Cortical Activity Patterns in Art Making vs. Fine Motor Movement as Measured by EEG

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ABSTRACT

This quantitative study explores the differences in cortical activation patterns when subjects create art versus when they engage in a rote motor task. It is hypothesized that a statistically significant difference occurs in cortical activity patterns during art making compared with non-creative rote motor behavior and that such differences can be detected and quantified with the electroencephalogram (EEG.) Ten consenting study subjects (one with formal art training, three with some art experience, and six with no art experience) underwent EEG recording at baseline (multiple measures) and with art making, and also with rote motor tasking. Baseline control recordings showed minimal changes in EEG while art making was associated with a persistent change from baseline of significant direction and amplitude involving both hemispheres, a change that was similar to the persistent change in EEG following rote motor tasks. These preliminary findings suggest that EEG may be a meaningful biomarker for cortical activation in the study of creative arts and points to further exploration using Mobile Brain Body Imaging (MoBI) in experimental designs. This system provides a reproducible, measurable, and quantitative methodology for evaluating brain activity and function in the study of the neuroscientific basis of creative arts, neuroaesthetics, and art therapy.

Keywords: art therapy, creative arts, creativity, EEG, qEEG, neuroaesthetics, neurophysiology, rote motor movement
DEDICATION

This work belongs to the recipients of art therapy, who bring a willingness to healing, you are my delight. I believe that if you dream big and work hard great accomplishments can be made. I’m so happy to share this very special moment with my beautiful family and friends. Without their love and support, none of this would be possible.

Alex Shaikh
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Alex Shaikh
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I would like to dedicate my contributions to my family. To my mother, your support and encouragement knows no bounds. To my father, your passion for knowledge has always served as a guiding force throughout my entire education. And to my loving partner, Jesse, for the smiles and laughs that helped me through my academic journey. Were it not for my family, none of this would have been possible.

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Kaitlin E. Knapp
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CHAPTER I
INTRODUCTION

Understanding the mechanisms involved in any psychic process is difficult, as the ambiguities involved in human behavior and expressions are inherently complex and multidimensional. Creativity is no exception, and historically the creative process has been difficult to explore scientifically as it is not localized to one area, or even one network, within the brain. It might not be possible or desirable to find a cogent definition of creativity that is generalizable across society, but increasing our understanding of how the creative process works, what it is, and how to measure it will enhance innovation and the ability to effectively solve problems in a range of disciplines related to the health and well-being of our society. Research regarding the processes involved in creativity and the brain is especially important in the realm of medicine and healthcare, as we are faced with complex challenges in the research and implementation of effective treatments to address diseases of the brain, the resultant behaviors, and the impacts these have on patients and their families.

According to a report of *How Creativity works in the Brain* offered through the National Endowment for the Arts (2015), research in neuroscience and cognitive psychology has identified some of the components of creativity including memory, divergent and convergent thinking, and flow. Cognitive science has expended due diligence to understand the implicit and explicit systems in the brain as they are involved in the creative process (Dietrich, 2004), yet the more we learn about these dynamic potentials the more questions we have about why and how things work as they do. For example, identifying the existence of implicit and explicit systems might help us understand (1) some distinctions between consciousness and unconsciousness, and (2) how emotions and memories may be connected to behavior and thought processes. However,
some neurologist will acknowledge that a cogent definition of consciousness is difficult to articulate. Such a definition is important to understand as it is a foundation for most evidence-based practices.

Neuroaesthetics does not address therapeutic implications, therefore further investigation of how the physiological and psychological aspects of aesthetic experience relate to one another is an important goal for the future (Chatterjee, 2010). The field of neuroaesthetics is moving us toward a greater understanding of creativity by focusing on the nature of visual perception and brain function, the cortical patterns involved in both viewing and making art, and the areas of the brain where art making likely takes place (Chatterjee, 2014; Chatterjee & Vartanian, 2014; Freedberg & Gallese, 2007; Ramachandran & Hirstein, 1999; Umilta et al., 2012; Zeki, 1999b). Utilizing data gained from the field of neuroaesthetics can provide a foundation upon which to study the implied processes that take place throughout art therapy assessment and intervention. This area of research is particularly important for the profession of art therapy as it is becoming more aware of the value of neuroscience in both theoretical and applied practice (Hass-Cohen & Findlay, 2015; Kaplan, 2000; Lusebrink, 2014; Malchiodi, 2003; McNamee, 2004; Riley, 2004). Without empirical evidence to support frameworks for understanding and applying clinical art therapy interventions, art therapists must rely on interpretive frameworks, which are often idiographic and do not allow generalizations to be made for larger populations.

Efforts to study the relationship of brain function and art making have been made by researchers interested in art therapy practice (Belkofer & Konopka, 2008; Belkofer, Konopka, & Van Hecke, 2014). These studies compared brainwave patterns before and after art making using electroencephalogram, EEG as a measure. The study in 2008 was a single subject design and the 2014 study included a sample size of ten participants. Results included higher frequency bands
of alpha and beta, with decreases in theta and delta. While this research does not involve art therapy is does create a foundation for continued research which would include therapeutic interventions.

A study with normal participants showed a difference in cortical motor (neocortex) activation when viewing original abstract art versus a graphic representation of the same piece (Umilta et al., 2012). These results indicate the original art as dynamic and the result of an artist’s creative gesture, while the static graphic representation lacked a perceptual context (Umilta et al., 2012). These findings suggest that the motor system of the brain is involved differently based on the elements of art that the viewer perceives. This current project seeks to explore the differences in neocortical, more conscious brain activity when subjects actually engage in the creative act of drawing versus simply moving. It is hypothesized that there will be a statistically significant difference in the cortical activation patterns when a person makes art versus a simple movement, and these distinctions will provide evidence to enhance our understanding of brain function and art. A manuscript article has been placed in the results, discussion and conclusion sections for review. These data will also provide evidence to support the study of clinical art therapy interventions and understanding of how creative expression contributes to patient health and well-being in the context of the therapeutic relationship.
CHAPTER II
LITERATURE REVIEW

Introduction

We can understand that all mental processes involved in art therapy and in art making are derived from activity in the brain (Kapitan, 2010), but there is little research involving EEG recordings and analyses of the brain in regards to the creation of visual imagery. Taking an EEG involves a noninvasive medical procedure, which measures brainwave activity from the scalp’s surface. Malchiodi (2003) argued that science will be central to understanding how art therapy works, will better define its effectiveness, and will improve the ability to develop more effective protocols to test art therapy interventions. Although there have only been a handful of neuroimaging studies in the field of art therapy, qEEG has been a promising method to research art-making, the distinctions in properties of art materials, and art processes (King & Kruk, 2016). The medical term, qEEG defines the analysis of EEG measures, through current algorithms which provide a brain mapping of activation patterns. This current project will contribute to the limited yet growing knowledge base on the subjects of art therapy and neuroscience. A review of empirical data shows all proposals on the neural basis of creativity fail when generalized to creativity as a whole (Dietrich, 2004). Gaining a greater understanding of the neural correlates involved in artistic expression will provide evidence for why and how art therapy is effective. This type of scientific evidence is crucial for validation and growth of the art therapy profession and also contributes to the growing fields of neuroaesthetics and cognitive neuroscience.

Neuroanatomy

The human brain is made up of three major areas: the forebrain, midbrain, and hindbrain (National Institute of Neurological Disorders and Stroke, 2015). Of these, the largest is the
forebrain, or prosencephalon, which sits atop both the midbrain and hindbrain. As indicated in Figure A1 (see Appendix A), almost all of the dorsal, or upper section of the human brain is comprised of the forebrain. Directly beneath this large subsection is the smallest unit, the midbrain or mesencephalon (Nolte, 1999). Working further into the ventral (lower half of the brain) is the hindbrain, which consists of the brain stem, cerebellum, and part of the spinal column. In order to understand complexities of the human brain, visual maps and reports have been included in the appendix to illustrate the neuroanatomical landscape.

A complex organ, the brain is responsible for a variety of tasks. The cerebral cortex is the outermost layer of the brain’s dominant cerebrum (Carter, Aldridge, Page, & Parker, 2014). Given these complexities and responsibilities, the brain’s cortices are broken down into areas or lobes. These four major lobes depicted graphically in Figure B1 (see Appendix B) include the (1) frontal lobe, (2) parietal lobe (Appendix C), (3) occipital lobe (Appendix D), and (4) temporal lobe (Appendix E) (Patestas & Gartner, 2016; Ribas, 2010).

**Systems of the brain.**

Reducing the functions of the lobes and cortices does not provide an understanding of the brain’s interactive and interconnect system. The brain’s connectivity has been more recently understood in terms of a complex system, a network (Telesford, Simpson, Burdette, Hayasaka, & Laurienti, 2011). According to Telesford et al. (2011), networks do not need to be anatomically connected to influence functions. Using network science as a framework and approach to brain studies is crucial to value the complex system of the brain. In our current investigation the sensory, motor, and visual processing systems are be discussed.

**Sensory processing system.**

Making sense of the world requires that the brain and environment interact through the
body’s somatosensory system via connections of light, sound waves, and pressure (Carter et al., 2009). External stimuli are transmitted as electrical signals to areas of the cerebral cortex, which is involved in the coordinated processing of sensations including, sight, sound, touch, smell, and taste (Carter et al., 2009). The sensory system processes external stimuli and internally creates neural connections, related to memory, emotion, and other internal drivers (Sadock & Sadock, 2007). Association material from the sensory system provides a stimulus for actions to the motor system. While an abundance of sensory information enters the brain, only a small amount is made visible to conscious sensation. Most sensory information is extinguished immediately in processing and what remains is either made conscious or unconscious, the latter which also influences our behaviors (Carter et al., 2009).

**Motor processing system.**

According to Sadock and Sadock (2007), motor system information processing is modulated by cortical influence. This motor information processing may look like the planned and executed choreography of movement. The motor system includes large coordinated movements through the primitive system of the brainstem that develops in infancy (Sadock & Sadock, 2007). The basal ganglia (see Appendix F, Figure F1) makes up a portion of nerve-cell bodies, called nuclei, located in the midbrain, which are involved in motor control (Carter et al., 2009).

These nuclei oversee the smooth integration of sensory input and output responses. Involvement of the basal ganglia system includes planned movement and unconscious learned coordination with rapid response. The functional response of these intricate systems require cooperation from each area, while any component that does not relay the circuitry signals impedes the motor response. In terms of motor system processing, any break in the signal
processing is like a scratched record that is stuck on a loop, stopping the entire album from playing.

According to Hass-Cohen and Findlay (2015), the organization of the motor system could be considered a *three-tier schematic*. In similarity, the triune brain theory developed by P. D. Mclean is a model of human brain evolution, which includes the reptilian, paleomammalian (limbic system), and neomammalian brains. These three basic anatomical and biological formations interconnected in neural assembly indicate a greater amount of information processing than would occur in independent operation (Mclean, 1990). Tier one, includes the parietal, temporal, and frontal lobes of cortical association. The middle tier includes the motor cortex (Figure G1, see Appendix G), the thalamus, hypothalamus, and cerebellum. The spinal cord and brainstem account for tier three at the bottom (Kalat, 2012). Reconsidering views that motor and sensory organization are separate means that “...sensory pathways also carry copies of the motor instructions so that sensorimotor processing is unified throughout all levels of thalamocortical functions” (Sherman & Guillery, 2011, p. 1075). The higher association circuits receive information from the middle level; in particular, the basal ganglia (see Appendix F, Figure F1) supports emotional regulation and the cerebellum (Hass-Cohen & Findley, 2015). The field of art therapy uses this knowledge to amplify understanding in intervention and media choice within the therapeutic relationship for the betterment of patients and clients.

The cerebellum coordinates signals from the motor cortex to integrate the motor neurons, see Appendix H (Carr et al., 2009); this process modulates movements with concern to precise timing. The cerebellum facilitates a variety of functions, such as retaining memories of fine motor sequences. This particular function is significant to our current study: evaluating cortical activity in relation to fine motor movements. Lower levels of the motor system transmit
information to the middle level and receive commands from the higher levels (Hass-Cohen & Findlay, 2015). In relation to art making, this sequence may be illustrated like this:

[when] one picks a paintbrush, the motor cortex receives the information and, in turn, sends the appropriate messages to the hand. The hand’s muscles adjust and balance fine motor actions, allowing one to fulfill the action and load the brush with paint, thus allowing art making to become an executed reality. (Hass-Cohen & Findlay, 2015, p. 62)

This mind-body connection is integrated in the neuroscience of processing sensation, association, and movement.

*Visual processing system.*

The sensation of sight is processed in the visual cortex, seen in Appendix I, which is part of the brain’s visual processing system, taking exterior information and distributing it to other cortices (Nolte, 1999). In the act of observing a piece of art, it is the visual processing system that translates visual details gleaned from the production into readable information (Figure I1). Pulses are sent to other visual areas (V1-V5) for further processing (Figure I2 and Figure I3). These five areas make up part of the dorsal and ventral visual pathways (Carter et al., 2014).

“The cells of area V5, specialized for visual motion” (Lo & Zeki, 2014, p. 1), become activated, or excited, when they are presented with the perception of visual movement. It can be inferred that movement will be involved during a directive art making task as well as during a rote motor task. Therefore, it is possible that the fifth visual area, V5, will become activated during our EEG readings. One study (Dursteler, Wurtz, & Newsome, 1987) found that if the V5, also known as the middle temporal visual area (MT), were to become damaged, the difficulty perceiving motion and processing movement stimuli would ensue, suggesting V5 does function as the “motion center” proposed by Zeki (1999a). These five visual areas are seated within various cortices
across the brain. In particular, motor system information processing, which takes place in V5, is also regulated in other areas of the brain.

**Neuroaesthetics: History and Field of Research**

In the nineteenth century, Gustav Fechner introduced the term empirical aesthetics to describe a branch of experimental psychology (Bergeron, 2011; Seeley, 2011). Chatterjee (2011b) proposed that “artists during the early twentieth century were dissecting their visual world and in the process ‘discovered’ modules that neuroscientists later found in the visual brain” (p. 8). More recently, the field of neuroaesthetics has made efforts “to characterize neuroaesthetics as the cognitive neuroscience of aesthetic experience” (Pearce et al., 2016, p. 265). Neuroaesthetics aims to investigate the neurocognitive and evolutionary strengths of the aesthetic experience, through devices of study including beauty and art. While these studies may lead to factions of beauty, the focus remains on “emergent states, arising from interactions between sensory-motor, emotion-valuation, and meaning-knowledge neural systems” (Chatterjee & Vartanian, 2014, p. 371).

Neuroaesthetics can relate to areas such as dance/movement, literature, and music (Chatterjee, 2010); however, for the purpose of our research and this literature review, we will be discussing visual neuroaesthetics as it pertains to viewing and creating works of art. One area of particular interest for individuals investigating neuroaesthetics is whether or not artistic productions and/or aesthetic preference is predetermined by evolutionary basis or universal laws (Kirk et al., 2009; Myin, 2000; Ramachandran & Hirstein, 1999; Zaidel, 2010; Zaidel, Nadal, Flexas, & Munar, 2013; Zeki & Lamb, 1994), which will be explored in more length following this section.

Previous neuroaesthetic studies utilizing neuroimaging have largely focused on viewing...
artwork and the associated brain activation as opposed to creating artwork and comparing
cortical functions to movement, as is the case in our study. Current neuroimaging technology
allows for advanced understanding of art and how the viewer’s brain reacts (Jacobsen et al.,
2006), illuminating motion, emotion, and empathy within the aesthetic experience (Freedberg &
Gallese, 2007). By comparison, the contribution of neuroimaging research on the brain during
the creation of artwork is limited. The act of creating art engages the whole brain (Likova, 2012),
which progressive research methodology and neuroimaging technology affirm (Dietrich, 2004).
Bergeron (2011) states that by utilizing neuroimaging research, we can gain a better
understanding of an individual’s “aesthetic engagement with artworks” (p. 13).

The brain is a complicated organ; similarly, the fields that aim to better our understanding
share in its complexities. Related fields include the larger umbrella of empirical aesthetics,
perceptual psychology, and cognitive neuroscience. In Nadal and Skov’s (2015) article, the
similarities and differences between the cognitive neuroscience of art and neuroaesthetics are
explained. The principle aim of the cognitive neuroscience of art is to better understand the
biological underpinnings, or neural mechanisms, involved in the creation of art. While
neuroaesthetics maintains a broader interest in aesthetic appeal and production, the point at
which these two fields overlap is their interest of aesthetic qualities in artistic productions (Nadal
& Skov, 2015). Seeley (2011) states that “the cognitive neuroscience of art is a subdivision of
empirical aesthetics devoted to just that, the application of neuroscientific methods to the study
of our engagement with artworks” (p. 1). Seeley (2011) later states that if we are to understand
how humans are psychologically connected to the exterior world, we must continue to explore
the field of neuroscience.

Huang (2009) further investigates the differences of art and neuroscience, stating that
while art is not commonly known for its scientific merits, both science and art endeavor to gain more knowledge. In fact, several researchers and theorists have made the claim that artists are neuroscientists in their own right (Cavanagh, 2005; Zeki, website). Cavanagh (2005) attributes an artist’s ability to represent the visual world in “simpler, reduced physics” as a neuroscientific process, while Zeki’s claim revolves around an artist’s interest in investigating the capacities of the human brain. According to Nadal and Skov, (2015) the primary goal of the cognitive neuroscience of art is to better understand the biological underpinnings involved in producing works of art. Given that this field is akin to that of neuroaesthetics, it makes sense that biological theories can be found within both areas of study. Current neuroscience research on the aesthetic experience favors evolutionary perspectives on humans’ ability to “integrate observations, identify problems, and seek solutions” (Phenninger & Shubik, 2001, p. 235).

