal importance of creativity did indeed have higher scores of creativity.

AUT Sum. The fully reduced model found only one demographic predictor variable for AUT sum scores. A main effect of college standing was observed. This supports a significant increase of creativity in both AUT median and sum based on college standing. Seniors had significantly higher scores than freshmen, which suggests that creativity increases with more knowledge. As one progresses with their education, their critical thinking skills and abstract thought experience increase, which are tools used in creativity.

DV: CAQ. The Creative Achievement Questionnaire (CAQ) was the self-report lifetime creativity score. This is a general creativity score, and post hoc analyses focused on who is likely to have a higher CAQ score. When predicting participants CAQ score, there was a main effect of cannabis use frequency. Infrequent users reported less creative achievements than heavy users. This suggests that heavy users of cannabis have achieved more lifetime creative accomplishments than infrequent users. The CAQ has been shown to be a predictor of instance specific creativity (Carson et al., 2005), which is inline with the results. Those who had a higher score on the CAQ had a higher median and sum AUT score. Our results fall in line with past research, which suggests that those who have a high CAQ score would have a high divergent thinking skill, which is correlated with striatal and frontal cortex dopaminergic processing (Zabelina et al., 2016).

When predicting CAQ scores, the belief of cannabis increasing creativity, the belief cannabis increases happiness, and one's creative identity score, were all significant predictors of lifetime creative achievement. The two beliefs about cannabis (e.g. creativity and happiness) suggest that the positive perception one has of cannabis can influence participants' creativity. If participants believed that cannabis can increase creativity and happiness, than they are more likely to report more lifetime creative achievements than those who do not. It is also possible that the positive perception of the participants' influenced participant self-selection in the study. This is in line with research by Minor et al. (2014), who found 50% of cannabis users believe cannabis increases creativity. When recruiting for a study on cannabis and creativity, those who have a positive perspective for both may be more likely to participate in the study than those who do not.

These results also suggest those who have a strong creative identity report higher lifetime creative achievements. If one identifies as a creative type, then it's reasonable to expect them to produce more acts of creativity.

DV: CUF. The factors that influence one's likelihood of being a cannabis user is diverse and not well researched. We tested possible demographic predictors on cannabis use frequency. Our results suggest that participants are more likely to have higher cannabis use frequencies if they think that cannabis use increases creativity or think that cannabis use increases their happiness. Previous literature supports the perception that cannabis use can increase creativity in cannabis users (Minor et al., 2014). Additionally, the positive effects of cannabis use, such as the increase of happiness with use, are viewed to outweigh the potential negative costs associated with use (Reilly, Didcott, Swift, & Hall, 1998). For example, Hapsari, Pumarino, Oviedo-Joekes, and Richardson (2017) investigated the influence of one's belief of the positive and negative effects of cannabis on cannabis use. They found a positive relationship between positive beliefs of cannabis and cannabis use. The idea of increases happiness was among the listed positive beliefs of cannabis use. This suggests the perception of the benefits and costs of cannabis greatly influence cannabis use frequency.

This suggests no other factors such as income, sex, family education, or even age of first use, influences who is likely to be a cannabis user. One's perception of its effects are the main predictors of use frequency. This rationale is supported by Young et al.

(2012), who found that heavy users of cannabis used cannabis to regulate their emotions, rather than casual users who used cannabis for aim of pleasure. Thus, cannabis use seems to have a circular relationship, where continued cannabis use increases the reasons to use cannabis. However, for heavy users of cannabis this is likely motivated by emotional regulation. This cyclical reasoning is related to the well-being differences related to cannabis use (Somanini et al., 2012), where heavy users are found to have higher rates of negative affects and use cannabis to alleviate their symptoms.

Limitations

There were several limitations in this study that may explain why we were unable to support our main hypotheses. These limitations concerned both cannabis use frequency, the mood manipulation, and no measure of dopamine, which underlies the hypotheses concerning both CUF and mood.

A key limitation of this research stems from properly defining different types of cannabis users. The field is currently not at a consensus when categorizing different cannabis users. This makes the interpretation of the results of studies on cannabis often at odds with other studies that have defined their cannabis use frequencies differently, and makes any follow-up investigations difficult to appropriately replicate or extend. Currently, this research is faced with the immediate dilemma of legislation and medical advice based on possibly misinterpreted results. Considering the differences between cannabis use frequencies and changes in dopamine levels, (Sami et al., 2015), a one size fit all approach to the interpretations of cannabis studies is both not possible, but also not advisable. Increased standardization that considers the biological differences and personal use frequencies, that can be accessed and agreed upon by the scientific community, would greatly enhance the future cannabis research.