**Neuroaesthetics: Evolutionary and Biological Theory**

Historically, producing art implied a biological function for survival. Art and the evolutionary approaches of aesthetics direct their attention to gaining knowledge about the world (Dietrich, 2004, 2015; Solso, 2003; Zaidel, 2010, 2013, 2015; Zeki, 2001). The brain regions involved in producing art serve various functions related to biology, communication, creativity, and insight (Zaidel, 2009). Biology is related to an artist’s genetic qualities such as skill, creativity, cognitive ability, and physical energy (Zaidel, 2015).

**Evolutionary theory of art.**

Dissanayake’s bottom-up approach to the study of *homo aestheticus* builds a relationship between the ubiquity of art and the primordial need for art in terms of biology. She writes, “art is more than aesthetics and aesthetics is more than art” (Brown & Dissanayake, 2009, p. 43). The meaning of art is understood more intensely than the modernized view of aesthetic features in
that the term aesthetics has bearing in any visual perception, whether or not it is art (Dissanayake, 2015).

Art as an adaptation contributes to survival and reproductive success (Dissanayake, 2015). In pre-modern civilizations, art was primarily used during rituals, which signified important periods or transitions in life. The interaction between mother and infant ritualized the biological evolution of bonds through attention and communication. Here, the perennial stress of survival is alleviated in the connection of attachment. Historically, art was primarily participatory and children learned about their culture through viewing, producing, and engaging with art (Dissanayake, 2015).

From a biological perspective, art is first about an object that is made special through the ingredients of art, including the formal elements, all of which signify the environment to be in and where attention should be directed. According to Dissanayake (2016):

Today, artification may provide the same results to individuals when making/participating; hence, the benefits of arts therapies, such as the treatment of trauma through neurobiologically-informed relational non-verbal communication (Chapman, 2014). Although much contemporary art is often deliberately conceptual, anarchic, and private, its makers, like their Pleistocene predecessors, continue to artify important things and to make ordinary reality extraordinary. (p. 19)

**Biological theory of art and the brain.**

Dr. Eric Kandel, Nobel laureate and expert in neurobiological and behavioral research, also explores the research between science and art (Kandel, 2012, 2016). Bottom-up and top-down processing are basic components of neurological study. When applied in the context of viewing and making art, these processes are intricately involved in perception and experience.
The prediction and regulation of sensory information is modulated in the bottom-up and top-down processes; this modulation acts as a volume control versus a mediating on-off switch (Kandel, 2012).

While the midbrain and hindbrain house neurons of the bottom-up processing, the neurons of the top-down processing are located particularly in the prefrontal cortex (Kandel, 2012). The bottom-up modulatory system, which in part is genetically determined, relies heavily on early stages of the visual system. The bottom-up process includes the influence of the oxytocin-vasopressin modulatory system, which is concerned with social bonding, exchange, and trust. An elementary component of the top-down processing system is ‘reappraisal, which relies, on inferences and comparisons to previous experiences stored in memory’ (Kandel, 2012, p. 422). The top-down modulatory system involves the hippocampal memory storage and medial prefrontal cortex (Kandel, 2012). These simultaneous systems have been understood to impact the viewer of art perception in the social brain (Brothers, 1990).

**Theories of creativity and the brain.**

In *Some Notes on Brain, Imagination and Creativity*, Antonio Damasio (2001) writes, “from an evolutionary perspective, the oldest decision-making device pertains to basic biological regulation; the next, to personal and social realms, and the most recent, to the collection of abstract-symbolic operations under which we can find artistic and scientific reasoning…” (p. 59). Furthermore, individuals interact with the environment to create social and cultural artifacts (Damasio, 2001). Theories of creativity and the brain cannot be reductionistic from the perspective of three levels: a (1) genome and (2) activity-specified level of brain circuitry and (3) changes in the brain as a result of interactions within physical, social, and cultural environments (Damasio, 2001).
Theories of art and the brain.

According to Zaidel (2010), there are three major theories of art related to the brain. Of these three brain theories of art, the first contains the most pertinent information for our study, stating there are specific brain regions that “link art [making] to multiple neural regions” (p. 177); meaning, art is not solely connected with one specific cerebral hemisphere, pathway, or region. Zaidel first explored art’s link to multiple neural regions in an earlier study (2005), which explored physiological responses and the pathways involved in the neuropsychology of art. The most common manner of exploring the connection between brain regions and art making is by researching artistic expressions following damage to specific regions of the brain (Zaidel, 2010). Zaidel’s 2005 study compared both pre- and post-damage output from subjects with previous artistic experience. The findings indicated that a participant’s artistic skill is preserved despite lateral damage or its cause. This suggests that artistic expression is a “multi-process activity...that depends on several brain regions...rather than on a single cerebral hemisphere, region or pathway” (Zaidel, 2010, p. 178), as mentioned previously.

Laws of Neuroaesthetics

Neuroaesthetics is a discipline much like others with laws and principles that contribute to and govern the field. Semir Zeki proposed laws pertaining to the visual system (Zeki & Lamb, 1994) as well as the visual brain (Zeki, 2001) while Vilayanur Ramachandran contributed eight laws of aesthetic experience (Ramachandran & Hirstein, 1999). And while not formally labeled as a law of neuroaesthetics, Erik Myin (2000) proposed two theories of perception and visual art, which assist in distinguishing between the neuroaesthetics of viewing and creating art.

Laws of the visual system.

Kinetic art was reportedly the springboard for research investigating the connections
between brain activity, aesthetic experiences within viewing art, and the physiology of visual perception (Zeki & Lamb, 1994). In order to understand how viewing and creating art affects the brain, we must look for research pertaining to the activation of brain regions given the assigned tasks. Zeki and Lamb (1994) postulated that all artistic expressions must obey what they call “laws of the visual system”; the first law states that visual stimuli from the exterior world does not singularly affect the retina (see Appendix I, Figure I1), the part of the eye that receives images and relays them to the brain. The second law states that visual stimuli are processed in separate sections of the visual cortex prior to being united as one image. In other words, when an exterior stimulus occupies the viewer’s attention, this information is collected by the light sensitive retina and other associated areas of the visual system and is processed by multiple areas of the visual cortex before finally coming together to make one cohesive image in the viewer’s brain.

The separate sections of the visual cortex, mentioned in Zeki’s second law, include five separate visual areas (V1-V5), as seen in Appendix I, Figure I3. V1 operates as the primary visual area, and V5 acts as the principle location for visual motion. The latter is largely unresponsive to static stimuli, meaning that the likelihood that V5 will be activated when presented with stimuli that lacks movement is low. Contrary to earlier studies, Zeki and Lamb (1994) found that when participants were presented with Isia Leviant’s work Enigma, which strategically tricks the eye into perceiving movement from static, geometric imagery, changes occurred in regional cerebral blood flow (rCBF) within the visual cortex and was limited only to V5. These results were compared to an additional condition that observed a similar image that had been altered to diminish the perception of movement within the rings.
Laws of the visual brain.

Semir Zeki (2001) proposed two “supreme” laws of the visual brain: constancy and abstraction. The term constancy refers to staying the same and within the visual brain. Variances occur constantly while processing external visual stimuli, which, as we have learned from the laws of the visual system, do not singularly affect the retina and are processed in parts. Zeki (2001) states that despite the dynamic changes in an object’s distance, illumination, and viewing angle, the human brain is capable of retaining specific characteristics of the visual stimuli for future recognition. One example of this law in action is a person’s facial recognition abilities at various angles other than straight on, an ability previously attributed to the fusiform gyrus (Kanwisher, McDermott, & Chun, 1997). In visual art, an artist may attempt to produce an object based on its essence or core principles as opposed to an exact rendering, which additionally encompasses irrelevant dynamic properties. The second law of the visual brain is abstraction, which plays a crucial role in our efficient knowledge-acquiring system (Zeki, 2001). “Art,” as stated by Zeki (2001), “abstracts and externalizes the inner workings of the brain” (p. 52).

Eight laws of aesthetic experience.

Neuroaesthetic pioneer and theorist Ramachandran (1999) and his colleague Hirstein proposed the eight laws of the aesthetic experience in their text *The Science of Art: A Neurobiological Theory of Aesthetic Experience*. Ramachandran and Hirstein (1999) theorized that these eight laws aid our understanding of design, visual art, and aesthetics. The laws are (1) grouping, (2) peak shift experience, (3) isolation, (4) contrast, (5) symmetry, (6) generic viewpoint, (7), perceptual problem-solving and (8) visual metaphor. These laws are meant to convey a set of universal principles, a common denominator of art, which can be applied across cultures. The principles, or laws, of their essay suggest heuristics that artists either consciously or
unconsciously create art to excite the visual areas of the brain (Ramachandran & Hirstein, 1999). Three foundations of this suggestion support their position of essentials in art: (1) internal logic in the phenomenon of art, (2) evolutionary rationale, a question of why arts particular form, and (3) neurophysiology, concerning activated brain circuitry. In an attempt to render the laws through one visual expression, an image titled *Still Walk* has been included for reference and delineation (see Appendix J, Figure J1). These principles offer logical, biological, and neurophysiological foundations for considering aesthetics. Influential British, scientist and novelist, C. P. Snow (1959) talked about two severed cultures of the sciences and humanities, which until merged could not solve the intellectual problems of the western world. Ramachandran and Hirstein (1999) propose that in the interface of the brain, and perhaps through art these two cultures do meet. Neuroaesthetics, a science of art, offers progressive integration, especially when implemented through the clinical field of art therapy.

**Visual sciences.**

In his article “Two Sciences of Perception and Visual Art,” Myin (2000) explores two kinds of *vision science*, representational and nonrepresentational. According to Myin, it is assumed that the human brain uses a certain “code” while creating these representations. The role of the brain is compared to the artist during the creation of visual representations of physical objects (Myin, 2000):

Given that both the brain and the artist are in the same business of representation, perhaps the overt representing of the artist is highly constrained by how the brain represents the visual world internally. Art could be classified in respect to how successful it is in manipulating the brain’s representational schemes. The artist can then be portrayed as a kind of experimental psychologist who probes the visual system with pictures (p. 45).
As previously stated, Cavanagh (2005) and Zeki (website) have made the claim that artists are neuroscientists in their own right. Here, Myin attributes the artist’s ability to portray and alter reality as a kind of experimental psychologist.

The latter in this dichotomy, Myin’s nonrepresentational alternative, states that invariants replace the mind’s representations. It is not uncommon for the term nonrepresentational to be associated with abstract art, but within this context, vision utilizes the surrounding environment to create a nonrepresentational image as opposed to using only what lies internally (Myin, 2000). According to Myin, and given what we know about this nonrepresentational alternative, the materials which an artist uses may take part in the artistic production itself, regardless of where the artistic process falls within this dichotomy.

**Neuroaesthetics of Viewing Art**

Within the spectrum of neuroaesthetic research, both viewing art and creating art may be found, both of which are of interest to our present study. Research regarding the neuroaesthetics of viewing art encompasses both aesthetic appeal and artistic preference, exploring their impact on the human brain.

**Brain regions involved: Activation, art, & preference.**

Primarily, neuroimaging studies explore brain activation while viewing art as opposed to creating it (Zaidel, 2010). Several studies explore artistic preference and aesthetic appeal (Kawabata & Zeki, 2004; Nadal et al., 2008; Vartanian & Goel, 2004). Neurologist Vartanian and Cognitive Neuroscientist Goel (2004) discovered through their investigation of abstract and representational images that the right caudate nucleus, bilateral occipital, and fusiform gyri, as well as the left cingulate sulcus, all showed an increase in activation when a participant showed aesthetic preference for an image. All of these brain regions play a part in “evaluating reward-
based stimuli that vary in emotional valence” (Vartanian & Goel, 2004, p. 897).

In Zaidel’s (2010) review of previous literature, which relates to the link between art and brain localization in theories of art and the brain, a study viewing “beautiful” and “ugly” paintings was cited (Kawabata & Zeki, 2004). This study found that the brain regions involved in such comparisons appeared within both the motor cortex and the orbitofrontal cortex. When showing an aesthetic preference for art, it makes logical sense that the orbitofrontal cortex is involved due to its role in the cognitive processing of decision-making (Fuster, 1997).

**Motor cortex and viewing art.**

Ramachandran (2000) makes a link between mirror neurons and what he calls *motor command neurons* based on Rizzolatti’s (1999) research with monkeys. Oberman et al. (2005) found that these motor command neurons were activated in the premotor cortex during observed actions. Based on neuroanatomy research (Vanderah & Gould, 2016), the premotor cortex sends signals to the spinal column, which implies that the premotor cortex is, in part, responsible for the planning and/or execution of an individual’s actions. McGregor and Gribble (2015) state that the mirror neuron system (see Appendix G, Figure G1) is “part of a broader action observation network (AON) including supplementary motor area (SMA), premotor, primary motor (M1) and primary somatosensory (S1) cortices, superior parietal lobule (SPL), and middle temporal visual area (V5/MT)” (p. 677).

A study completed by Keysers and Gazzola (2009) concluded that mirror neurons do not solely exist in the premotor cortex, but can be found in at least five brain regions (see Appendix G, Figure G1) including the inferior parietal lobe, the temporal lobe, the ventral and dorsal premotor cortex, and the supplementary motor cortex. The parietal and temporal lobes have been found to activate during sensory input processing (Radua et al., 2010; Smith & Kosslyn, 2007).
Several studies have found that an observer of art can both physically and emotionally be stimulated through viewing art (Freedberg & Gallese, 2007; Umilta et al., 2012). Freedberg and Gallese (2007) studied physical, or body empathy, experienced by viewers, which can be defined as a parallel physiological response located in the parts of the body experiencing the sensation in both the subject and the observer.

Umilta et al. (2012) elaborated on Freedberg and Gallese’s findings, the aim of investigation was to explore the motor system’s role in the viewing of art. In their study, high-density electroencephalography (EEG) was utilized to measure the level of intensity of mu rhythm suppression within the motor cortex of fourteen healthy volunteers (Umilta et al., 2012). Images were displayed via monitors of both original artworks and digital graphic renderings of the originals, creating a collection of six images that were randomly presented fifteen times each.

After the EEG recordings were taken, the participants were asked to score each of the six images on (1) familiarity, (2) aesthetics, (3) amount of movement present, and (4) whether or not the image was “real” (Umilta et al., 2012). The findings showed that in comparison to the digital renderings of the static works of art, viewing cuts in a canvas incited higher scores for both aesthetic appraisal and the level of perceived movement, making it the first study to collect evidence of cortical motor systems involved in the observation of static images without the representation of explicit movement as subject matter (Umilta et al., 2012). This motor activation, as measured by EEG, during the observation of static art is a strong indication of motor cortex involvement in the perception of visual art.

Carr (2014) further elaborated on the function of mirror neurons in the observation of pain, whether in reality or by subject of a portrait. She found that, in both instances, the neural networks of the viewer were activated as if they were personally experiencing the pain they
witnessed. These findings were collected from a single-subject case study of a 49-year-old male diagnosed with Chronic Obstructive Pulmonary Disease (COPD), a progressive lung disease. The case study investigated four portraits, which were co-designed and painted by the researcher for the patient, Paul. Carr painted these portraits following the participant’s response to a stimulus artwork, *Broken Column* by Frida Kahlo. The participant reported that he chose the work created by the Latina Surrealist due to his level of empathetic understanding, stating, “you know what she’s going through” (p. 61).

An understanding of how an individual perceives a work of art includes both somatic responses within the body (Carr, 2014) as well as motor cortex activation in the brain (Freedberg & Gallese, 2007; Umilta et al., 2012), both of which have been attributed to mirror neurons. According to Hass-Cohen and Findlay (2015), “fine motor and perceived movement have traditionally been expressive components of art therapy,” suggesting that there are “cognitive and emotional advantages to incorporating motion into the interpersonal space and to exploring images of actual and implied action” (p. 10). The authors write that mirror neuron functions can be used therapeutically to strengthen the link between cognition and emotion (Hass-Cohen & Findlay, 2015).

**Neuroaesthetics of Creating Art**

Our present study focuses on the production of art in a directive approach, in order to differentiate how the brain functions during art making compared to simply moving. A directive art making method allows for reduced variability between subjects. This area of the neuroaesthetics spectrum explores theoretical approaches of creativity, and research regarding art production with implications for clinical art therapy practice and the brain regions associated with work on the Expressive Therapies Continuum (ETC), seen in Appendix K, Figure K1.
Direction of neuroaesthetics research.

As reviewed earlier, the field of neuroaesthetics has developed its characterization as “a cognitive neuroscience of aesthetics” (Pearce et al., 2016, p. 265), which includes studies of individuals, sensory stimuli, and context. Along with colleagues, Anjan Chatterjee (2010) developed the Assessment of Art Attributes (AAA), in order to equip researchers with instrumentation to assess art attributes in a computational and quantitative measure. As an initial instrument design the AAA provides potential solutions of quantification. Progress in the field of neuroaesthetics to understand the impact of creativity on individuals and communities will take place with multimodal investigations, including art production. The needed and interesting anecdotal observations (Chatterjee et al., 2010, p. 256) of neuroaesthetics research are in excess. However, quantifiable, computational modes of inquiry are limited and needed, further elaborating that “neurophysiological investigations of art production and perceptions have the potential to offer critical insight into the biology of art” (Chatterjee et al., 2010, p. 256). Research focused on how physiological and psychological aspects of aesthetic experience relate to one another while support needed therapeutic implications, such as clinical art therapy.

Neuroaesthetics research.

According to Chatterjee (2015), there is not a specific art center of the brain to study the effect of art making. Contrary to popular belief, individuals who are categorized as creative do not solely rely on the right hemisphere of the brain. “The production of art is highly complex with different components mediated by different parts of the brain” (p. 343), with the resulting artwork operating as a cogent collaboration of these different components (Chatterjee, 2015).

Ferber et al. (2007) identified brain regions associated through fMRI, using a modified drawing tablet as the control for movement tasks to copy and draw from memory. This study
which included twelve healthy volunteers, found that the drawing task could activate the anterior cingulate, described by Ferber et al. (2007) as “an area associated with motor control and linking intention with action” (p. 1089). The drawing from memory task also evoked stimulus in the medial frontal gyrus. The anterior cingulate is where motor control, drive, and cognition interface due to proximity with the motor and prefrontal cortex and parietal areas, “pointing to its role in conflict monitoring, and linking intention with action” (Paus, 2001, p. 417). Drawing requires the access of memory and sustained attention as the external stimuli is retrieved and internal modulating assesses whether the production is congruent with the original intention. Visual processing and crossmodal attention were required during the copying task.

Likova (2012) wrote that the creation of art, specific to drawing, involves, "an amazing process that requires precise orchestration of multiple brain mechanisms, perceptual processing, memory, precise motor planning and motor control, spatial transformations, emotions, and other diverse cognitive functions” (p. 1). The totality of brain processes that art production elicits connects the relationship of creativity and survival. Likova (2012) details this process by saying, “drawing, and in particular memory-guided drawing, challenges the encoding of detailed spatial representations, their retrieval from memory and ‘projection’ back into a mental high resolution ‘screen,’ so as to guide the motion of the drawing hand with the requisite precision” (p. 1). Likova (2012), using fMRI measurement, investigated how the brain of a congenitally blind individual was activated during drawing. The subject was analyzed during pre- and post-training drawing exercises. Training included a drawing from tactile memory, with the use of a cognitive-kinesthetic approach and a raised-line drawing model, which was explored with the left hand before drawing them from memory with the right. This is one of the few studies to investigate the involvement of the primary visual cortex (V1) in non-visual memory. With detailed results of
topographical brain mapping, V1 has been shown to operate as a “visual-spatial buffer, or ‘sketchpad,’ for working memory” (Likova, 2012, p. 1). The cognitive-kinesthetic, tactile-memory task may be used to explore plasticity rehabilitation of individuals with blindness.

Bolwerk, Mack-Andrick, Dörfler, and Maihöfner Bolwerk (2014) completed the first study linking the neural effects of visual art production with psychological resilience in adulthood. Fourteen adult participants 65 years and older were divided into two groups for 10-week-long art interventions, one visual art production group, created art in an art class and one cognitive art evaluation group, viewed art at a museum. The neural effects of each group were measured before and after each week of participation by fMRI to investigate the brain’s default mode network (DMN). Analysis of the DMN was identified through a seed voxel correlation analysis (SCA) in the posterior cingulate cortex. The German equivalent of the Resilience Scale (RS-11) was used to relate the covariance of fMRI results and psychological resilience. Results for the visual art production group versus the cognitive art evaluation group showed a greater spatial increase in functional connectivity of the posterior cingulate cortex to the frontal and parietal cortices. In the study, significance to psychological resilience was related to the visual art production group, indicating a stabilizing effect of art production and well-being, especially in older adults.

**Creativity and the Brain Research**

According to Dietrich (2004), the study of how creativity happens in the brain encourages new insights through study. Notions of creativity include the mad artist, right hemisphere predominance, and divergent thinking. In view of advanced neuroimaging technology and the evolution of creativity, an organized mode of creativity and the brain emerged. Dietrich (2004) explores creativity in his text *The Cognitive Neuroscience of Creativity*: 
Concisely stated, creativity results from the factorial combination of four kinds of mechanisms. Neural computation that generates novelty can occur during two modes of thought (deliberate and spontaneous) and for two types of information (emotional and cognitive). Regardless of how novelty is generated initially, circuits in the prefrontal cortex perform the computation that transforms the novelty into creative behavior. To that end, prefrontal circuits are involved in making novelty fully conscious, evaluating its appropriateness, and ultimately implementing its creative expression. (p. 1023)

Professor of Cognitive Neuroscience Arne Dietrich and Riam Kanso (2010) argue that there are subdomains of creativity and three are presented, that researchers use to study creativity. In whole review, the categories present a variety of data and fragmented notion of creativity that cannot be generalized, which further supports the notion of types of creativity and their various neural mechanisms (Dietrich and Kanso, 2010). In their meta-analysis, Dietrich and Kanso (2010) reported that in 1950 Joy Paul Guilford proposed that divergent thinking would assist in the study of creativity, which is under much scrutiny and criticism as a legitimate method of study for human creativity. Divergent thinking, as defined by Guilford (1967), is the “ability to generate multiple solutions to an open-ended problem” (Dietrich & Kanso, 2010, p. 822). The second category is artistic creativity and includes: (1) free drawing and/or composing music, (2) imaging the creative act of painting, and (3) creating abstract drawings. The third category, insight, can be argued to be a “right[ful] subfield of creativity because the first step toward a finished creative product is...a creative insight” (Dietrich & Kanso, 2010, p. 823). Comparing neuroimaging studies of divergent thinking and artistic creativity, some studies have found that there are additional brain structures, like the motor areas, which were not found in divergent thinking studies.
Art Therapy and the Brain Research

Lusebrink (1990) understood the support of brain research on contemplating art production and stated that visual expression is processed on different levels of complexity. In a later text (2004) Lusebrink wrote, “an expression through art media can also originate from complex cognitive activity involving decisions and internal imagery, thus activating the sensory channels and motor activity” (p. 125). The brain makes use of visual, somatosensory, and motor information processing, with conjunction to areas of emotional and memory processes (Lusebrink, 2004).

The expressive therapies continuum (ETC) was developed as a model of creative functioning through human development and information processing (Lusebrink, 1990). The vertical spine of creativity is balanced through hierarchical planes of the sensory-kinesthetic level, perceptual-affective level, and cognitive-symbolic level. During art production, an individual’s choice in media corresponds with levels of the ETC and reflects brain functions of the temporal, orbital, parietal, and frontal lobes (Hinz, 2009). This three-tier hierarchical structure provides for the variety of component functions involved in visual expression and suggests a commanding functional level.

Vertical and horizontal movement on the ETC reflect levels of hierarchical brain processing. Multiple functions may be involved in visual expression, but usually there is a particular component that predominate (Lusebrink & Hinz, 2016). On a therapeutic level, recognizing a client’s component preference can “reflect strengths in visual expression and which reflect respective deficits” (Lusebrink & Hinz, 2016, p. 49). The particular level of strength and/or deficit in component functioning “mirror[s] preferences in the reception, processing, integration, and expression of information, emotion, and action in other aspects of
Direction of art therapy research: Art making and neuroimaging.

Belkofer and Konopka’s (2008) study is a modified, single-subject design that used electroencephalograph (EEG) data to explore the human brain after one hour of art making. The primary author of this study, Belkofer, acted as the single subject (N = 1). In order to study the effects of art making on the brain, two 22-minute EEG readings were taken; the first acted as a baseline measure, and the second was taken immediately following the art making process. This study was without direction for the participant’s art making. Following the first EEG reading, the single participant was asked to make art for one hour and was given materials that are commonly found in art therapy settings including (1) charcoal sticks, (2) graphite pencils, (3) a pad of 11” x 8.5” white paper, (4) watercolor paints, and (5) watercolor brushes (Belkofer & Konopka, 2008).

The participant created two images, one using drawing materials and the other using watercolors. EEG recordings were taken pre- and post-art making, and the researchers choose to leave the electrodes attached in order to quickly obtain post results. However, the researchers reported that the movement from one space to another may have influenced the recordings, stating that “the simple shift from sitting still to movement may have caused changes in brain chemistry that lingered after returning to the booth for the second reading” (Belkofer & Konopka, 2008, p. 60). They found that in comparing pre-and post-data, higher frequency bands, like alpha and beta waves, were present after drawing and painting (Belkofer & Konopka, 2008).

The results of this study show that activation occurred predominantly within the occipital, parietal, and temporal lobes (Belkofer & Konopka, 2008). And while alpha and beta waves showed marked increases, delta and theta brainwaves decreased in the same brain regions. Parietal and occipital lobe activation is an indication that the participant has “increased visual
processing demands” (p. 61). In terms of the increased activity within the temporal lobe, it is believed that this is where spiritual and emotional connections can be made (Belkofer and Konopka, 2008).

Belkofer and Konopka (2008) reference Rubin (2001) in regard to how art therapy treatment modalities explore a client’s spirituality in order to achieve self-awareness. Rubin’s study provides the framework for future research incorporating art therapy, perhaps following this study’s method in assessing a participant before and after an art therapy intervention (Belkofer & Konopka, 2008). “Artistic experience, the length of treatment, the size and choice of media, and the willingness to actively engage with images are just a few of many variables that could help determine certain neurobiological processes…” (Belkofer & Konopka, 2008, p. 62).

In a recent study that explored residual effects of a drawing activity in brain activity in a small sample, Belkofer, Van Hecke, and Konopka (2014) stated that their non-directive art approach may have been too general and suggested the use of a less open-ended art task. Choosing a directive, which reduces the spontaneous artistic response, is an approach that may reduce variability within a group’s body of artwork. This particular study was completed as a pre/post within-group study, this time utilizing quantitative electroencephalogram (qEEG) to measure the effects of 20 minutes of art making on the brain. The sample increased (N = 10) with six participants being artists and the remaining four lacking previous artistic skill.

Unlike in the first study, participants were given more direction, “...for the next 20 minutes, use the materials to create an image. Your image can be representational (people, places, or things), abstract (shapes and lines), or both” (Belkofer, Van Hecke, & Konopka, 2014, p. 63). Each participant received one piece of 14” x 17” paper and a set of 16 oil pastels. Results of the study indicated changes in the frontal areas of their non-artist participants, which they
attributed to the unfamiliar tasks. By comparing these two groups, researchers also found an increase in alpha frequency may play an important role in drawing (Belkofer, Konopka, & Van Hecke, 2014). However, unlike the previous study, the results showed activity in the spatial/visual regions of the cortex.

A study using qEEG, by Kruk, Aravich, Deaver, and deBeus (2014) compared the brain activity during drawing and clay sculpting in fourteen female participants between the ages of 22 and 25. At the time of its completion, “...there [were] few randomized controlled studies of the effects of art making and the neurobiological substrate of different art-making processing streams” (Kruk et al., 2014, p. 53). Participants completed a pre- and post-measure of state versus trait anxiety using the State-Trait Anxiety Inventory, STA1 Form Y1. Nineteen EEG electrode sites were placed on the left and right medial frontal lobes as well as the left and right medial parietal lobes. Control readings required the participants to open and close their eyes and crumple tissue paper; readings were taken before and after five minutes of freely sculpting with clay and five minutes of drawing.

Choosing two different tasks allowed for more specific investigation into how certain tasks, e.g. drawing and sculpting with clay, affect the brain. The first task, clay making, was nondirective, instructing participants to “make something out of the clay. It doesn’t have to be ‘some thing’ It can be abstract” (p. 54). For the drawing task, participants were asked: “make a picture of your favorite weather for 5 minutes” (p. 54). Results indicated the right medial parietal lobe increased in gamma power activation with the drawing and clay conditions. In comparison, the right medial frontal lobe showed a decrease in gamma power and an increase in theta power during the clay condition. One suggestion made for future inquiry is that manipulating tissues as a control may not be an adequate condition. For the drawing task, materials included felt-tipped
markers and 9” x 12” gray drawing paper. Kruk, Aravich, Deaver, and deBeus hypothesized that by including a drawing task in addition to a nondirective clay making task, the directive would evoke a perceptual reaction and cognitive response (Kruk et al., 2014). Results indicated that using a directive during the drawing task affected the frontoparietal network differently when compared to the non-directive art making using clay. The researchers stated that “drawing on paper in response to a directive likely would elicit a cognitive reaction and possibly a perceptual response” (Kruk et al., 2014, p. 54).

**Neuroimaging**

Creativity and the neural mechanisms involved in its process are not well known (Dietrich & Kanso, 2010). American Psychological Association published a meta-analysis (Dietrich & Kanso, 2010) comparing 72 experiments that explore insight, creativity in art, and divergent thinking. The method of data collection within these experiments include electroencephalogram (EEG), event-related potential (ERP), and other neuroimaging techniques such as functional magnetic resonance imaging (fMRI), near-infrared imaging (NIRS), positron emission tomography (PET), single-photon emission computerized tomography (SPECT), and magnetic resonance imaging (MRI). According to Zaidel (2010), neuroimaging techniques have been repeatedly used to uncover more about the “nature of art from the viewer’s perspective” (p. 179). And while neuroimaging technologies have been used for the neuroaesthetics of viewing art, the challenge of exploring the physical brain of an artist during the artistic process remains. Utilizing the electroencephalogram (EEG), we explored the differences in cortical function between art making and rote fine motor tasks.

**EEG justification.**

EEG was not widely used as a method of interpreting the brain’s involvement in
creativity until the late 1990s (Dietrich & Kanso, 2010). Electroencephalography is a noninvasive measurement of electrical patterns at the surface of the scalp that reflects brain activity, commonly referred to as brainwaves. According to Dietrich and Kanso (2010):

EEG data are reported in frequency ranges. At the low end of the scale is delta activity, which is a regular, low-amplitude wave of 1–5 Hz. This frequency band reflects a low neuronal firing rate and is mostly associated with deep sleep. Theta activity is a medium-amplitude, medium-frequency rhythm of 5–8 Hz. A person exhibiting this rhythm reports feeling drowsy. Alpha activity is a fairly regular pattern between 8 and 12 Hz. The alpha band is prominent when a person is minimally aroused—awake but relaxed. Beta activity, which is an irregular pattern between 12 and 30 Hz, occurs mostly during alertness and active thinking. Finally, there is the gamma rhythm, which represents oscillations around the 40 Hz mark that are associated with the binding of perceptual information. (p. 824)

Understanding how brain waves interact will illustrate the strength of their relationship. A stronger excitatory and inhibitory postsynaptic potentials, convergence of brainwave connections relates to a more efficient synchrony transfer of information and sensory binding (Dietrich, 2010). The use of quantitative electroencephalogram (qEEG), or brain mapping, provides an analysis of the EEG measurement. By using qEEG, we can map brain activation, which will be important to provide a clear visual of neural mechanisms. Researchers Bhattacharya and Petsche (2005) found that EEG was more appropriate than other neuroimaging procedures for measuring higher brain functioning, stating that “...modern imaging studies using functional magnetic resonance imaging (fMRI) or positron emission tomography (PET) are extremely popular and useful in the localization of brain functions...they are not ideal to detect the functional cooperation between distant cortical regions” (2005, p. 2).
Other neuroimaging techniques, such as MRI, have been used to measure brain activity as a portrait artist created art (Solso, 2000). Like the EEG, MRI technology also uses noninvasive means to evaluate soft tissue in the human body by taking pictures of the head. Computed tomography (CT) scans, X-ray, and ultrasounds are also used in medical imagery, but do not provide as much information as MRI. Limitations of using MRI include limited space during the scan and the subject’s head must be held tightly for the machine to obtain a readable impression.

Radiation exposure is one disadvantage to PET scans, also known as positron emission tomography. In addition, the temporal resolution (TR) or measurement precision with reference to time is limited by its recording speed. Similarly, fMRI and fNIRS are also limited by TR. PET neuroimaging works by identifying blood flow in the brain. It can also be used in cardiology, oncology, musculo-skeletal imaging, and the study of infectious diseases (Carlson, 2012). Even with its multi-use appeal, clinical and research PETs are difficult to maintain. The cost of a PET scan is also a distinct disadvantage when coupled with maintenance issues.

PET scans are not the only costly method of neuroimaging; fMRIs and MEGs are also on this list. In contrast, research that incorporates EEG and ERP technologies is less expensive to maintain. Functional magnetic resonance imaging (fMRI) measures blood flow, much like PET scans. Brain activity and cerebral blood flow (CBF) are interconnected (Logothetis et al., 2001), allowing brain activity to be detected by measuring CBF. Therefore, when a participant is completing a task and a particular lobe, pathway, or cortex is activated, more blood will flow to the area in use. Disadvantages and associated risks with an fMRI scan are nerve tingling, high-pitched noises, and claustrophobia (Huettel, Song, & McCarthy, 2009). Given the space limitations of fMRI, MRI, PET, and SPECT scanners, other neuroimaging techniques, such as
EEG, are more appropriate to study cortical activation during art making and rote motor tasks.

Near infrared spectroscopy (NIRS) also utilizes cerebral blood flow to localize brain activation sites. Specifically, NIRS technology absorbs and transmits NIR light into the human body in order to assess changes in an individual’s hemoglobin concentration (Zeller, 2013). NIRS can both assess amount of activity and specific location within the brain due to the individual’s hemoglobin levels. This process is noninvasive and more portable than other neuroimaging technologies such as fMRI. NIRS technology is available in a wireless format, making it more usable during participant tasks, but it is limited to scanning cortical tissue and cannot accurately assess activation throughout the entire human brain.

Event-related potential (ERP) is largely used in the evaluation of cognitive diseases and, as the name suggests, explores the effect of an event-related stimuli, such as motor, sensory, and/or cognitive stimuli, on the brain. When a subject is presented with a particular event the ERP or event-related potential scan shows the activity, which then allows technicians to understand how the information is processed in the brain. One of the major advantages of this form of neuroimaging is that it is done in real time. Like other neuroimaging technologies, ERP has its disadvantages. While ERPs have very good temporal resolution, they also have unsatisfactory spatial resolution (Luck, 2012); because of this, ERPs are less appropriate for research interested in identifying location of specific brain activity and more appropriate for studying neural activation speed.

Motor imagery.