Our study revealed several limitations concerning mood. One major issue stemmed from the failed mood manipulation check. The purpose of the mood manipulation check was to identify whether moods were changed due to the presentation of the mood music and whether the changes reflected the intended mood associated with the music. The mood manipulation check was presented by a question before and after each mood manipulation addressing the participant’s current mood. With a failed mood manipulation check, we cannot claim to have induced the participants into the intended moods. Thus for our independent variable of mood, no conclusions can be made about the influence of mood in our study.

Previous research suggests there a difference between positive, negative, and neutral moods on creativity tasks (De Dreu et al., 2008). However, our study did not successfully change moods. There are several explanations for this. First, the music that was intended to induce moods was not coded to loop. This means that, if participants took longer than 10 minutes in each condition, the music would stop. As a consequence, this removes the mood manipulation all together because the mood stimuli is no longer present. Second, although past studies have used the stimuli used in this experiment for inducing positive and negative mood, the music in this study were not presented in the same manner as past studies (Koelsch et al., 2006). Past research has presented this stimuli as their own unique clips, while we presented them in a continuous stream where the next music clip was presented immediately after the termination of another clip. The clips used in the previous study was not presented in the same manner so it may be the case that the shift from one clip to another was not only abrupt (negative), but also possibly distracting. One participant noted that the music presentation was "hilarious", especially in the negative mood condition, and so in addition to the failed manipulation, the music induced an alternative outcome to the participants. Third, the type of music used in this study was not personally relevant. Previous research has used positive and negative music in relation to the participant's own preference, suggesting that one's musical preferences matters when manipulating one's mood with music (Jolij & Meurs, 2011). It could also be the case that the particular music stimuli used in this experiment may have resulted in unintended consequences that do not pertain to mood. It is possible that the positive music distracted participants or the negative music entertained people, as noted by a few participants.

The order of mood conditions was also a limitation. In hopes to get an accurate reading of one's current mood without crossover effects, the neutral mood condition was always first. The negative and positive mood conditions were counterbalanced, but since the mood manipulation check failed, the changes across condition cannot be related to the participant's mood.

There is evidence to suggest a possible fatigue effect or possibly unintended effects of the mood music. Although mood conditions were insignificant for AUT median and sum (DV: AUT sum: Neutral (*Mean* = 4.15, *SD* = 1.27; Positive (*Mean* = 3.97, *SD* = 1.33); Negative (*Mean* = 3.86, *SD* = 1.32); $p = .06$), the results were trending towards the neutral condition having higher rates of creativity compared to the positive or negative conditions. However, the variance between the conditions were very similar (DV: AUT sum: Neutral = 1.62; Positive = 1.77; Negative = 1.73), and within the neutral condition between CUF (DV: AUT sum: Infrequent = 1.94; Moderate = 1.55; Heavy = 1.17) which supports the original analysis of insignificance between mood conditions and CUF. The literature suggests when a participant is in a neutral mood, they perform worse when compared to an enhanced mood (De Dreu et al., 2008). Considering the p-value for mood condition on creativity and the failed mood manipulation check, it is possible an extraneous variable influenced the study. Asking participants to produce as many possible alternative uses for 15 words is mentally taxing, and it is possible for participants to get fatigued as the experiment progressed. This could easily reduce response rate in each portion of the task. This may help to explain the approaching significance between condition, rather than claiming participants were better in the neutral mood condition.

It should be noted that the rationale for cannabis use and moods' effects on creativity stem from an underlying influence of dopamine. However, our study did not measure individual levels of dopamine within our participants. Previous literature suggests there is a difference between infrequent and heavy users on cognitive tasks (Ramaekers et al., 2009) and creativity tasks (Chermahini & Hommel, 2010; Kowal et al., 2015). It was hypothesized that heavy cannabis users would have a dopamine deficit, while infrequent users would be at their optimal dopamine level. This premise would predict that heavy cannabis users would perform worse than infrequent users on divergent thinking tasks like the AUT unless they were under the influence of cannabis (Kowal et al., 2015; Minor et al., 2014). However, we cannot definitively speak to this prediction on the basis of dopamine, as we did not measure one's current or changing dopamine levels throughout the experiment. Although no difference was found on divergent thinking between those who reported being under the influence and those who did not, we suggest future studies to look at the strain of cannabis, THC and CBD concentration, the amount of cannabis, and method of ingestion because all of these variables can influence cognition and dopamine levels (Kowal et al., 2015).