Of our two motor tasks--flipping a coin and rotating a pencil--the latter required some forethought as it likely was an unfamiliar task. Mental visualization will assist subjects as they attempt to approach these movement tasks. One study (Glevins, Smith, McEvoy, & Yu, 1997)
found increases in theta brainwaves as the difficulty level of a cognitive task elevated, eliciting increased attention and need for practice. The same study also found that “decreases in alpha...indicates that this signal is inversely related to the amount of cortical resources allocated to task performance” (p. 374). Much has been done to explore cortical activation via EEG following motor imagery tasks (Decety, 1996; Neuper, Scherer, Reiner, & Pfurtscheller, 2005; Pfurtscheller, Brunner, Schlögl, & Lopes de Silva, 2006; Posner & Presti, 1987; Requin, 1991), with findings suggesting participation from the frontal lobe, prefrontal lobe, and mu desynchronization.

Motor imagery is a process whereby individuals visualize and rehearse a particular action, which can be felt by the practitioner (Decety, 1996). In his article *Do Imagined and Executed Actions Share the Same Neural Substrate?*, neuroscientist Jean Decety found that motor imagery and motor control share the same neural mechanisms via (1) regional cerebral blood flow (rCBF), (2) mental chronometry, and (3) autonomic responses. Results indicated that the frontal cortex plays a major role in both motor imagery and execution, while dorsolateral frontal and prefrontal cortices are responsible for the brain’s ability to time an action (Decety, 1996; Posner & Presti, 1987; Requin, 1991). Further support for prefrontal cortex activation comes from Duncan’s (1986) study, which found that damage to this section of the human brain impacts the individual’s behavior control and executive functions. Neuper, Scherer, Reiner, and Pfurtscheller (2005) found similar results, stating that “motor imagery of motor actions can produce replicable EEG patterns over primary sensory and motor areas” (p. 668) with fourteen normal subjects. Participants were asked to perform four tasks: (1) motor execution (ME), squeezing a ball; (2) imagery of hand movement (MIK), imagining the kinesthetic act of squeezing a ball; (3) observation of hand movement (OOM), watching someone squeeze a ball;
and (4) imagery of hand movement (MIV), visualizing the movements that go into squeezing a ball (Neuper et al., 2005). This study is different in that it examined two aspects of motor imagery, visual-motor representation, i.e. a mental video of the required movements, and kinesthetic representations, i.e. how the overt motor output would feel, both showing notable changes in the EEG recording.

One year later a follow-up study (Pfurtscheller et al., 2006) explored mu rhythms through EEG as nine participants imagined right and left hand, tongue, and foot movements. This was done with 60 EEG electrodes, resulting in desynchronization in mu rhythm during the motor imagery of hand movements (Pfurtscheller et al., 2006). To reduce artifacts and truly measure motor imagery, subjects were asked to keep still and relaxed as they watched the visual stimuli on a screen. After presented with the image, each participant was asked to imagine the motor execution (ME) involved in moving those body parts. What Pfurtscheller found was event-related desynchronization (ERD) as well as event-related synchronization (ERS) when participants imagined such movement tasks (Pfurtscheller et al., 2006).

In review of the neuroaesthetics and art therapy literature it is clear that discussing, viewing and creating art from a neuroscientific perspective is natural because humans and therefore the brain make art. While qualitative research is crucial to the context of an understanding of how art is responsible for physiological and psychological changes in the body, it is also part of a larger system of research. Neuroimaging holds a promising potential to be a beneficial tool in providing quantitative research to contribute numerical, and objective data collection. The collective of such research methods may join the fields of science and art in partnership of the humanities, to support one another.
CHAPTER III
METHODOLOGY

Art Making Task

Diagnostic drawing series.

Our study’s art task was taken from Barry Cohen’s (1988) Diagnostic Drawing Series (DDS), which originally was designed to assess a participant with three directives. According to its creator, the DDS is the most extensively researched art therapy assessment, providing researchers and clinicians with a valid and reliable directive task. The materials used throughout the three drawings are 18” x 24” white paper and a 12-pack of Alphacolor or Blick pastels. Pastels offer ease of application, sophistication over crayons, and versatility in use (Cohen, 1985). And while previous studies included the use of grey paper, the DDS requires white drawing paper which works as a “bright surface” (Cohen, 1985, p. 1) behind the colored pastel and is durable, while the size avoids constricting boundaries, encouraging large movements. The paper may be turned in any direction, allowing room for personal preference and accessibility.

First, the individual is asked to “make a picture using these materials” (Cohen, 1985, p. 12). This spontaneous task can evoke a spectrum of affective responses from the individual, ranging from bad to good (Cohen, Hammer, & Singer, 1988). For the second drawing, participants are asked to “draw a picture of a tree” (Cohen, 1985, p. 13). The tree stimulus was chosen because it is a common image in daily life and is seen in most early childhood drawings. In terms of structural level, the drawings move from least structured to most structured, ending with a subjective task that also allows for self-reflection and assertion (Cohen, Hammer, & Singer, 1988). This third task, applied to our present study, asks participants to “make a picture of how you’re feeling, using lines, shapes, and colors” (Cohen, 1985, p. 13).
In a therapeutic setting, the resulting artwork would be used to explore the client’s inner experience, stating that “the person best placed to understand the experience of the patient is the patient” (Cohen, Hammer, & Singer, 1988, p. 13). Given that this drawing series has been evaluated for its reliability and validity as an art therapy assessment (Mills, Cohen, & Meneses, 1993), our study utilized the same materials and administration technique, which encourages a largely nonverbal exchange during the art making task. The DDS’s reliability and validity does not apply in our study as the DDS is not being administered to subjects in standardized form. Our study excluded the DDS in three parts and only allow for the third directive to “make a picture of how you’re feeling, using lines, shapes, and colors within the circle.” This choice to use one of the three tasks in the DDS relates to the amount of time available with each participant.

The time allotted each participant to complete this task was 12 minutes, similar to the DDS’s allotted 15 minutes per task. Participants were provided with a 12-count pack of color pastels and a 18 x 24 sheet of white paper with a pre-drawn mandala. The drawing paper that participants received only included the pre-drawn mandala/circle boundary without any guidelines inside or outside the mandala/circle. This choice was made to potentially enhance the creative space. Providing the mandala, which is a circle that represents unity and symbolizes containment, will likely increase the participant’s focus and attention according to Michele Roush’s (2013) dissertation which investigated how mandalas help those with severe mental illness. Among her many successful post-intervention findings, one was “increased focused attention” (Roush, 2013, p.296). In Susanne Fincher’s Creating Mandala’s for Insight, Healing and Self-Expression, mandalas are described as producing an “inner order” (p. 18). Fincher describes the ancient and cross-cultural impact of mandalas and how they “have traditionally served as instruments of meditation to intensify one’s concentration on the inner self in order to
achieve meaningful experiences” (p.18).

The intent of including a pre-drawn mandala is to provide structure, boundaries, and containment, increase attention, improve mood, and reduce anxiety. Brown and Robbins (1996) showed that children with ADHD and ADD who worked with mandalas improved their focus. Curry and Kasser (2005) showed mandalas can alleviate anxiety, which is especially relevant to the current study as Belkofer and Konopka (2014) suggested EEG procedures might be anxiety provoking. Babouchkina and Robbins (2015) completed a randomized study providing subject groups work with mandalas and squares using a similar directive of, draw how you feel. The group using mandalas had elevated mood responses versus the group who used squares. It was said the unity of the circular shape proved to be an “active ingredient” (Babouchkina & Robbins, 2015, p. 34).

The DDS was designed for adolescents and adults in clinical settings in order to collect information on a patient's behavioral and affective states and their cognitive capacity (Brooke, 2004). The overall purpose was to connect the analysis of artwork to a Diagnostic and Statistical Manual of Mental Disorders (DSM) diagnosis and assess client’s responses to various levels of structure throughout the tasks. The third task chosen for our study was originally intended to promote abstract thinking and to explore a client’s ability to access and represent their affective state in a work of art (Brooke, 2004). By choosing this directive task results may be be more standardized across our sample size (N = 10) in contrast to a more open-ended or nondirective approach to art making.

In a formal DDS assessment, the client would complete a Drawing Inquiry Form, with 4-6 questions per task including “how would you describe this picture?” and “what do these images represent for you?” (Cohen, 1985, p. 9), and later rated using the Diagnostic Drawing
Series Drawing Analysis Form II (DAF2) (Cohen, 1985/2012). Given that the present study did not include a formal DDS administration and did not result in further art therapy sessions, this inquiry form and rating guide was omitted from the data collection process.

**Motor Tasks**

Given that our motor task control took place for 12 minutes, it was important to insure that participants do not lose interest in the task, which could result in a decline in brain activity. In order to maintain attention and engagement throughout the movement condition, two tasks were used for 6 minutes each. This approach allowed data to be collected with the same interval markers as the 12-minute drawing task previously mentioned. Participants began by flipping a coin for 6 minutes. Next, they were asked to rotate a pencil for 6 minutes between fingers. These fine motor movement tasks require attention for successful completion. It is hypothesized that, participants are accessing the primary motor cortex to plan how to best accomplish the movements.

**Movement conditions.**

As mentioned previously, Kruk et al. (2014) utilized a movement condition as a control, but later criticized the choice for being inadequate in comparison to the two art-making tasks, specifically its difference in clay making. The movement control condition required subjects to crumple a facial tissue in their hand for three minutes. This particular movement was chosen to simulate the movements enacted during the clay making task, minus the intention of creating art. Crumpling tissues was designed as a condition in order to control for general movements over more specific movements like eye and head movements (Kruk et al., 2014).

**Coin rotation task.**

The coin rotation task (CRT) requires individuals to utilize rapid, coordinated fine motor
movements as they rotate a nickel 180 degree using the thumb, index finger, and middle finger (Mendoza, Apostolos, Humphreys, Hanna-Pladdy, & O'Bryant, 2009). The coin rotation task (CRT) is effective at measuring psychomotor processing speed and proves to be cost effective in comparison with similar task measurements (Mendoza et al., 2009). The grooved pegboard test (GPT) is also a standard criterion measure of psychomotor processing speed, but includes bulky, expensive, and complicated handling. The CRT is a standard research instrument of psychomotor processing, which has influenced our choice in motor tasks for being valid, convenient, and inexpensive.

The procedure for the CRT involves participants rotating a coin through continuous 180-degree turns with the use of their thumb, index, and middle fingers. According to Halstead (1947), the ability of upper body mobility and dexterity function proves to be instrumental in understanding the brain’s processing, which can also be seen in flipping a coin. As a test of neurophysiological integrity and brain function, the use of the CRT may be assessed with a patient in a matter of ten seconds. In clinical diagnosis, the CRT has been researched for dexterity measurement in relation to limb kinetic apraxia (LKA) with various populations including people with neurodegenerative disorders (Gebhardt, Vanbellingen, Baronti, Kersten, & Bohlhalter, 2008; Quencer et al., 2007; Vanbellingen et al., 2011). Foki et al. (2010) conducted the first neuroimaging research study while using the CRT as a measure of dexterity of patients with Parkinson’s disease (PD). The fMRI results of neural correlates demonstrated that the CRT is an effective measure of limb kinetic apraxia (LKA). Participants of the healthy control group performed faster rotations of the CRT per 20-second intervals compared to the patients with PD. In healthy patients, the most significant neural activation was in the left postcentral cortex, along with observable synchrony of the right occipito-parietal and parastriate cortices (Foki et al.,
Design

The current preliminary experimental study is an evidenced-based human-subjects design. The intention is to provide information with which to further establish and explore the links between creativity and neuroscience in the effort of advancing the field of art therapy. Researchers exploring art and the brain use a variety of neuroimaging devices, including the noninvasive electroencephalogram (EEG), to record cortical activity. By extension of the EEG, quantitative electroencephalogram (qEEG) is the analysis of EEG digitized data. However, Dietrich and Kanso (2010) state that there is not a cohesive picture of which brain mechanisms are involved in the process of making art.

The reproduction and application of the investigation’s results will contribute to objectivity in the use of scientific understanding. This study will add to a limited body of research involving EEG recordings and analyses of the brain during the creation of visual imagery and seek to further explore how art making impacts the brain. There have been a few studies in art therapy literature that have shown preliminary results while using qEEG technology for measuring brainwave activity in response to art making (Belkofer & Konopka, 2008; Belkofer, Van Hecke, & Konopka, 2014; Kruk et al., 2014). Using these data as foundation for further inquiry, this current research is constructed as a within-subject design because every participant (N = 10) is subjected to every treatment condition, a directive art making task and two rote motor tasks. In order to control for variations in time of day, food eaten, and amount of sleep from the night before, all tasks were completed in one session. Each subject was also asked to complete every task, eliminating the need for a control group by using every participant as their own control.
Location

EEG equipment for recording and computerized technology for assessments was made available for the conduct of this study from a midsize research hospital in the Midwest. Participants were escorted to the second floor reading room to review and sign the informed consent form (see appendix.) Following this, subjects were seated in one of several EEG testing rooms where they were introduced to the machinery and the individuals conducting the research: a Neuro technologist, a Neurophysiologist consultant; and two graduate research assistants. After the completion of the data collection, participants were brought to the second floor washroom and back to their vehicles.

Enrollment Information

The first participant was recruited by early January of 2017 with data collection taking place in two phases on Saturday, February 4, 2017 and Saturday, February 11, 2017 from 7:00 AM to 6:00 PM both days. Each day five subjects were seen, with ten total participants (N = 10). Six participants were female; four were male. Ages ranged from 23 years of age to 68 years. All subjects identified themselves as Caucasian and were right-handed, which was important to know when viewing the EEG recorded and analyzed data given that the hand used impacts the side of the brain that is firing and data analysis. Information related to the participant’s dominant eye was not taken during this study.

Subject type and source.

Participants were normal volunteers from a capital city and surrounding suburbs, in the Midwest. The aim of the present study was to explore variances in cortical activity between the various tasks; therefore, an abnormal population was not required to accomplish this goal. Utilizing a normal population makes the results more generalizable to a broader population. With
an almost even number of males to females and a wide age range, the results will be more
generalizable to a wider span of individuals.

**Recruitment**

Subjects were recruited using a convenient sample—students and faculty of a University and
surrounding community members of a capital city in the Midwest. Participants were
recruited by word of mouth, flyers (Appendix L) and emails. Participants were either made
aware of the study and its aims due to their connections with the facility in which the study took
place or were in direct contact with the graduate research assistants. Each participant expressed
an interest in supporting the researchers or contributing to the expansion of neuroscience and art
making research. The present study was advertised on a university campus and surrounding
community via word of mouth.

**Subject Inclusion/Exclusion Criteria**

Criteria for participation included being 18 years or older, identified as a part of a normal
non-patient population, and able to provide consent. Exclusion characteristics included being a
minor, having a prior history of major head injury, stroke, seizure disorder, or brain or skull
surgery, or taking psychotropic or other medications, such as narcotics, that can affect EEG
recording.

**Investigational Methods and Procedure**

Following recruitment, subjects were asked to attend one of the two data collection dates
(Saturday February 4 or Saturday February 11), with five participants per day. Sessions occurred
every two hours on the top of the hour, allowing time for these steps: obtain informed consent,
introduce subjects to the research team, measure scalps, place electrodes, take three baseline
readings, have subjects complete one directive art making task and two rote motor tasks, and
clean up. Upon arrival at their predetermined session time, each subject was brought to the second floor for the graduate research assistants to obtain informed consent. Informed Consent (Appendix N) included the study title, investigation methods, time commitments, confidentiality, potential risks, and use of the data. Subjects’ names and signatures can be found on this document only. From that point, all participants were assigned a code to which all raw data would be attached, keeping the identity of each subject confidential.

It took approximately 30 minutes for a subject to read and sign the informed consent and to have his/her scalp measured for electrode placement. Following this, subjects began the first baseline measurement sequence. This 12-minute process included two intervals of eyes open and eyes closed instructions for 3 minutes each. This baseline procedure was repeated after both of the directive task sequences. The total time of baseline measures for each participant lasted 36 minutes (three 12-minute recordings). After the first baseline reading, participants were asked to use the 12 pack of chalk pastels to draw for 12 minutes how they were feeling, using line, shape, and color within the pre-drawn mandala. Next, the second of three baseline measures was taken. Every participant followed the same order of data collection: (1) baseline, (2) art making, (3) baseline, (4) coin flip, (5) pencil rotation, (6) baseline. The rote fine motor condition was divided into two tasks taking 6 minutes each. Participants were asked to flip a Presidential $1 gold coin (8.100 g in mass and 26.49 mm in diameter) for the first 6 minutes and to rotate an unsharpened No. 2 pencil between their fingers using their dominant hand for the remaining 6 minutes. The final phase of the EEG data collection was to complete the third baseline measure.

Materials

The art making portion of this study required a 12 pack of chalk pastels and a 12” x 18” sheet of white paper with a pre-drawn mandala. Chalk pastels were chosen because they are a
diverse medium that can be used in different ways (i.e. controlled clean lines, smeared and loose line quality). These art materials were also chosen based on their ease of availability to art therapists in various locations. A Presidential $1 gold coin was chosen for the coin flip task because it is larger (26.49 mm) in diameter than the standard American quarter (0.955 mm), contributing to the ease of the task for subjects who may be unfamiliar with the task. The standard No. 2 pencil was also chosen for ease of availability. In order to take a continuous EEG reading throughout the various tasks, an EEG monitoring machine, electrodes, and electrode cream were utilized.

**Informed Consent**

Informed consent was obtained in person and in written form. (Appendix N) The form was read individually by the participant and signed with a witness, a graduate research assistant who was made available should questions arise. After giving consent, participants were directed to the EEG exam room for electrode placement and introductions to the tasks to be completed. The materials and directive were stated aloud to each participant prior to the task with short demonstrations of how the motor tasks were to be completed. Prior to data collection, subjects were also offered the opportunity to practice the motor tasks to ensure they were able to perform them during the data collection.

**Data Collection**

**Reliability and validity of the measure.**

Teplan (2002) posits that the EEG’s greatest attribute is speed, stating, “complex patterns of neural activity can be recorded occurring within fractions of a second after a stimulus has been administered” (p. 3). Given the limitations above, the literature supports our use of EEG and qEEG over other neuroimaging devices (Bhattacharya & Petsche, 2005; Kruk et al., 2014;
Teplan, 2002). Detecting collaborations between cortical regions will be an essential component in our analysis of how the brain responds to various tasks.

**Baseline (36 minutes total).**

To obtain a baseline control, rest measurements were taken by asking the participant to open and close eyes. Electrical impulses in the brain are evaluated using an EEG. The test measures the electrical activity through several electrodes placed on a participant’s scalp. (An electrode is a conductor through which an electric current can pass safely.) The electrodes transfer information from the brain through wires to an amplifier and a machine that measures and records the data. The tests involved three steps. First, the participant was asked to sit in a chair at a table. Second, the technician measured the participant’s head, using a pencil to mark where electrodes would be attached to the scalp. These spots are scrubbed with a special cream to help the electrodes transmit a high-quality reading. In the third step the technician put a sticky gel adhesive on 16 to 25 electrodes and placed these electrodes at various marked spots on the scalp. The electrodes are flat metal disks with wires attached that lead to the computer system.

In this study, the technician fitted the EEG on the subject and the graduate research assistants delivered the directives in the presence of the technician, who constantly monitored to ensure ease of data collection and control for artifact. Artifact in EEG is electrical data gathered from areas other than the cerebral cortex, such as from other body parts or elements in the environment. Once the test began, the electrodes sent electrical impulse data from the brain to the recording machine. This machine converts the electrical impulses into visual patterns that can be seen on a screen and saved to a computer. On the screen, the electrical impulses look like wavy lines with peaks and valleys, which indicate brainwave frequencies. The technician directed the participants to do certain things while the test was in progress, such as lie still, open
and close eyes, or loosen the jaw. After the directives were complete, the technician removed the electrodes. During the EEG procedure, very little electricity passes between the electrodes and the participant’s skin. The electrodes do not send any electrical current, and the participants will feel little to no discomfort.

**Art making task (12 minutes).**

In a recent study that explored residual effects of a drawing activity in brain activity in a small sample, Belkofer, Van Hecke, and Konopka (2014) stated that their non-directive art approach may have been too general and suggested the use of a less open-ended art task, such as drawing a face or a house. Choosing a directive, or objective, approach may reduce variability between subjects. Further support for the use of a directive art task comes from Kruk, Aravich, Deaver, and deBeus (2014) who found that drawing with markers following a directive had a different effect on the frontoparietal network when compared to the non-directive art task using clay. Based on the limitations found using a nondirective task, a directive task of “draw a picture of how you feel using lines, shapes and colors in the circle” was chosen. The mandala was provided as a mechanism to introduce boundary and has been shown to alleviate anxiety (Curry and Kasser, 2005); the latter point is especially relevant to our study as EEG has been cited as being potentially anxiety provoking (Belkofer & Konopka, 2014).

**Rote fine motor task (12 minutes).**

The participants assigned to this condition were asked to perform two rote fine motor tasks: flipping a coin and rotating a pencil. This condition was separated into two tasks to ensure that participant’s attention was held on the tasks, to subsequently maintain an activated level of brain activity. The coin flip task was chosen due to its use in other qEEG studies (Foki, et al., 2010; Mendoza, Apostolos, Humphreys, Hanna-Pladdy, & O'Bryant, 2009), while the pencil
rotation task was chosen after reviewing a similar art making and qEEG study done by Kruk et al. (2014) that introduced a motor task of crumbling a tissue as a control of movement from art making movement. The current study design organized the rote fine motor tasks with increasing difficulty (coin flip then pencil rotation) to increase the level of cortical brain activation.

**Data Analysis**

To analyze the raw EEG data, we tested differences within individual subjects, across all subjects and within groups. More specifically, we compared three treatment levels within individual subjects, across all ten subjects and within three artistic experience groups using the EEG total power measurements for each frequency interval. The three levels of the considered treatments are baseline eyes closed, after art making eyes closed, and after rote motor task eyes closed, respectively. The EEG measurements are recorded in the form of square root of total Power v. Frequency across specified time periods and geographic locations. The analysis was done for each frequency level and each location thereby allowing for the detection of a greater number of variations in the data. ANOVA with repeated measure models are applied and PROC MIXED procedure in SAS is used to perform the analysis. For an elaborated statistical analysis, reference the 2.4 and 2.6 in the Materials and Methods section of the manuscript submitted to Frontiers in Neuroscience.

**Possible Risks & Special Precautions**

Subjects are notified that they may experience some mild discomfort from the electrode adhesive, which is similar to a Band-Aid. Participants do not experience any additional feelings or discomforts, as the EEG procedure only receives electrical activity and does not transmit electrical current. Participants’ identifying information is kept confidential as subjects were assigned numerical identification for purposes of communication within the study. However,
there is a risk of loss of confidentiality as consent forms are retained for the study’s records.
Cortical Activity Patterns in Art Making vs Rote Motor Movement as Measured by EEG

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Keywords: art therapy, creative arts, creativity, EEG, qEEG, neuroaesthetics, neurophysiology, rote motor movement

Abstract

This quantitative study explores the differences in cortical activation patterns when subjects create art versus when they engage in a rote motor task. It is hypothesized that a statistically significant difference occurs in cortical activity patterns during art making compared with non-creative rote motor behavior and that such differences can be detected and quantified with the electroencephalogram (EEG). Ten consenting study subjects (one with formal art training, three with some art experience, and six with no art experience) underwent EEG recording at baseline (multiple measures) and with art making, and also with rote motor tasking. Baseline control recordings showed minimal changes in EEG while art making was associated with a persistent change from baseline of significant direction and amplitude involving both hemispheres, a change that was similar to the persistent change in EEG following rote motor tasks. These preliminary findings suggest that EEG may be a meaningful biomarker for cortical activation in the study of creative arts and points to further exploration using Mobile Brain Body Imaging (MoBI) in experimental designs. This system provides a reproducible, measurable, and quantitative methodology for evaluating brain activity and function in the study of the
neuroscientific basis of creative arts, neuroaesthetics, and art therapy.

Keywords: art therapy, creative arts, creativity, EEG, qEEG, neuroaesthetics, neurophysiology, rote motor movement

1 Introduction

The creative process is difficult to explore with science as it is not localized to one area, or even one network, within the brain. It might not be possible or desirable to find a cogent definition of creativity that is generalizable, but increasing our scientific understanding of the creative process, what it is, and how to measure it will enhance innovation and problem solving related to the health and well being of patients and society. Research regarding creativity and the brain is crucial for medicine and healthcare, as we are faced with complex challenges to identify evidence based interventions that consistently address how to optimally treat diseases of the brain, the resultant behaviors, and the impact on patients and their families. Neuroaesthetics, defined simply as “the study of the neuronal processes that underlie aesthetic behavior” (Skov & Vartanian, 2009, p. 3) crests the wave of the avant garde and provides opportunity to explore the many complexities involved in the neurosciences and arts.

Neuroaesthetics does not address therapeutic implications, therefore a further investigation of how the physiological and psychological aspects of aesthetic experience relate to one another is an important goal for the future (Chatterjee, 2010). The field of neuroaesthetics is moving us toward a greater understanding of creativity by focusing on the nature of visual perception and brain function, the cortical patterns involved in both viewing and making art, and the areas of the brain where art making likely takes place (Chatterjee, 2014; Chatterjee & Vartanian, 2014; Freedberg & Gallese, 2007; Ramachandran & Hirstein, 1999; Umilta et al., 2012; Zeki, 1999b). Since its inception in the 1940’s, the field of art therapy has intuited the connections between artistic expression and brain processes with the identification of three primary tenets, all of which can be underscored with neurobiological principles: (1) the bilateral and multidirectional process of creativity is healing and life enhancing; (2) the materials and methods utilized affect self-expression, assist in self-regulation, and are applied in specialized ways, and (3) the art making process and the artwork itself are integral components of treatment that help to understand and elicit verbal and nonverbal communication within an attuned therapeutic relationship (King, 2016). However, without empirical evidence to prove these tenets, art therapists must rely on interpretive frameworks, which are often idiographic and do not allow generalizations to be made for larger populations.

Efforts to study the relationship of brain function and art making have been made by researchers in art therapy (Belkofer & Konopka, 2008; Belkofer et al., 2014). These studies compared brainwave patterns before and after art making using Quantitative Electroencephalogram (qEEG) as a measure. [Note: qEEG is a medical term used to differentiate simple interpretation of raw data waveforms based on visual inspection from algorithm based information extraction, yet any processed EEG other than the raw EEG is quantitative. For the purposes of this paper, the term EEG will be used and will define both terms.] The study in 2008 was a single subject design and the 2014 study included a sample size of ten participants. Results of the 2008 study results included higher frequency bands of alpha and beta activation, with decreases in theta and delta. The 2014 study utilized EEG to measure residual changes after 20 minutes of drawing. Their ten subjects included six artists and four non-artists, showing a significant difference among artists in the left posterior temporal, parietal, and occipital EEG
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recordings. In contrast, non-artists showed changes in right parietal and prefrontal brain.

A study with normal participants showed a difference in cortical motor activation when viewing original abstract art versus a graphic representation of the same piece. These results indicate the original art as dynamic and the result of an artist’s creative gesture, while the static graphic representation lacked a perceptual context (Umilta et al., 2012). These findings suggest that the motor system of the brain is involved differently based on the elements of art that the viewer perceives. Our current project seeks to explore the differences in cortical activity when subjects engage in the creative act of drawing versus simply moving. It is hypothesized that there is a statistically significant difference in the cortical activation patterns when a person makes art versus a simple movement, enhancing our understanding of brain function and artistic expression.

We can understand that all mental processes involved in art therapy and in art making are derived from activity in the brain (Kapitan, 2010), but there is limited research involving EEG recording in regards to the creation of visual imagery. This current project contributes to the limited yet growing knowledge base on the subjects of art therapy and neuroscience and explores the use of EEG to capture data. A review of empirical data shows all proposals on the neural basis of creativity fail when generalized to creativity as a whole (Dietrich, 2004). Gaining a greater understanding of how the brain functions in art and in artistic expression will provide evidence for why and how art therapy is effective. This type of scientific evidence is crucial for validation and growth of the art therapy profession and also contributes to the growing fields of neuroaesthetics and cognitive neuroscience.

The brain is an intricate organ; similarly, the fields that aim to better our understanding share in its complexities. Related fields include the larger umbrella of empirical aesthetics, perceptual psychology, and cognitive neuroscience. More recently, the field of neuroaesthetics has made efforts to be characterized, as the “cognitive neuroscience of aesthetic experience” (Pearce et al., 2016, p. 265). Neuroaesthetics aims to investigate the neurocognitive and evolutionary strengths of the aesthetic experience through devices of study including beauty and art. While these studies may lead to factions of beauty, the focus remains on “emergent states, arising from interactions between sensory-motor, emotion-valuation, and meaning-knowledge neural systems” (Chatterjee & Vartanian, 2014, p. 371).

Previous neuroaesthetic studies utilizing neuroimaging have largely focused on viewing artwork and the associated brain activation as opposed to creating artwork (Chatterjee, 2010) and comparing cortical functions to movement, as is the case in our study. Current neuroimaging technology allows for advanced understanding of art and how the viewer’s brain reacts (Jacobsen et al., 2006), illuminating motion, emotion, and empathy within the aesthetic experience (Freedberg & Gallese, 2007). Thus far, the contribution of neuroimaging research on the brain during the creation of artwork is limited. The act of creating art engages the whole brain (Likova, 2012), which progressive research methodology and neuroimaging technology affirm (Dietrich, 2004). Recording what the brain does during movement such as art making is difficult due to artifact and it is essential to ferret out the noise so that the data may be reduced in a meaningful way. Advanced technology such as Mobile Brain Body Imaging (MoBI) allows for a recording of brain activity using EEG and fNIRS to capture what the brain does, organizes, and senses (Gramann et. al 2014). This innovative technology is relatively low cost and provides great opportunities for art therapy research in the efforts to correlate the value of symbolic and non-verbal expression with brain function throughout the therapeutic process. Bergeron (2011) states that by utilizing neuroimaging research, we can gain a better understanding of an individual’s
“aesthetic engagement with artworks” (p. 13).

One area of interest in neuroaesthetics investigation is whether or not artistic productions and/or aesthetic preference is predetermined by evolutionary basis or universal laws (Dissanayake, 2015; Kirk et al., 2009; Myin, 2000; Ramachandran & Hirstein, 1999; Zaidel, 2010; Zaidel et al., 2013; Zeki & Lamb, 1994), which will later be explored in more length. According to Nadal and Skov, (2015) the primary goal of the cognitive neuroscience of art is to better understand the biological underpinnings involved in producing works of art. Historically, producing art implied a biological function for survival. Art and the evolutionary approaches of aesthetics direct their attention to gaining knowledge about the world (Dietrich, 2004, 2015; Solso, 2000; Zaidel, 2010, 2013, 2015; Zeki, 2001) and the brain regions involved in producing art serve various functions related to biology, communication, creativity, and insight (Zaidel, 2009).

From a biological perspective, art is first about an object that is made special through the ingredients of what comprise it, including the formal elements, all of which signify the environment to be in and where attention is directed (Dissanayake, 2015). Theories of creativity and the brain cannot be reductionistic from the perspective of three levels: a (1) genome; (2) activity-specified level of brain circuitry; and (3) changes in the brain as a result of interactions within physical, social, and cultural environments (Damasio, 2001).

According to Zaidel (2010), there are three major theories of art related to the brain. Of these, the first contains the most pertinent information for our study, stating there are specific brain regions that “link art [making] to multiple neural regions” (p. 177); meaning, art is not solely connected with one specific cerebral hemisphere, pathway, or region. The most common manner of exploring the connection between brain regions and art making is by researching artistic expressions following damage to specific regions of the brain (Zaidel, 2010). Zaidel’s 2005 study compared both pre- and post-damage output from subjects with previous artistic experience. The findings indicated that a participant’s artistic skill is preserved despite damage to the brain or its cause.

Neuroaesthetics is a discipline much like others with laws and principles that contribute to and govern the field. Zeki and Lamb (1994) postulated that all artistic expressions must obey what they call “laws of the visual system”; the first law states that visual stimuli from the exterior world does not singularly affect the retina, the part of the eye that receives images and relays them to the brain. The second law states that visual stimuli are processed in separate sections of the visual cortex prior to being united as one image. In other words, when an exterior stimuli occupies the viewer’s attention, this information is collected by the light sensitive retina and other associated areas of the visual system and is processed by multiple areas of the visual cortex before finally coming together to make one cohesive image in the viewer’s brain. The separate sections of the visual cortex, mentioned in Zeki’s second law, include five separate visual areas (V1-V5). V1 operates as the primary visual area, and V5 acts as the principle location for visual motion. The latter is largely unresponsive to static stimuli, meaning that the likelihood that V5 will be activated when presented with stimuli that lacks movement is low.

Further, Zeki (2001) proposed two “supreme” laws of the visual brain: constancy and abstraction. The term constancy refers to staying the same within the visual brain. In visual art, an artist may attempt to produce an object based on its essence or core principles as opposed to an exact rendering, which additionally encompasses irrelevant dynamic properties. The second law of the visual brain is abstraction, which plays a crucial role in our efficient knowledge-acquiring system (Zeki, 2001). “Art,” as stated by Zeki (2001), “abstracts and externalizes the
inner workings of the brain” (p. 52).

Ramachandran and Hirstein (1999) proposed eight laws of the aesthetic experience in *The Science of Art: A Neurobiological Theory of Aesthetic Experience*. They theorized that these eight laws aid our understanding of design, visual art, and aesthetics. The laws are (1) grouping, (2) peak shift experience, (3) isolation, (4) contrast, (5) symmetry, (6) generic viewpoint, (7) perceptual problem-solving and (8) visual metaphor. These laws are meant to convey a set of universal principles, such as logical, biological, and neurophysiological foundations for considering aesthetics. C. P. Snow (1959) discussed two severed cultures of the sciences and humanities, while Ramachandran and Hirstein (1999) propose that in the interface of the brain, and perhaps through art, these two cultures do meet. Neuroaesthetics offers progressive integration, especially when implemented through the clinical applications of art therapy.

Several studies explore artistic preference and aesthetic appeal (Kawabata & Zeki, 2004; Nadal et al., 2008; Vartanian & Goel, 2004). Neurologist Vartanian and cognitive neuroscientist Goel (2004) discovered through their investigation of abstract and representational images that the right caudate nucleus, bilateral occipital, and fusiform gyri, as well as the left cingulate sulcus, all showed an increase in activation when a participant showed aesthetic preference for an image. All of these brain regions play a part in “evaluating reward-based stimuli that vary in emotional valence” (Vartanian & Goel, 2004, p. 897).

Through literature review, Zaidel (2010) examines the link between viewing art and brain localization and cites a study viewing “beautiful” and “ugly” paintings (Kawabata & Zeki, 2004). This study found that the brain regions involved in such comparisons appeared within both the motor cortex and the orbitofrontal cortex. Further, the orbitofrontal cortex is involved in aesthetic preference of art due to its role in the cognitive processing of decision-making (Fuster, 1997). These studies in neuroaesthetics support our question of motor cortex involvement when exploring the differences between rote fine motor and art making tasks. This region of the brain is made up of the (1) primary motor cortex, (2) the premotor cortex, and (3) the supplementary motor area, all of which work together and are tasked with the planning and execution of the body’s movements (Campbell, 1905). Several studies have found that an observer of art can both physically and emotionally be stimulated through viewing art (Freedberg & Gallese, 2007; Umilta et al., 2012). Freedberg & Gallese (2007) studied physical, or body empathy, experienced by viewers, which can be defined as a parallel physiological response located in the parts of the body experiencing the sensation in both the subject and the observer.