In relation to dopamine and mood, it is possible participants received a positive feedback from simply participating in the study. This is supported by the neuropsychological reward process in relation to creativity (Hidi, 2016). There is strong influence of reward processing upon the individual's anticipation and participation in the act of obtaining the reward. If the participant perceived they did well in the AUT, it is possible the participant's dopaminergic reward process was activated. The ventral striatum, medial prefrontal cortex, and posterior cingulate cortex are all related to the processing of delayed reward values. This suggests individuals that perceived they did well in the AUT, their dopamine levels were raised by their anticipation of the reward, and thus influences their future creativity. Additionally, this phenomenon could have overridden the mood induction.

Mood induction was conducted at the exact same time as the AUT experiment. This could have influenced the mood manipulation, because it is possible mood was no induced long enough for the mood to take hold on the participant. In the original study by Koelsch et al. (2006), participants were presented with the music stimuli multiple times, throughout three days, while in an fMRI machine, and were instructed to focus on the music. These features could influence the participants' perception of the music. This study did not make mention of the music of any kind to the participants, and so the participants could have ignored or used the music as background noise, instead of engaging with it to influence their moods. It is suggested to induce moods prior to the experiment, if time permits for future studies.

Another participant influence of creativity could have been their age. The average age of the participants was about 21 years old, which is below the age of full adult development. This could influence participant's moods, their perception of cannabis use, or even their perception of the task itself.

Lastly, there is a possibility of a history effect. The study collected data from October 4th to December 9th. On November 8th, California voted in a new law allowing recreational use of cannabis. After that date, 16 students participated in the experiment under the influence of cannabis.

Conclusion

This study aimed to address two perceptions: that cannabis use can increase creativity, and the depressed artist is more creative than a cheerful one. Past research has found that cannabis use and positive moods increase dopamine (Bossong et al., 2009; Zabelina et al., 2016). Our hypotheses were based on the inverse U-shaped relationship of dopamine and creativity (Chermahini & Hommel, 2010). We found no relationship between cannabis use frequency and mood on participant's creativity, via AUT median or sum score. Our results suggest that there is no difference between cannabis use frequency and mood while performing a divergent thinking task. However, heavy users did have a higher lifetime creativity score. Thus, with respect to the perspective that cannabis use increases creativity, we concluded this is only a perception for momentary creativity. However it is possible that heavy cannabis use is associated with increased creativity over lifetime (CAQ). With respect to mood and creativity, our mood manipulation failed, and so we cannot make any claims about current moods and divergent thinking. However, CAQ score in relation to how one generally feels (BMIS) found no differences between moods and lifetime creativity. Thus with respect to the perception of the talented, but distraught artist, we conclude there is no difference between mood and creativity.

Although 50% of people believe cannabis can increase creativity, it appears that this belief is only a perception, both within our study and previous research (Minor et al, 2014). Thus far, the relationship between cannabis use and creativity is tenuous and may be distorted by one's biased perceptions and memories of their creative endeavors.

Although this study was not able to provide a definitive answer on the matter, previous literature suggests otherwise. The relationship between cannabis use frequency, mood, and creativity is connected through dopamine levels within the individual (Bossong et al., 2009; De Dreu et al., 2008; Kuepper et al., 2010; Wu et al., 2015). Future studies should use a consistent scale of cannabis use frequency, measure dopamine levels within the participant, along with a mood manipulation that occurs prior to the experiment.

This research can help provide a clearer insight between the relationship between the levels of cannabis use and mood, with creative thinking. Although previous cannabis research suggests differences on cognitive tasks (Ramaekers et al, 2009), our research suggests otherwise. It is possible that cannabis use frequencies may have more similarities than differences. Consequently, it is important to highlight similarities within cannabis use frequencies groups just as much as highlighting their differences, or else one cannot get a full perspective of that group. Through understanding the biological and emotional differences between cannabis use frequencies, one can interpret the influence cannabis has on an individual.

With this in mind, this study has implications for research in harm reduction and the therapeutic effects of cannabis. Creative therapy could be helpful for patients who are chronic users of cannabis who may wish to stop their dependence on the substance for emotion regulation. Our research suggests that those who use cannabis to regulate their emotions are more likely to be heavier users. This means that they may be using cannabis to treat underlying emotional disturbances. However, heavy cannabis users also report more instances of creativity over their lifetime. Thus, it is possible to use creative expression as a tool to alleviate emotional disturbances without or in conjunction with reduced cannabis doses. Notwithstanding, the current study found that cannabis use did not impact one's creativity in an experimental divergent thinking task. The link between cannabis use, mood, and creativity may still rely upon a dopamine explanation.