Umilta et al. (2012) elaborated on Freedberg and Gallese’s findings to explore the motor system’s role in the viewing of art. In their study, high-density electroencephalography (EEG) was utilized to measure the level of intensity of mu rhythm suppression within the motor cortex of fourteen healthy volunteers (Umilta et al., 2012). Images were displayed via monitors of both original artworks and digital graphic renderings of the originals, creating a collection of six images that were randomly presented fifteen times each. The findings showed that in comparison to the digital renderings of the static works of art, viewing cuts in a canvas incited higher scores for both aesthetic appraisal and the level of perceived movement, making it the first study to collect evidence of cortical motor systems involved in the observation of static images without the representation of explicit movement as subject matter (Umilta et al., 2012). This motor activation, as measured by EEG, during the observation of static art is a strong indication of motor cortex involvement in the perception of visual art.

Progress to understand creative expression requires multimodal investigations that include the exploration into the production of art. Cognitive neuroscientist Arne Dietrich (2004)
has worked towards gaining a better understanding of the explicit and implicit systems which are involved in the creative process and helps us see that a task like art making in a state of flow involves the smooth sensory input and motor output that cleanly bypasses consciousness. Gramann et. al (2010) assert that human cognition is inseparable to our own (and others) motor behavior; movement is an essential component of the flow state. The state of flow (Csikszentmihalyi, 1996) is ‘the designing or discovering of something new’ within a psychological state of optimal attention and engagement. A type of creativity, the state of flow may be beneficial to people in art therapy because unconscious material may be elicited more easily via extraction of the implicit system. Art therapist Gioia Chilton (2013) discussed the process of flow during art making and theorized that artistic visual expression which involves cerebral systems that process sensory information are related to the functions and structures of the brain. She discussed how movement elicits the implicit system in the artist, while the explicit system is prominently activated during the process of reintegrating information during verbalizations in response to the work. An artist’s declarative moment of surprise to discover their artwork may indicate the engagement of the implicit system and therefore a flow state: “When artists say that they ‘do not know what the artwork means,’ it is quite possibly due to the down-regulation of the prefrontal cortex that limits this kind of cognitive processing” (Chilton, 2013, p. 66). Clinical implications include the assessment of a client’s artistic skills and potential alleviation of anxiety while attending to tasks at hand.

Ferber et al. (2007) identified brain regions associated through fMRI, using a modified drawing tablet as the control for movement tasks to copy and draw from memory. This study, which included twelve healthy volunteers, found that the drawing task could activate the anterior cingulate, described by Ferber et al. (2007) as “an area associated with motor control and linking intention with action” (p. 1089). The drawing from memory task also evoked stimulus in the medial frontal gyrus. The anterior cingulate is where motor control, drive, and cognition interface due to proximity with the motor and prefrontal cortex and parietal areas, “pointing to its role in conflict monitoring, and linking intention with action” (Paus, 2001, p. 417).

Likova (2012), using fMRI measurement, investigated how the brain of a congenitally blind individual was activated during drawing. The subject was analyzed during pre- and post-training drawing exercises. Training included a drawing from tactile memory, with the use of a cognitive-kinesthetic approach and a raised-line drawing model, which was explored with the left hand before drawing them from memory with the right. This is one of the few studies to investigate the involvement of the primary visual cortex (V1) in non-visual memory. With detailed results of topographical brain mapping, V1 has been shown to operate as a “visual-spatial buffer, or ‘sketchpad,’ for working memory” (Likova, 2012, p. 1). The cognitive-kinesthetic, tactile-memory task may be used to explore plasticity rehabilitation of individuals with blindness and supports the sensory and kinesthetic approaches used by the art therapist as an effective method of enhancing neuroplasticity for therapeutic benefit.

Bolwerk et al., (2014) completed the first known study linking the neural effects of visual art production with psychological resilience in adulthood. Fourteen adult participants 65 years and older were divided into two groups for 10-week-long art interventions. One ‘visual art production group’ created art in an art class and one ‘cognitive art evaluation group’ evaluated art at a museum. The neural effects of each group were measured with fMRI before and after each week of participation to investigate the brain’s default mode network (DMN). Analysis of the DMN was identified through a seed voxel correlation analysis (SCA) in the posterior cingulate cortex. The German equivalent of the Resilience Scale (RS-11) was used to relate the
covariance of fMRI results and psychological resilience. Results for the visual art production group versus the cognitive art evaluation group showed a greater spatial increase in functional connectivity of the posterior cingulate cortex to the frontal and parietal cortices. In the study, significance to psychological resilience was related to the visual art production group, indicating a stabilizing effect of art production and well-being, especially in older adults.

Art therapists rely on these stabilizing effects in clinical treatment and generating neuroscientific evidence to support otherwise trusted interventions has become crucial for the understanding and acceptance of the field in our current healthcare climate. Lusebrink (1990) understood the support of brain research on contemplating art production and stated that visual expression is processed on different levels of complexity. She wrote that “an expression through art media can also originate from complex cognitive activity involving decisions and internal imagery, thus activating the sensory channels and motor activity” (Lusebrink, 2004 p. 125). In other words, the brain makes use of visual, somatosensory, and motor information processing in conjunction to areas of emotional and memory processes.

Kagin and Lusebrink (1978) developed what perhaps remains the most utilized theory of intervention in the profession of art therapy called the Expressive Therapies Continuum (ETC), which was developed as a model of creative functioning through human development and information processing (Lusebrink, 1990). The vertical spine of creativity is balanced through hierarchical planes of the sensory-kinesthetic level, perceptual-affective level, and cognitive-symbolic level. According to theory, during art production, an individual’s choice in media corresponds with levels of the ETC and reflects brain functions of the temporal, orbital, parietal, and frontal lobes (Hinz, 2009). This three-tier hierarchical structure provides for the variety of component functions involved in visual expression and suggests a commanding functional level. The materials and methods chosen by the art therapist in the development of specific therapeutic interventions for patients often emerge from these constructs.

Over the last decade art therapists have joined with neuroscientists to begin the exploration of artistic processes and brain activity by using EEG as a mechanism for inquiry. Belkofer and Konopka (2008) conducted a modified, single-subject design (N = 1) that used EEG to explore brain activity after 1 hour of art making. In order to study the effects of art making, two 22 minute EEG recordings were taken; the first acted as a baseline measure, and the second was taken immediately following the 1 hour art making process. They found that when comparing pre-and post-data, higher frequency bands of alpha and beta were present after drawing and painting. The results of this study show that activation occurred predominantly within the occipital, parietal, and temporal lobes (Belkofer & Konopka, 2008). While alpha and beta waves showed marked increases, delta and theta brainwaves decreased in the same brain regions. Parietal and occipital lobe activation is an indication that the participant had “increased visual processing demands” (p. 61) and it was believed that spiritual and emotional connections can be made in the temporal lobe based on evidence increased activity in this area.

In a later study, Belkofer et al. (2014) explored residual effects of a drawing in brain activity in a pre-post within-group study, using EEG as measurement and discussed results in terms of brain mapping. In this study participants were given more direction: “...for the next 20 minutes, use the materials to create an image. Your image can be representational (people, places, or things), abstract (shapes and lines), or both” (p. 63). Results indicated changes in the frontal areas of the non-artist group, which they attributed to the unfamiliarity of the tasks. By comparing these two groups, they also found that an increase in alpha frequency may play an important role in drawing. However, unlike the previous 2008 study, the results showed activity
in the spatial/visual regions of the cortex. These include the left parietal (P3), occipital (O1), and temporal (T5) lobes, as well as in the posterior central (Cz) and right parietal (P4) regions (Belkofer & Konopka, 2014).

Kruk et al. (2014) compared the brain activity during drawing and clay sculpting in fourteen female participants between the ages of 22 and 25. Participants completed a pre- and post-measure of state versus trait anxiety using the State-Trait Anxiety Inventory, STA1 Form Y1. Control readings required the participants to open and close their eyes and crumple tissue paper; readings were taken before and after five minutes of freely sculpting with clay and five minutes of drawing. Choosing two different tasks allowed for more specific investigation into how certain tasks, e.g. drawing and sculpting with clay, affect the brain. Results indicated the right medial parietal lobe increased in gamma power activation with the drawing and clay conditions. In comparison, the right medial frontal lobe showed a decrease in gamma power and an increase in theta power during the clay condition. These results also indicated that using a directive during the drawing task affected the frontoparietal network differently when compared to the non-directive art making using clay. The researchers stated that “drawing on paper in response to a directive likely would elicit a cognitive reaction and possibly a perceptual response” (Kruk et al., 2014, p. 54).

Malchiodi (2003) asserts that science will be central to understanding how art therapy works, will better define its effectiveness, and will improve the ability to develop more effective protocols to test art therapy interventions. Although there have only been a handful of neuroimaging studies in the field of art therapy, EEG has been a promising method to research art making, the distinctions in properties of art materials, and art processes (King & Kruk, 2016). This current project will contribute to the limited yet growing knowledge base on the subjects of art therapy and neuroscience.

2 Materials and Methods

This study was completed with adherence to the Human Subjects Guidelines of the Indiana University Institutional Review Board, (IRB approval # 1507398603, see Appendix M) with informed written consent obtained from every subject.

A convenience sample of ten participants was taken using a within-subjects comparison of EEG recordings with the intent to further establish and explore the links between creativity and neuroscience for the purpose of advancing the field of art therapy. EEG recordings were taken during a single session and compared baseline (eyes closed) recordings to post art making and subsequently post rote motor task recordings.

2.1 Participants

Participants were recruited using a convenience sample including graduate students from the Indiana University Purdue University Indianapolis campus, Indiana University School of Medicine faculty, and surrounding community members through the use of flyers, social media postings, and email notices. Criteria for participation included being 18 years or older, identified as a part of a normal non-patient population, and able to provide consent. Exclusion characteristics included having a prior history of major head injury, stroke, seizure disorder, or brain or skull surgery, or taking psychotropic or other medications, such as narcotics, that can affect EEG recording.
Prior to data collection, participants met with the graduate research assistants to read and sign an informed consent form and with the neuro technologist for a brief explanation of EEG recording processes and expectations. The informed consent form included information regarding the overall purpose of the study, participation procedures, risks and benefits of taking part in the study, how confidentiality would be maintained, and the voluntary nature of the study. Also included in the informed consent form was a release for their artistic production to be used in future publications and/or presentations pertaining to art therapy. Participants were asked to complete a short demographics form (see Appendix N) indicating handedness, level of artistic ability, age, and gender following the completion of the data collection.

2.2 Materials

The art making portion of this study required a 12 pack of chalk pastels and an 18” x 24” sheet of white paper with a pre-drawn mandala, or circle, at the center. The mandala, commonly used in art therapy practice and intervention, is essentially a circle outline, which can be used as a focal point within which to explore the self. The diameter of the pre-drawn mandala was 15”. Chalk pastels were chosen because they are a diverse medium that can be used in a variety of ways (i.e. controlled clean lines or smeared/loose line quality) and are commonly found in a variety of art therapy settings. A Presidential $1 gold coin was chosen for the first motor task, coin flip, because it is larger (8.100 g and 26.49 mm) in diameter than the standard American quarter (5.67 g and 0.955 mm). A standard No. 2 pencil was also chosen for ease of availability for the second motor task.

2.3 Procedure

EEG equipment for recording and computerized technology for assessments were made available for the conduct of this study from the Indiana University Health Neuroscience Center. Data collection took place on two separate days with five participants scheduled per day. EEG recordings took place in a well lit EEG testing room within the Indiana University Health Neuroscience Center with a neuro technologist (R. EEG T.), neurophysiologist, and graduate research assistant present. Standard gold cup EEG surface electrodes were placed by the neuro technologist using the International 10-20 system of electrode placement, conductive paste, and sticky gauze squares. Recording electrodes were placed at (Fp1, Fp2, F3, F4, C3, C4, P3, P4, O1, O2, F7, F8, T3, T4, T5, T6, FZ, PZ, CZ). A ground electrode was placed on the forehead, A1 and A2 electrodes were placed behind the ears. Electrodes were also placed at the outer canthus of each eye, to help detect and eliminate eye movement artifacts, and an ECG electrode was placed to identify ECG artifacts. Electrode impedances were kept below 5 KOhms throughout all recordings. Every participant followed the same order of EEG data collection: (1) baseline, (2) art making, (3) post art making, (4) coin flip, (5) pencil rotation, (6) post motor tasks. The baseline, post art making, and post rote motor task intervals all followed the same 12 minute sequence; four 3 minute epochs of time, eyes open, eyes closed, eyes open, eyes closed.

After completion of the 12 minute baseline, the table holding the paper and chalk pastels was moved into reach of the participant with the following directive (see Appendix P for full script):

Use the 12 pack of chalk pastels and 18” x 24” sheet of white paper with the pre-drawn...
circle provided to explore how you feel using lines, shapes, and colors in the circle. You will have 12 minutes to complete this task, please continue to make art for the duration of this task. You will not be judged based on the artwork created, there is no right or wrong way to complete this task.

The study’s art task (Appendix Q, Figure Q1) was taken from Cohen’s (1988) Diagnostic Drawing Series (DDS), which originally was designed to provide a baseline assessment of participants using a three-part directive. This section of the DDS was chosen to promote abstract thinking. In addition, a pre-drawn mandala was included to provide structure, boundaries, containment, increase attention and reduce anxiety (Babouchkina & Robbins, 2015; Curry & Kasser, 2005; Fincher, 1991; Smitheman-Brown & Church, 1996; Roush, 2013). Reducing anxiety was especially relevant to the current study as Belkofer and Konopka (2014) suggested EEG procedures may be anxiety provoking.

Next, the post-art making data collection occurred. This consisted of four 3 minute epochs of time, eyes open, eyes closed, eyes open, eyes closed. Following this, the rote motor tasks were performed. In order to maintain attention and engagement throughout this segment of testing, two tasks were administered in 6 minute, consecutive intervals. The prompt read as follows:

This intervention will be divided into two 6 minute tasks. For the first 6 minutes we will ask you to continually flip a coin. Next, we will ask that you rotate a pencil between your fingers using your dominant hand for the remaining 6 minutes.

The final phase of the EEG data collection was to complete the post motor task measure. Again, this consisted of four 3 minute epochs of time, eyes open, eyes closed, eyes open, eyes closed. For the preliminary data analysis, only the epochs of data identified as Epoch 1: Subsets 2 and 4, Epoch 3: Subsets 2 and 4, and Epoch 5: Subsets 2 and 4, as shown in Table R1 (see Appendix R) were utilized. All data will undergo analysis in future studies.

2.4 EEG Recording and Analysis

The EEG was recorded utilizing a Nihon Kohden, EEG-1200, with a low frequency filter of 0.16 seconds and a high frequency filter of 70 HZ. A bipolar, longitudinal montage was utilized for data collection, and the EEG was later reformatted to a Laplacian average reference montage for quantitative analysis. Prior to analysis of the data, raw EEG underwent visual inspection, with epochs of excessive artifact removed throughout all recording periods. Persyst 12, InsightII software was utilized to perform a Fast Fourier Transform (FFT) of the EEG, yielding numerical output of total power in sqrt(uV), at 2 HZ epochs of frequencies, ranging from 0-2 HZ to 30-32 HZ. The FFT was calculated with a sampling rate of 128 HZ, and non-overlapping epochs of 1 second duration. FFT was conducted on various “channel” groupings of electrodes as detailed in Table S1 (see Appendix S). For this preliminary data analysis, only the channel groupings of Left and Right Hemisphere were analyzed. All channel groupings will undergo analysis in future studies.
2.5 Self-Reports

The study participants were asked to complete a form that indicated a level of artistic ability. This single form included three options to rate experience, (1) no experience, (2) some experience, or (3) formal training. Of the ten individuals involved in the study, six indicated that they had no experience related to art making, three reporting having some experience with art, and one was formally trained in fine arts.

2.6 Statistical Analysis

To analyze the raw EEG data, we tested differences within individual subjects, across all subjects and within groups. More specifically, we compared three treatment levels within individual subjects, across all ten subjects and within three artistic experience groups using the EEG total power measurements for each frequency interval. The three levels of the considered treatments are baseline eyes closed, after art making eyes closed, and after rote motor task eyes closed, respectively. The EEG measurements are recorded in the form of square root of total Power v. Frequency (0-2 HZ, 2-4 HZ, ..., 30-32 HZ) across specified time periods (around 400 time periods) and geographic locations (Left Hemisphere and Right Hemisphere). The analysis was done for each frequency level and each location thereby allowing for the detection of a greater number of variations in the data. ANOVA with repeated measure models are applied and PROC MIXED procedure in SAS is used to perform the analysis.

To compare individual subject differences in the data (i.e. compare the three treatment levels for Subject ARP001, etc.), we applied the model with Power as the response variable, Treatment as the factor and Time periods as the repeated measure for each subject. We first tested for the overall treatment effect using F test through type3 analysis. Then we performed a pairwise comparison using Tukey adjustment to do t-tests for the mean power difference between each pair of the three treatments. These pairwise comparison results are summarized in Table T1 (see Appendix T).

Next, we tested for the treatment effect while considering the subject variation. The same ANOVA model was applied, as above, but this time we included Subject as a random effect. We tested for the overall treatment effect using F test through type3 analysis and treatment effect is found to be highly significant (p<0.001) under almost all frequency intervals, except one case for Frequency 0-2 HZ at left Hemisphere. We then performed pairwise comparison to do t-tests for the mean power difference among the three treatments. These pairwise comparison results are summarized in Table U1 (see Appendix U). Then, we tested for the treatment effect within the three artistic experience groups. We applied the same ANOVA model as above and included Subject as the random effect and Artistic Experience as the between subject effect. We also evaluated the interaction between Treatment and Artistic Experience. First, we tested for the main effect of treatment and Artistic Experience and their interaction effect using F tests through type3 analysis. The main effect of treatment is found to be highly significant for all most all cases, while that of Artistic Experience is not significant (p >0.05), but there are highly significant interactions found between them under many frequency intervals. Then we used slice statement in Proc Mixed to perform pairwise comparisons between each pair of treatment levels sliced by each level of Artistic Experience using t-tests. These pairwise comparison results are summarized in Table V1 (see Appendix V). Additionally, we also performed a comparison of the two eyes closed baseline sessions (BaseEC1 and BaseEC2) which were both recorded prior to art
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making or rote motor task, as an internal control, so that we could rule out any random variations that might affect the accuracy of our tests. By frequency and location, we applied ANOVA model with Power as the response, Treatment (two levels: BaseEC1 and BaseEC2) as the factor, Subject as the random effect, and Time as the repeated measure. We tested for the mean power difference between BaseEC1 and BaseEC2 using t-tests. The results are summarized in Table W1 (see Appendix W).

3 Results

Table X1 (see Appendix X) shows a demographic summary of our subjects, detailing age range, handedness, and artistic experience.

Table W1 (Baseline Difference Control) shows estimated mean differences of left and right hemisphere power by frequency and location, for the Baseline (Eyes Closed) epoch 1 subset 4 compared to the Baseline (Eyes Closed) epoch 1, subset 2 (see Table R. Procedure Time with Epoch Notation). These results show that the later epoch of time (epoch 1 subset 4) shows a general decrease of power in frequencies between 1-12 HZ, with a gradual trend upward in power from 12-32 HZ. In the left hemisphere, the decrease in power is statistically significant in the 8-12 HZ range, and the increase in power is statistically significant in the 22-32 HZ range. In the right hemisphere, the decrease in power is statistically significant in the 0-18 HZ range, and the increase in power is statistically significant in the 26-32 HZ range. Statistically significant estimated mean differences from both hemispheres ranged from -0.0424 to 0.02948. This shows that variation in brainwaves occurred over time, prior to interventions. To account for this in after intervention comparisons, a threshold line of estimated mean difference values was set at +/-0.045. This was established to identify after intervention findings that could potentially reflect random fluctuations in the EEG.

Table U1 (Pairwise Comparison by Frequency, Location) details a pairwise comparison by frequency and location, showing estimated mean differences of power 1) after art making task to the baseline, 2) after motor tasks to the baseline, and 3) after motor tasks to after art making task.

Results for after art making task compared to baseline showed a general increase in power throughout all frequencies, trending upward in power from 0-10 HZ, with a gradual trend downward from 10-30 HZ. In the left hemisphere, the increase in power is statistically significant from 2-32 HZ, and it exceeds the threshold lines of +/-0.045 (set to show potential random variance), from 6-14 HZ, and 30-32 HZ. In the right hemisphere, the increase in power is statistically significant from 0-32 HZ, and it exceeds the threshold of 0.045 from 6-16 HZ.

Results for after motor tasks compared to baseline showed a general increase in power throughout all frequencies, trending upward in power from 0-10 HZ, with a gradual trend downward from 10-32 HZ. In the left hemisphere, the increase in power is statistically significant from 2-32 HZ, and it exceeds the threshold of 0.045 from 6-14 HZ. In the right hemisphere, the increase in power is statistically significant from 0-32 HZ, and it exceeds the threshold of 0.045 from 6-16 HZ.

Results for after motor tasks compared to after art making task showed little to no change in power in the left hemisphere, with a more noticeable decrease in power from 8-24 HZ on the right. Statistically significant changes in mean power were seen on the left with increased power at 4-6 HZ and decreased power at 14-18 HZ, and on the right with decreased power from 14-24 HZ. No variances exceeded the +/-0.045 threshold lines set to show potential random variance.

Figure Y1 and Figures Y2 (see Appendix Y) shows a graph depicting the changes from
baseline that are seen after art making and after the motor tasks, detailed in Table T1, as compared to the baseline control (Table W1). Threshold lines at +/-0.045 estimated mean difference are drawn. Differences greater than those seen in the control are found in both hemispheres for both interventions (after art making compared to baseline and after motor tasks compared to baseline), from 6-14 HZ.

Table T1 (Pairwise Comparison by Subject, Frequency, Location) details a pairwise comparison by subject, frequency and location, showing estimated mean differences of power 1) after art making task to the baseline, 2) after motor tasks to the baseline, and 3) after motor tasks to after art making task for each subject. Results in this table did not significantly vary from those seen in Table U1.

Table V1 (Pairwise Comparison Slice by Artistic Experience by Frequency, Location) shows estimated mean differences of power divided until three (3) subsets of no experience, some experience, and formal training for the following: 1) after art making task to the baseline, 2) after motor tasks to the baseline, and 3) after motor tasks to after art making task.

Results for after art making task compared to baseline, by artistic experience showed a general increase in power throughout all frequencies, and artistic experience levels trending upward in power from 0-12 HZ, with a gradual trend downward from 12-32 HZ, with differences more pronounced in the left hemisphere over the right, for those having no or some experience. For those with formal training (N = 1), the trend was upward in power from 0-10 HZ on the left, and 0-8 HZ on the right, followed by a downward trend in power that became negative (less power than baseline) on the left at 12-18 HZ and on the right at 10-18 HZ.

In the left hemisphere, the increase in power is statistically significant and exceeds the threshold lines of +/-0.045 (set to show potential random variance), from 6-16 HZ for those having no or some experience, and from 6-8 HZ for those having formal training. In the right hemisphere, the increase in power is statistically significant from 0-32 HZ, and it exceeds the threshold of 0.045 from 6-16 HZ.

Figure Z1 and Figure Z2 (see Appendix Z) shows a graph depicting these changes, seen by artistic experience for after art making as compared to baseline, detailed in Table V1, as compared to the baseline control (Table W1).

Results for after motor tasks compared to baseline, by artistic experience showed a general increase in power throughout all frequencies, and artistic experience levels trending upward in power from 0-10 HZ, with a gradual trend downward from 10-32 HZ for those having no or some experience. For those with formal training (N = 1), the trend was upward in power from 0-10 HZ on the left and right, followed by a downward trend in power that became negative (less power than baseline) on the left from 14-18 HZ and on the right at 12-18 HZ.

In the left hemisphere, the increase in power is statistically significant and exceeds the threshold lines of +/-0.045 (set to show potential random variance), from 6-14 HZ for those having no experience, from 6-16 HZ for those with some experience, and from 6-10 HZ and 20-28 HZ for those having formal training.

In the right hemisphere, the increase in power is statistically significant and exceeds the threshold lines of +/-0.045 (set to show potential random variance), from 6-14 HZ for those having no experience, and from 2-16 HZ for those with some experience. No power differences met these criteria on the right for those having formal training.

Figure Z2 and Figure Z3 shows a graph depicting these changes, seen by artistic experience for after motor tasks as compared to baseline, detailed in Table V1, as compared to the baseline control (Table W1).
Results for after motor tasks compared to after art making task showed varying differences, with a general loss of power after 6-8 HZ for those having no to some experience, and variable positive and negative variance in power for those with formal training (N = 1). No variances exceeded the +/-0.045 threshold lines set to show potential random variance, with the exception of those with formal experience showing a decrease in power from 1-4 HZ.

Figure Z5 and Figure Z6 shows a graph depicting these changes, seen by artistic experience for after motor tasks as compared to after art making, detailed in Table V1, as compared to the baseline control (Table W1).

Overall, the recordings post art making show a persistent neurophysiological change lasting at least 12 minutes, of significantly greater magnitude than the baseline variations (p<0.001). The recordings post rote motor tasks show a similar magnitude and length of persistent physiological change (p<0.001). Meaningful hemispheric differences were not detected, as similar changes were evident in the right and left hemisphere recordings. A trend in power changes as compared to level of artmaking experiences suggests that subjects with some art making experience appear to have greater increases in power after art making, than those with no experience. Those with formal training appear to experience less impact on EEG power with art making, and with motor tasks.

4 Discussion

Among the different approaches to research creativity, neuroimaging and neurophysiology hold strong potential and are complementary. Preliminary key findings and analysis in this study suggest that EEG is a meaningful biomarker for cortical activation and processing in creative arts expression. The use of EEG may be complementary to functional imaging (fMRI and PET) and mobile Brain Body Imaging (MoBI) as fundamental research tools in the study of the neuroscience of creative arts.

Changes in EEG due to baseline normal variation were identified and quantified so as to allow for determination of statistically meaningful effects from art making and rote motor tasking. It is essential for meaningful interpretation of serial measurements pre and post intervention to understand the magnitude of random variation in EEG measurements. This study established these baseline changes as obtained in serial baseline measurements from each subject. This quantification serves to best define the baseline variation in EEG measurements for comparing and interpreting post intervention changes. Future studies should further clarify the magnitude and characteristics of baseline variation so as to limit the risk of misinterpretation of post intervention changes. In the current study the post-intervention persistent cortical neurophysiological changes were of substantially greater magnitude than the baseline variations and thus suggest that art making and rote motor tasking were associated with a significant persistent neurophysiological change. This study reinforces the importance of establishing normal baseline variations in serial EEG records. A component of this study is the use of multiple measurements of baseline (pre-activity) EEG in all subjects. These data indicate the magnitude of EEG changes in a random or normal baseline state and provide important clarification of the degree of baseline variation necessary for optimal interpretation of post intervention EEG.

Persistent physiological changes were seen in both hemispheres following art making and also rote motor tasking. Therefore, our hypothesis that there is a statistically significant difference in the cortical activation pattern of art making compared with rote motor tasking is not proven. However, we recognize the impact of having a small number of subjects in this study as
well as a potential impact of the sequencing of interventions that should add caution to this interpretation. Also there are clear trends in our data suggesting a greater effect from art making than from rote motor tasks and justify further studies to clarify if there are meaningful changes specific to art making. Changes of similar magnitude were seen following art making as well as rote motor tasks. In this study, all patients were given the art making activity prior to the trials of rote motor tasking. We do not know the duration of the persistent EEG effect seen post art making. While this study indicates it is present for up to 12 minutes post art making we observed the same findings post rote motor. One explanation is the rote motor and creative art making induce a similar cortical activation and persistent physiologic effect. On the other hand, we cannot rule out that the effects from art making continued on through the rote motor activity and thus could be responsible in part for those similar findings. This issue can be clarified by repeating the protocol but reversing the order of art making and rote motor activity. Furthermore, these trends suggesting a greater effect from art making than rote motor may require further studies using a larger number of subjects and avoiding a type 2 error to clarify if there are any meaningful changes specific to art making.

Data from the current study show no compelling evidence for a right hemisphere versus left hemisphere localization for aspects of the art making process. This study shows promising results and ultimately provides a reproducible, measurable and quantitative methodology for evaluating cortical activity and brain function in the study of the neuroscientific basis of creative arts, neuroaesthetics, and art therapy. Our observation of a persistent neurophysiological change of meaningful direction and magnitude in the cerebral cortex generates several important questions. What is the underlying functional basis for this persistent change? Is this a cortical activation effect or is it a post activation exhaustion? How long does this persistent cortical effect last? And is the persistent EEG change correlated with or related to the degree, quality, impact of the therapeutic effect of a creative art therapy intervention. And if so, is there application for such EEG measurements to measure the impact or likely success of an intervention?

This study reinforces the importance of establishing normal baseline variations in serial EEG records. A component of this study is the use of multiple measurements of baseline (pre-activity) EEG in all subject. These data indicate the magnitude of EEG changes in a random or normal baseline state and provide important clarification of the degree of baseline variation necessary for optimal interpretation of post intervention EEG.

Observations regarding localization are as follows: Significant persistent EEG changes following art making were detected in both hemispheres. As the laterality and localization of creative brain function has been disputed for many years the data from this current study show no compelling evidence for a right hemisphere versus left hemisphere localization for aspects of the art making process. Further study should be conducted to confirm this observation including the study of larger numbers of subjects. To the degree that right hemisphere persistent changes are observed in art making, one related research question that can be answered using this methodology would include clarification of the variables involved with selective right hemispheric/cortical localization. In right handed individuals the right parietal lobe is largely responsible for spatial orientation and conducting a similar study using rote and non-creative tasks of spatial orientation (such as clock drawing) compared with novel creative drawing would clarify the variables responsible for the right hemisphere persistent EEG changes.

Our study subjects included six inexperienced, three partially experienced, and one with formal art training. Differences were observed with increased magnitude of persistent physiologic change in the six subjects with limited artistic training. While the numbers are small
the questions generated with this observation include the following: 1) What is the meaning of a greater persistent physiological change as seen in those with no artistic training; 2) Does this relate to enhanced use of cortical regions for a creative process or enhanced use of non-creative regions related to components of attention, effort, stress, or cognitive processing/interpretation; 3) In those with formal training and experience is the lesser magnitude of the persistent physiological change related to more efficient and learned processing of a creative task requiring less utilization of novel cognitive regions in order to process a creative work.

An analogy may be seen with a cognitive function such as language. For example, if one is fully fluent in the French language then the cortical “effort” to produce the French language efficiently and meaningfully is ostensibly far less than in an individual who is a novice and may struggle and require word by word processing in order to communicate in French. Such differences may relate to the degree and localization for cortical activation and may influence the degree of a prolonged neurophysiological cortical change in EEG. Further study including a larger cohort of formally trained artists using the current model will add clarity to the effect of such training on brain localization and function. Identifying more completely the cortical “effort” put forth in expediting an artistic task may provide implications for understanding art therapy clinical interventions in the future. For example, art therapists rely heavily on brain-based theoretical structures such as the Expressive Therapies Continuum (Kagin and Lusebrink, 1978) to develop intervention strategies using a range of art materials that influence the quality of self expression within the context of patient symptoms and goals for treatment. Clarifying the effect of formal artistic training may lead to studies that seek to explore the preparedness for art therapy interventions and eventually may influence an understanding of a candidate’s readiness for treatment.

With respect to the question of hemispheric and cortical localization we note that all of the subjects in the current study were right handed and further evaluation of left handed individuals may provide additional insight into associations that may be related to handedness and cerebral dominance.

This system provides a reproducible, measurable, and quantitative methodology for evaluating cortical activity and brain function in the study of the neuroscientific basis of creative arts, neuroaesthetics, and art therapy. Although in early stages, these data point to the use of wearable technology (MoBI) to more fully investigate the links between brain activity and behavior during movement (Makeig et. al 2009), which provides accessible and promising methods to more fully identify the brain processes during therapeutic events that historically have been intuited. Simultaneously, experimental studies in clinical art therapy interventions may contribute to the exploration of motivated motor behavior and aspects of embodied cognition as assessed by MoBI. Clarifying the interactions between brain and body dynamics may lead to evidence of a biological model of cognition (Gramann et. al, 2010) and the exploration of artistic expression in the context of the therapeutic relationship may provide useful data to inform protocols that study neuroimaging.

5 Conclusion

This quantitative study explores the differences in cortical activation patterns when subjects create art versus when they engage in a rote motor task. Baseline control recordings showed minimal changes in EEG. Changes in EEG due to baseline normal variation were identified and quantified so as to allow for determination of statistically meaningful effects from art making and rote motor tasking.
Art making was associated with a persistent change from baseline of significant direction and amplitude involving both hemispheres, a change that was similar to the persistent change in EEG following rote motor tasks. The hypothesis that art making is associated with significant differences in cortical activation compared with rote motor tasks is not proven in the current study. However, trends in our data suggest a greater effect from art making than from rote motor tasks and justify further studies to clarify if there are meaningful changes specific to art making. These preliminary findings suggest that EEG may be a meaningful biomarker for cortical activation in the study of creative arts. This system provides a reproducible, measurable, and quantitative methodology for evaluating brain activity and function in the study of the neuroscientific basis of creative arts, neuroaesthetics, and art therapy.

Our study contributes to the much-needed empirical evidence that will validate the impact of art therapy assessment and intervention. Merging neuroscience and art therapy through scientific research offers evidence for how brain science and artistic processes inform one another to support the overall health and amelioration of disease for patients and their caregivers.

6 Ethics Statement

This study was completed with adherence to the Human Subjects Guidelines of the Indiana University Institutional Review Boards, (IRB approval #1507398603) with informed written consent obtained from every subject.

7 Authors Contributions

JK was the Principal Investigator and was responsible for the hypothesis, the design and conduct of the trial, KK was an art therapy graduate research assistant involved with the design, conduct and analysis, AS was an art therapy graduate research assistant involved with the design, conduct and analysis, FL was the statistician, DS was the neurologist EEG expert, RP was the neurologist involved with conduct and analysis, and LO was the neurophysiologist responsible for neurophysiology recordings, data extraction and interpretation. All individuals were involved with preparation of the manuscript.

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9 Conflict of Interest Statement

All authors attest that this research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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CHAPTER V

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Appendix A

Triune Brain

Figure A1. Lateral view of the human brain including the three major areas, the forebrain, midbrain, and hindbrain. Also known as the triune brain made up of the neomamalian, paleomamalian, and reptilian brain.
Appendix B

Frontal Lobe

The frontal lobe, seen in Figure B1, operates with the help of its functional areas; the primary motor cortex, prefrontal cortex, the premotor area, and Broca’s area (Vanderah & Gould, 2016). According to Carter et al. (2009), the following brain areas of the cortex relate to approximated functions: insula (gustation/taste faculty); occipital cortex and temporal cortex (vision); medial temporal lobe, posterior cingulate cortex (memory); medial temporal cortex (olfaction/smell faculty); temporal lobe (audition/sound); parietal lobe (body sensation); anterior cingulate and orbital cortex (emotion); and frontal lobe (motor).

Figure B1. The four major lobes of the brain in lateral view. The four lobes make up the brain’s cerebrum, or the largest portion of the human brain.
The frontal lobe, with its functional areas, contains several motor regions of the brain (Nolte, 1999). As the name suggests, the primary motor cortex, located in the dorsal portion of the frontal lobe, works in tandem with the premotor cortex during the preparation and execution of voluntary motor movements (Vanderah & Gould, 2016). Miller, Freedman, and Willis (2002) theorize that the prefrontal cortex participates in, “the ability to take charge of [these] actions and direct them toward future, unseen goals is called cognitive control” (p. 1134).