References

Baas, M., De Dreu, C., & Nijstad, B., (2008). A meta-analysis of 25 years of mood-creativity research: Hedonic tone, activation, or regulatory focus? *Psychological Bulletin, 134*, 779-806. doi:http://dx.doi.org/10.1037/a0012815

Barkus, E., Morrison, P., Vuletic, D., Dickson, J., Ell, P., Pilowsky, L. S., … Murray, R. M. (2011). Does intravenous 9-tetrahydrocannabinol increase dopamine release? A spet study. *Journal of Psychopharmacology*, *25*, 1462-1468. doi:10.1177/0269881110382465

Beaty, R. E., Benedek, M., Wilkins, R.W., Jauk, E., Fink, A., Silvia, P. J., … Neubauer, A. C. (2014). Creativity and the default network: A functional connectivity analysis of the creative brain at rest. *Neuropsychologia*, *64*, 92-98. doi:https://doi.org/10.1016/j.neuropsychologia.2014.09.019

Befort, K. (2015). Interactions of the opioid and cannabinoid systems in reward: Insights from knockout studies. *Frontiers in Pharmacology, 6*, 6. doi:10.3389/fphar.2015.00006

Bonn-Miller, M. O., Boden, M. T., Bucossi, M. M., & Babson, K. A. (2014). Self-reported cannabis use characteristics, patterns and helpfulness among medical cannabis users. *American Journal of Drug & Alcohol Abuse*, 40, 23-30. doi:10.3109/00952990.2013

Bossong, M., Mehta, M., van Berckel, B., Howes, O., Kahn, R., & Stokes, P. (2015). Further human evidence for striatal dopamine release induced by administration of Δ9-tetrahydrocannabinol (THC): Selectivity to limbic striatum. *Psychopharmacology*, *232*, 2723-2729. doi:10.1007/s00213-015-3915-0

Buckner, J., Zvolensky, M., & Schmidt, N. (2012). Cannabis-related impairment and social anxiety: The roles of gender and cannabis use motives. *Addictive Behaviors*, *37*, 1294-1297. doi:https://doi.org/10.1016/j.addbeh.2012.06.013

Carson, S. H.; Peterson, J. B.; Higgins, D. M. (2005). Reliability, validity, and factor structure of the creative achievement questionnaire. *Creativity Research Journal, 17*, 37-50. doi:10.1207/s15326934crj1701_4

Cheung, J. W., Mann, R. E., Ialomiteanu, A., Stoduto, G., Chan, V., Ala-Leppilampi, K., & Rehm, J. (2010). Anxiety and mood disorders and cannabis use. *American Journal of Drug & Alcohol Abuse, 36*, 118-122. doi:10.3109/00952991003713784

Chermahini, S., & Hommel, B. (2010). The (b)link between creativity and dopamine: Spontaneous eye blink rates predict and dissociate divergent and convergent thinking. *Cognition*, *115*, 458-465. doi:https://doi.org/10.1016/j.cognition.2010.03.007

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A Global Measure of Perceived Stress. *Journal of Health and Social Behavior, 24*, 385-396. doi:http://www.jstor.org/stable/2136404

Davis, M. (2009). Understanding the relationship between mood and creativity: A meta-analysis. *Organizational Behavior and Human Decision Processes, 108*, 25-38. doi:https://doi.org/10.1016/j.obhdp.2008.04.001

De Dreu, Carsten K. W., Baas, M., & Nijstad, B. A. (2008). Hedonic tone and activation level in the mood-creativity link: Toward a dual pathway to creativity model. *Journal of Personality and Social Psychology, 94*, 739-756. doi:http://dx.doi.org/10.1037/0022-3514.94.5.739

Dunn, R. E. (1997). Creative thinking and music listening. *Research Studies in Music Education 1*(8), 42-55.

Fernández-Ruiz, J., Hernández, M., & Ramos, J. (2010). Cannabinoid-dopamine interaction in the pathophysiology and treatment of CNS disorders. *CNS Neuroscience & Therapeutics*, *16*, 72. doi:10.1111/j.1755-5949.2010.00144.x

Flaherty, A. (2005). Frontotemporal and dopaminergic control of idea generation and creative drive. *The Journal of Comparative Neurology*, *493*, 147-153. doi:10.1002/cne.20768

Guilford, J. P. (1950). Creativity. *American Psychologist, 5*(9), 444-454. doi:http://dx.doi.org/10.1037/h0063487

Guilford, J. P. (1967). *The nature of human intelligence*. New York: McGraw-Hill.

Hapsari, A., Pumarino, J., Oviedo-Joekes, E., & Richardson, C. (2017). Examining the relationships between cannabis use expectancies and the intention to use, the initiation of use, and frequency of cannabis use among Canadian adolescents.

Journal of Adolescent Health, *60*, S121. doi:https://doi.org/10.1016/j.jadohealth.2016.10.417

Hidi, S. (2016). Revisiting the role of rewards in motivation and learning: Implications of neuroscientific research. *Educational Psychology Review*, *28*(1), 61-93.

Jauk, E., Neubauer, A., Dunst, B., Fink, A., & Benedek, M. (2015). Gray matter correlates of creative potential: A latent variable voxel-based morphometry study. *NeuroImage, 111*, 312-320. doi:http://dx.doi.org/10.1016/j.neuroimage.2015.02.002

Jolij, J., & Meurs, M. (2011). Music alters visual perception. *PloS One, 6*, e18861. doi:10.1371/journal.pone.0018861

Kaufmann, G. (2003). Expanding the mood-creativity equation. *Creativity Research Journal, 15*(2/3), 131-135. ISSN: 10400419

Koelsch, S., Fritz, T., Cramon, D., Müller, K., & Friederici, A. (2006). Investigating emotion with music: An fMRI study. *Human Brain Mapping, 27*, 239-250. doi:10.1002/hbm.20180

Kowal, M., Hazekamp, A., Colzato, L., van Steenbergen, H., van der Wee, N., Durieux, … Hommel, B. (2015). Cannabis and creativity: Highly potent cannabis impairs divergent thinking in regular cannabis users. *Psychopharmacology, 232*, 1123-1134. doi:10.1007/s00213-014-3749-1

Kuepper, R., Morrison, P. D., van Os, J., Murray, R. M., Kenis, G., & Henquet, C. (2010). Does dopamine mediate the psychosis-inducing effects of cannabis? A review and integration of findings across disciplines. *Schizophrenia Research, 121*(1), 107-117. doi:https://doi.org/10.1016/j.schres.2010.05.031

Lewis, C., & Lovatt, P. (2013). Breaking away from set patterns of thinking: Improvisation and divergent thinking. *Thinking Skills and Creativity, 9*, 46. doi:https://doi.org/10.1016/j.tsc.2013.03.001

Liu, C., Chiu, S., & Chiu, C. (2010). Intranetwork relationships, creativity, knowledge diversification, and network position. *Social Behavior and Personality*, *38*, 1173-1190. doi:10.2224/sbp.2010.38.9.1173

Makriyannis, A. (2014). 2012 Division of medicinal chemistry award address. Trekking the cannabinoid road: A personal perspective. *Journal of Medicinal Chemistry, 57*, 3891. doi:10.1021/jm500220s

Mayer, J. D., & Gaschke, Y. N. (1988). The experience and meta-experience of mood. *Journal of Personality and Social Psychology, 55*, 102-111. doi:http://dx.doi.org/10.1037/0022-3514.55.1.102

Minor, K. S., Firmin, R. L., Bonfils, K. A., Chun, C. A., Buckner, J. D., & Cohen, A. S. (2014). Predicting creativity: The role of psychometric schizotypy and cannabis use in divergent thinking. *Psychiatry Research, 220*, 205-210. doi:https://doi.org/10.1016/j.psychres.2014.08.044

Mitchell, R., & Phillips, L. (2007). The psychological, neurochemical and functional neuroanatomical mediators of the effects of positive and negative mood on executive functions. *Neuropsychologia*, *45*(4), 617-629. doi:https://doi.org/10.1016/j.neuropsychologia.2006.06.030

Panksepp, J., & Biven, L. (2007). The archaeology of mind: Neuroevolutionary origins of human emotions. *Norton & Company*, New York. doi:10.1111/1468-5922.12022_4

Psychology Software Tools, Inc. (2002). E-Prime user's guide. [Computer Software] Pittsburgh: Schneider, W., Eschman, A., & Zuccolotto, A.

Ramaekers, J., Theunissen, E., Brouwer, M., Toennes, S., Moeller, M., & Kauert, G. (2011). Tolerance and cross-tolerance to neurocognitive effects of THC and alcohol in heavy cannabis users. *Psychopharmacology*, *214*, 391-401. doi:10.1007/s00213-010-2042-1

Ramaekers, J., Toennes, S., Moeller, M., Kauert, G., & Theunissen, E. (2009). Neurocognitive performance during acute THC intoxication in heavy and occasional cannabis users. *Journal of Psychopharmacology, 23*, 266-277. doi:10.1177/0269881108092393

Reilly, D., Didcott, P., Swift, W., & Hall, W. (1998). Long-term cannabis use: Characteristics of users in an Australian rural area. *Addiction*, *93*, 837-846. doi:10.1080/09652149835350

Reisberg, D. (5 Ed.). (2012). *Cognition: Exploring the science of the mind*. New York: Norton.

RStudio Team (2015). RStudio: Integrated Development for R. [Computer Software]. Boston, MA: RStudio, Inc. Retrieved from http://www.rstudio.com/

Sami, M., Rabiner, E., & Bhattacharyya, S. (2015). Does cannabis affect dopaminergic signaling in the human brain? A systematic review of evidence to date. *European*

Neuropsychopharmacology: The Journal of the European College of Neuropsychopharmacology, 25(8), 1201-1224. doi:https://doi.org/10.1016/j.euroneuro.2015.03.011

Silvia, P., Beaty, R., Nusbaum, E., Eddington, K., & Kwapil, T. (2014). Creative motivation: Creative achievement predicts cardiac autonomic markers of effort during divergent thinking. *Biological Psychology, 102*, 30-37. doi:https://doi.org/10.1016/j.biopsycho.2014.07.010

Somaini, L., Manfredini, M., Amore, M., Zaimovic, A, Raggi, M., Claudio, L., … Gerra, G. (2012). Psychobiological responses to unpleasant emotions in cannabis users. *European Archives of Psychiatry and Clinical Neuroscience*, *262*, 47-57. doi:10.1007/s00406-011-0223-5

Taylor, B., & Mckean, R. (1967). Divergent thinkers and teacher education. *The Journal of Educational Research*, *61*(9), 417-418. doi: www.jstor.org/stable/27532096.

Wu, X., Yang, W., Tong, D., Sun, J., Chen, Q., Wei, D., … Jiang, Q. (2015). A meta-analysis of neuroimaging studies on divergent thinking using activation likelihood estimation. *Human Brain Mapping, 36*(7), 2703-2718.

Young, R., Gullo, M., Feeney, G., & Connor, J. (2012). Development and validation of the cannabis refusal self-efficacy questionnaire (crseq) in adult cannabis users in treatment. *Drug and Alcohol Dependence, 125*, 244. doi:https://doi.org/10.1016/j.drugalcdep.2012.02.018

Zabelina, D., Colzato, L., Beeman, M., & Hommel, B. (2016). Dopamine and the creative mind: Individual differences in creativity are predicted by interactions between dopamine genes dat and comt. *PloS One, 11*, e0146768. doi:https://doi.org/10.1371/journal.pone.0146768

Zentner, M., Grandjean, D., & Scherer, K. (2008). Emotions evoked by the sound of music: Characterization, classification, and measurement. *Emotion, 8*, 494-521. doi:http://dx.doi.org/10.1037/1528-3542.8.4.494

Appendices

Appendix A***:*** Brief Mood Introspection Scale (BMIS)

INSTRUCTIONS: Circle the response on the scale below that indicates how well each adjective or phrase describes your present mood.

(definitely do not feel)	(do not feel)	(slightly feel)	(definitely feel)
XX	X	V	VV

Lively	XX	X	V	VV		Drowsy	XX	X	V	VV
Happy	XX	X	V	VV		Grouchy	XX	X	V	VV
Sad	XX	X	V	VV		Peppy	XX	X	V	VV
Tired	XX	X	V	VV		Nervous	XX	X	V	VV
Caring	XX	X	V	VV		Calm	XX	X	V	VV
Content	XX	X	V	VV		Loving	XX	X	V	VV
Gloomy	XX	X	V	VV		Fed up	XX	X	V	VV
Jittery	XX	X	V	VV		Active	XX	X	V	VV

Overall, my mood is:

Very Unpleasant — Very Pleasant

-10 –9 –8 –7 –6 –5 –4 –3 –2 –1 0 1 2 3 4 5 6 7 8 9 10

Appendix B: Creative Achievement Questionnaire

Shelley Carson
Harvard University

I. Place a checkmark beside the areas in which you feel you have more talent, ability, or training than the average person.

__ visual arts (painting, sculpture)
__ music
__ dance
__ individual sports (tennis, golf)
__ team sports
__ architectural design
__ entrepreneurial ventures
__ creative writing
__ humor
__ inventions
__ scientific inquiry
__ theater and film
__ culinary arts

II. Place a checkmark beside sentences that apply to you. Next to sentences with an asterisk (*), write the number of times this sentence applies to you.

A. Visual Arts (painting, sculpture)

__ 0. I have no training or recognized talent in this area. (Skip to Music).
__1. I have taken lessons in this area.
__2. People have commented on my talent in this area.
__3. I have won a prize or prizes at a juried art show.
__4. I have had a showing of my work in a gallery.
__5. I have sold a piece of my work.
__6. My work has been critiqued in local publications.
*__7. My work has been critiqued in national publications.

B. Music

__0. I have no training or recognized talent in this area (Skip to Dance).
__1. I play one or more musical instruments proficiently.
__2. I have played with a recognized orchestra or band.
__3. I have composed an original piece of music.
__4. My musical talent has been critiqued in a local publication.
__5. My composition has been recorded.
__6. Recordings of my composition have been sold publicly.
*__7. My compositions have been critiqued in a national publication.

C. Dance
__0. I have no training or recognized talent in this area (Skip to Architecture)
__1. I have danced with a recognized dance company.
__2. I have choreographed an original dance number.
__3. My choreography has been performed publicly.
__4. My dance abilities have been critiqued in a local publication.
__5. I have choreographed dance professionally.
__6. My choreography has been recognized by a local publication.
*__7. My choreography has been recognized by a national publication.

D. Architectural Design
__0. I do not have training or recognized talent in this area (Skip to Writing).
__1. I have designed an original structure.
__2. A structure designed by me has been constructed.
__3. I have sold an original architectural design.
__4. A structure that I have designed and sold hasbeen built professionally.
__5. My architectural design has won an award or awards.
__ 6. My architectural design has been recognized in a local publication.
*__7. My architectural design has been recognized in a national publication.

E. Creative Writing
__0. I do not have training or recognized talent in this area (Skip to Humor).
__1. I have written an original short work (poem or short story).
__2. My work has won an award or prize.
__3. I have written an original long work (epic, novel, or play).
__4. I have sold my work to a publisher.
__5. My work has been printed and sold publicly.
__6. My work has been reviewed in local publications.
*__7. My work has been reviewed in national publications.

F. Humor
__0. I do not have recognized talent in this area (Skip to Inventions).
__1. People have often commented on my original sense of humor.
__2. I have created jokes that are now regularly repeated by others.
__3. I have written jokes for other people.
__ 4. I have written a joke or cartoon that has been published.
__5. I have worked as a professional comedian.
__6. I have worked as a professional comedy writer.
__7. My humor has been recognized in a national publication.
G. Inventions
__0. I do not have recognized talent in this area.
__1. I regularly find novel uses for household objects.

__2. I have sketched out an invention and worked on its design flaws.
__3. I have created original software for a computer.
__4. I have built a prototype of one of my designed inventions.
__5. I have sold one of my inventions to people I know.
*__6. I have received a patent for one of my inventions.
*__7. I have sold one of my inventions to a manufacturing firm.

H. Scientific Discovery
__0. I do not have training or recognized ability in this field (Skip to Theater
__1. I often think about ways that scientific problems could be solved.
__2. I have won a prize at a science fair or other local competition.
__3. I have received a scholarship based on my work in science or medicine.
__4. I have been author or coauthor of a study published in a scientific journal.
*__5. I have won a national prize in the field of science or medicine.
*__6. I have received a grant to pursue my work in science or medicine.
__7. My work has been cited by other scientists in national publications.

I. Theater and Film
__0. I do not have training or recognized ability in this field.
__1. I have performed in theater or film.
__2. My acting abilities have been recognized in a local publication.
__3. I have directed or produced a theater or film production.
__4. I have won an award or prize for acting in theater or film.
__5. I have been paid to act in theater or film.
__6. I have been paid to direct a theater or film production.
*__7. My theatrical work has been recognized in a national publication.

J. Culinary Arts
__0. I do not have training or experience in this field.
__1. I often experiment with recipes.
__2. My recipes have been published in a local cookbook.
__3. My recipes have been used in restaurants or other public venues.
__4. I have been asked to prepare food for celebrities or dignitaries.
__5. My recipes have won a prize or award.
__6. I have received a degree in culinary arts.
*__7. My recipes have been published nationally.

K. Please list other creative achievements not mentioned above.

III. Place a check mark beside sentences that apply to you.
__ One of the first things people mention about me when introducing me to others is my creative ability in the above areas.
__ People regularly accuse me of having an “artistic” temperament.

__ People regularly accuse me of being an “absent-minded professor” type.

Scoring of the Creative Achievement Questionnaire

1. Each checkmarked item receives the number of points represented by the question number adjacent to the checkmark.
2. If an item is marked by an asterisk, multiply the number of times the item has been achieved by the number of the question to determine points for that item.
3. Sum the total number of points within each domain to determine the domain score.
4. Sum all ten domain scores to determine the total CAQ score.

Appendix C: Creative Identity Scale

How important is it to view yourself as a creative individual?

- Extremely important
- Slightly important
- Neutral
- Not very important
- Not important at all

Do you often feel like you are a creative individual?

- Always
- Sometimes
- Unsure
- Not very often
- Never

How important is music to you?

- Extremely important
- Slightly important
- Neutral
- Not very important
- Not important at all

How does music relate to your creativity?

- Extremely important
- Slightly important
- Neutral
- Not very important
- Not important at all

Appendix D: Cannabis Use Frequency Scale

Please indicate how often you may have used the following substances over the past 12 months.

In the past year I have used:	Never or almost Never$_0$	Couple of times a month$_1$	Once a week$_2$	Couple of times a week$_3$	Nearly every day$_4$	Several times a day$_5$
Marijuana	○	○	○	○	○	○

Appendix E: Substance Use & History

For each question, fill in the circle to indicate a "Yes" to the question of the specific drug to each column, or fill in the box with your best guess answer.

Question	Cannabis	Nicotine	Caffeine	Alcohol	Prescription Painkillers	Prescription Mood Stabilizers or Anxiety Medication
Have you taken any of these drugs in the past 24 hours?	○	○	○	○	○	○
Do you believe you are still under the effects of any of these drugs?	○	○	○	○	○	○
Do you use the drug to regulate or alter your emotions?	○	○	○	○	○	○
Do you think you are a more creative individual while under the influence of this drug?	○	○	○	○	○	○
Do you think you are a happier person while using this drug?	○	○	○	○	○	○
Please fill in your age for the first in person exposure to the drug.	________ years old	________ years old	________ years old	________ years old	________ years old	________ years old
Please fill in the age you were when you first used the drug.	________ years old	________ years old	________ years old	________ years old	________ years old	________ years old

Appendix F: Demographics

What is your age?

____

What is your sex?

- Male
- Female
- Middlesex
- Other ____________

What is your gender?

- Man
- Woman
- Transman
- Transwoman
- Agender
- Genderfluid
- Other _____________

What is your ethnicity?

- Non-Hispanic White or Euro-American
- Black, Afro-Caribbean, or African American
- Latino or Hispanic American
- East Asian or Asian American
- South Asian or Indian American
- Middle Eastern or Arab American
- Native American or Alaskan Native
- Other__________________________

What is your household's annual income?

- <$10,000
- $10,000-$30,000
- $30,000-$50,000
- $50,000-$75,000
- $75,000-$100,000
- $100,000-$150,000
- >$200,000

What is your GPA?

____

What is your major?

____

What is your current standing in college?

- Freshman
- Sophomore
- Junior
- Senior
- Graduate Student

What is the highest level of education in your immediate family?

- No degree
- High school degree
- Bachelor's degree
- Master's degree
- Doctorate degree

What is the education level of your main caretaker as a child?

- No degree
- High school degree
- Bachelor's degree
- Master's degree
- Doctorate degree
- Certificate program

Appendix G: AUT Scoring Guide

List of non-alternative uses. These do NOT count for the AUT score.

Candle
- Light
- Decoration
- Heat (okay for cooking)
- To start a fire (but okay if use it to help light a larger fire, one cannot start start a fire with only a candle)

Cup
- hat (mini/bad hat okay)

Plate
- hat (shielding eyes or rain protection okay)

Shoe
- hat

Rock
- Skipping rocks
- Decoration

Plank of wood
- Cover a broken window
- Building anything (bridge, house, fence)

Brick
- Building anything (house, path, bridge)

Pillow
- Pillow fights
- Pillow forts (but to build a fort is okay)
- Cushion

Glass Soda Bottle
- Spin the bottle

General Acceptable Uses - Count for AUT score
- Art (used to make art, not decoration)
- Weapon
- Props
- Symbolism or meaning or a gesture or a sign as something