Several studies have also found that Broca’s area (Figure A3) plays an important role in controlling movement (Bonda, Petrides, Frey, & Evans, 1994; Rizzolatti, Fadiga, Gallese, & Fogassi, 1996). It is possible that the frontal lobe and its motor areas will aid in our understanding of the creative process as we compare movements during the creation of art and manipulating objects with the hand. The purpose of the present study is to explore the differences in cortical function between art making and rote fine motor tasks using EEG. We hypothesize that between the tasks (rote fine motor and directive art making) there will be a statistically significant difference in cortical functions. Within our study, we consider that these distinctions in cortical activity patterns will lead to an increased scientific understanding of the creative process.
Appendix C

Parietal Lobe

Figure B1 shows that the parietal lobe sits directly behind the frontal lobe and rests atop the temporal and occipital lobes. According to Vanderah and Gould (2016), the parietal lobe has three major functions; (1) it encompasses the somatosensory cortex, which is “concerned with the initial cortical processing of tactile and proprioceptive information; more specifically, it deals with sensory localization” (p. 58), (2) language comprehension, and (3) the ability to direct attention to an object or subject as well as spatial orientation. This lobe of the brain includes the inferior parietal and superior parietal lobes, both of which take part in spatial awareness given the sensory information taken from places around the body.

Much like the temporal lobe, the parietal lobe is also separated into right and left sectors. In addition to more general functions like processing sensory information and the comprehension of language, more specific roles such as right-body tactile function, verbal, and reading intelligence takes place in the left subsection (Hass Cohen & Findlay, 2015). The third major function introduced by Vanderah and Gould (2016) is controlled by the right parietal lobe (Hass-Cohen & Findlay, 2015).

From studies regarding right parietal damage (de Renzi, 1982), researchers have found that there is a decrease in accuracy when depicting 3-dimensional objects as well as incompleteness on the left side of artistic productions. Zaidel (2013) reported that these symptoms were present in both artists and non-artist groups. Therefore, these findings do not add to our understanding of “artistic-specialized neural substrates” (p. 3).
Appendix D

Occipital Lobe

At the back of the forebrain, lies the occipital lobe (Figure B1), which contains visual areas of the brain, including the primary visual cortex (Nolte, 1999). The occipital lobe is made up of several functional areas and visual pathways. There are two pathways, also known as the *What* and *Where* streams, which process visual imagery. Hass-Cohen and Findlay (2015) state that the *What* stream flows through the temporal lobe in order to determine image content, color, and texture. The *Where* stream, however, is involved with parts of the parietal lobe responsible for processing visuospatial environmental aspects. The dorsal stream, or *Where* stream, specifically focuses on motor actions.
Appendix E

Temporal Lobe

Beneath the parietal lobe, the temporal lobe, seen in Figure B1, collaborates with Wernicke’s area for language comprehension, but is predominantly responsible for processing general exterior sensory input. This is processed, in part, within the primary auditory cortex, which is seated next to Wernicke’s area. Hass-Cohen and Findlay (2015) specify that it is the left temporal lobe which specializes in language comprehension, as mentioned, as well as word retrieval and verbal memory. Within this lobe, nonverbal memory and sound comprehension are tasks managed on the right half of the temporal lobe. A recent review (Schott, 2012) reported by India Bohanna (2012), found that both the frontal and temporal lobes are involved in creativity. This study found that should the temporal lobe become damaged or naturally deteriorate as the result of a degenerative disease, the frontal lobe would be released from the temporal lobe’s, “mutually inhibitory nature”, (p. 1960) resulting in enhanced creativity.
Appendix F

Limbic System

*Figure F1.* A portion of the limbic system in lateral view, which resides underneath the cerebrum.
Appendix G

Cortices of the Brain

Making sense of the world requires that the brain and environment interact through the body’s somatosensory system via connections of light, sound waves, and pressure (Carter et al., 2009). External stimuli are transmitted as electrical signals to areas of the cerebral cortex, which is involved in the coordinated processing of sensations including, sight, sound, touch, smell, and taste (Carter et al., 2009). The sensory system processes external stimuli and internally create neural connections, related to memory, emotion, and other internal drivers (Sadock & Sadock, 2007). Association material from the sensory system provide a stimulus for actions to the motor system. While an abundance of sensory information enters the brain, only a small amount is made visible to conscious sensation. Some of this sensory information is immediately extinguished, the rest are considered to be unconscious sensations, which influence our behaviors (Carter et al., 2009).

According to Sadock and Sadock (2007), motor system information processing is modulated by cortical influence. The basal ganglia (Figure D1) makes up a portion of nerve-cell bodies, called nuclei, located in the midbrain, which are involved in motor control (Carter, Aldridge, Pager, & Parker, 2009). These nuclei oversee the smooth integration of sensory input and output responses. Involvement of the basal ganglia system includes planned movement and unconscious learned coordination with rapid response. Meaning that, the functional response of these intricate systems requires cooperation from each area, while any component that does not relay the circuitry signals impedes the motor response.

The motor system, central nervous system (CNS), and peripheral nervous system (PNS) are integrated and interdependent. According to Hass-Cohen and Findlay (2015), the
organization of the motor system could be considered a *three-tier schematic*. Tier one, the highest, includes the parietal, temporal, and frontal lobes of cortical association. In the middle, tier two, the motor cortex and subcortical structures are the thalamus, hypothalamus, and cerebellum. Lastly, the third tier incorporates the spinal cord and brainstem (Kalat, 2012). Reconsidering views that motor and sensory organization are separate means that, “...sensory pathways also carry copies of the motor instructions so that sensorimotor processing is unified throughout all levels of thalamocortical functions” (Sherman & Guillery, 2011, p. 1075). The higher association circuits receive information from the middle level; in particular, the basal ganglia support emotional regulation and the cerebellum (Hass-Cohen & Findley, 2015).

*Figure G1.* Cortices including the primary visual, somatosensory, primary auditory, primary motor, and two areas of the cerebral cortex, Broca’s and Wernicke’s area.
The cerebellum coordinates signals from the motor cortex to integrate the motor neurons (Carr et al., 2009), this process modulates movements with concern to precise timing. The cerebellum facilitates a variety of functions, such as retaining memories of fine motor sequences. This particular function is significant to our current study, evaluating cortical activity in relation to fine motor movements. Lower levels of the motor system transmit information to the middle level and receives commands from the higher levels (Hass-Cohen & Findlay, 2015). In relation to art making, this sequence begins when, “one picks a paintbrush, the motor cortex receives the information and, in turn, sends the appropriate messages to the hand. The hand’s muscles adjust and balance fine motor actions, allowing one to fulfill the action and load the brush with paint, thus allowing art making to become an executed reality” (Hass-Cohen & Findlay, 2015, p. 62). This mind-body connection is integrated in the neuroscience of processing sensation, association, and movement.
Appendix H

Theoretical Motor Neuron Location

Figure H1. Keysers & Gazzola (2009) stated that mirror neurons can be found in the (1) premotor cortex, (2) inferior parietal lobe, (3) temporal lobe, and the (4) supplementary motor cortex. McGregor & Gribble’s (2015) findings supported previous reports, but argued that mirror neurons are a part of an action observation network, which also include the (5) primary somatosensory cortices, (6) primary motor cortex, (7) the middle temporal visual area (V5/MT), and the (8) superior parietal lobe.
Appendix I

Visual Processing Systems of the Brain

This research concerns the cerebrum, which includes the frontal parietal, occipital, and temporal lobes, cortices, corpus callosum and their functional responses (Evans-Michaels, 2010). While those functions may be specified to a degree a contextual perspective accounts for the system of the brain’s activities. Reducing the functions of the lobes and cortices does not provide an understanding of the brain’s interactive and interconnect system. The nervous system is a complex network of neural activity that accounts for every aspect of life’s basic and higher functions (Ashwell, 2012).

*Figure 11.* The translation of exterior visual stimuli within the visual processing system. Light enters through the cornea, working with the lens to light onto the retina at the back of the eye.
The nervous system is made up of the central nervous system, which includes the brain and spinal cord and the peripheral nervous system, which includes sympathetic nervous system (SNS) ganglia and peripheral nerves (Evans-Martin, 2010). The coordination and complexity of the nervous system cannot be replicated and function include a control center, central relay center, transduction, motor commands, homeostasis, stress response, and digestion (Evans-Martin, 2010). According to Telesford et al. (2011), networks do not need to be anatomically connected to influence functions, and this happens through a force of temporal correlations. Limitations of a reduced, independent approach of networks renders an incomplete study of the brain (Telesford et al., 2011). Using network science as a framework and approach to brain studies is crucial to value the complex system of the brain.

In an effort to better comprehend the field of neuroaesthetics, we must first understand the neuroanatomy behind viewing images. The sensation of sight is processed in the visual cortex, which is part of the brain’s visual processing system; taking exterior information and distributing it to other cortices (Nolte, 1999). In the act of observing a piece of art, it is the visual processing system that translates visual details gleaned from the production into readable information. The lens and cornea (Figure I1) work together to refract photons (Nolte, 1999). This means an image can be created and then shone on the retina. In order for the photons to be understood as an image to other areas of the brain, the retina translates the visual information into pulses, which are then carried to the optic chiasm via the optic nerve (Nolte, 1999). Once these pulses reach the optic chiasm (Figure I2), the optic nerves decussate, or cross, making right become left (Vanderah & Gould, 2016).
Figure 12. A cross section of the brain showing the visual processing system from exterior stimuli (within the left and right visual fields) through the optic nerve to the optic chiasm, lateral geniculate nucleus, and finally, the primary visual cortex.

Many of the optic nerve fibers end once they have reached the lateral geniculate nucleus, (LGN) which connects the optic nerve behind the eye to the occipital lobe and primary visual cortex, or V1, situated at the back of the brain (Figure I3). Within the visual processing system, the first visual area, V1, detects the edges of objects and assists in spatial organization. V2 aids in depth perception while V3 helps to understand the speed and directionality of the visual object. The fourth visual area, V4, is known as the color center, leaving V5, the motion center (Zeki, 1999a).
The functional specialization of the visual cortex has been explored (Watson et al., 1993; Zeki et al., 1991) adding to previous literature supporting the claim that rCBF can be significantly affected following the presentation of a moving stimuli in more areas than the primary visual area. This increase in blood flow indicates that certain areas of the brain are being activated. However, V1 and V2 (Figure I3) have also been found to activate when participants view objects in motion (Zeki et al., 1991). The excitation of V1 is due to its role as primary receptor from the retina, while V2 becomes activated my motion after V1 distributes the visual signal through its site. Due to the acceptance and delegation of visual stimuli, both V1 and V2 are activated by all types of visual stimulations (Zeki et al., 1991). Research such as this helps better our understanding of the visual and motor cortices.
Neuroaesthetic pioneer and theorist Ramachandran (1999) and his colleague Hirstein proposed the eight laws of the aesthetic experience in their text *The Science of Art: A Neurobiological Theory of Aesthetic Experience*. Ramachandran and Hirstein (1999) theorized that these eight laws (Figure J1) aid our understanding of design, visual art, and aesthetics.

*Figure J1.* Eight laws of the aesthetic experience, by Ramachandran and fellow researcher, Hirstein (1999), outlined in one 35mm print photograph, *Still Walk*. The eight laws are, (1) peak shift experience, (2) grouping, (3) isolation, (4) contrast, (5) symmetry, (6) generic viewpoint, (7) perceptual problem solving, and (8) visual metaphor.
These laws are meant to convey a set of universal principles, a common denominator of art, which can be applied across cultures. The principles, or laws, of their essay suggest heuristics that artists either consciously or unconsciously create art to excite the visual areas of the brain (Ramachandran & Hirstein, 1999). While Ramachandran references photographs multiple items as an antagonist to support the eight laws, the inclusion in this essay is to broaden the semantics of these principles (Figure J2).

*Figure J2. Still Walk, a 35mm film photograph printed in 2014, on 1M black and white variable contrast glossy paper.*

The definition of art is considered ad nauseam, its visceral impact is accepted without question. Therefore, the survival value of art lies within the eight laws of aesthetic experience albeit as an aphorism. To begin with the (1) peak shift principle, is a psychological phenomenon
in discrimination learning. The first law stems from animal discrimination learning. Here, the peak shift effect relates to aesthetic preference and pattern recognition in humans by capturing the essence of an object to elicit an emotional response (Ramachandran & Hirstein, 1999). In animal studies, rats were trained to recognize a square and rectangle with an aspect ratio of 3:2, when a rectangle with a ratio of 4:1 was introduced the rats preferred the latter. It is perhaps the rectangularity of the shape that excited the preference (Ramachandran & Hirstein, 1999). The peak shift principle is important to the evocativeness of art where by what is essential becomes amplified and many times through characterization.

As a form, the feminine physique is characteristically more sensuous than the angular masculine physique (Ramachandran & Hirstein, 1999). In Still Walk, the area of peak shift is exhibited in the pelvis of the mannequin's feminine form. This amplification in the exaggerated female figure is represented in contrasting form, tone and compositional perspective. This choice has characterized an essence of the female pelvis. As Ramachandran and Hirstein (1999) point out, the image amplified in femininity on the female/male spectrum, results in “a ‘super stimulus’ in the domain of male/female differences” (Ramachandran & Hirstein, 1999, pg. 18). For comparison, a masculine mannequin form is unlikely to evoke the same degree of provocation. Men are constrained in various postures due to anatomical differences. In the view of Ramachandran & Hirstein (1999), this works “to subtract the male posture from the female posture to produce a caricature in ‘posture space’ thereby amplifying ‘fem-inine posture’ and producing a correspondingly high limbic activation” (p. 18). In ‘still walk’ the limbic activation and peak shift principle is pronounced in the pelvis of the mannequin’s feminine form, as an area of essentiality.

The second law (2) grouping is a binding and reinforcing process that developed early in
the visual processing system (Ramachandran & Hirstein, 1999). Perceptual binding and grouping is explained as a reinforcing task for individuals. This law is essentially saying that the act of perceptual grouping, or separating a figure from its background, can be a pleasurable act.

In order to locate predators, the visual system has evolved to detect objects in the visual field. For example, by grouping foliage in the visual field and then the camouflaged lion from one another, binding of the two objects is alerted in the brain as a survival mechanism. In ‘still walk’ the area of contrasting shapes in the upper left hand corner is an example of grouping. An example is in problem solving that the area is a shadow stream through foliage from a tree outside the frame. Binding in the brain of the harmless leaves, without an alert of an additional predatory object, say a crow about to attack, decreases the limbic system activation.

The last main principle of the eight laws is (3) isolation. It refers to a single visual modality, which is relevant to the form and shape. Isolation, refers to the act of isolating a single module, or aspect of an object, prior to “allocating attention” (Ramachandran & Hirstein, 1999). Essentially, this principle can be explained by the use of outlines or sketches as an artistic product to direct the viewer’s attention to one area, such as depth or form. Ramachandran and Hirstein (1999) theorize that because an individual can focus his/her attention more fully on one piece of the original image after being isolated, it can be considered more aesthetically appealing than an image of the original object. This is a process to extract what’s critical and discard what is irrelevant or cluttered and then introduce peak shift as a degree of exaggeration (Ramachandra & Hirstein, 1999). An outline of the mannequin’s bust from head to neck in ‘still walk’ demonstrates the principle of isolation. The focus here is on the salient areas of the profile and eliminating what’s irrelevant. In this instance the form appeals to, less is more.

The next five principles of the eight laws of aesthetic experience are comparatively lucid
concepts. Similar to grouping in the action of extracting reinforced information, (4) contrast is a phenomenon in the visual system that responds to edges (step changes in luminance) of color and not homogenous surface tone (Ramachandran & Hirstein, 1999). The fourth law, contrast, eliminates extraneous detail and thereby focuses the viewer’s attention. Researchers suggest that by formulating edges and creating contrast via changes in luminance, an image can become more pleasing (Ramachandran & Hirstein, 1999). Contrasts in the darkroom print ‘still walk’ exist in tonal changes of the exposure on light sensitive paper to create a photographic emulsion. Steps in tone contrast appear across the spectrum of white in the mannequin’s leg, blackened tones in between and shades of grey off the fading wall.

(5) Symmetry is the fifth law of aesthetic experience. Ramachandran and Hirstein (1999) reference the work of evolutionary biologists, which concludes that human beings show a preference towards symmetry due to parasitic infestation, which previously led to asymmetrical growths. These results suggest that, “we have a build-in aesthetic preference for symmetry” (Ramachandran & Hirstein, 1999, p. 27). As a common aesthetic preference, symmetry is considered biologically relevant in mate selection as a mechanism to avoid disease (Ramachandran & Hirstein, 1999). In a more obvious instance symmetry may imply the solidity of a form. The structured background wall in ‘still walk,’ where the mannequin’s loll is discernibly symmetrical. This is without coincidence since that wall is the exterior of an architecture college.

Aesthetics of vantage point, lie in the (6) generic viewpoint, which is favored by the visual system for not being suspiciously coincidental (Ramachandran & Hirstein, 1999). The law of generic viewpoint states that the human visual system has an aversion to interpretations that require a specific vantage point. The reason for this trust in generic viewpoints is the visual
system has a larger set of associations for this vantage point and therefore finds a unique vantage point as improbable and an occlusion (Ramachandran & Hirstein, 1999). In ‘still walk’ the generic viewpoint of the central mannequin’s legs are squared up in direct angle on the frame, which demonstrates this principle. The visual system is not fighting a unique vantage point, there are infinite sets of this eye level, frontal perspective in the visual system.

The seventh law proposed by Ramachandran and Hirstein (1999) introduces perceptual problem solving. They hypothesize that the brain can find aesthetic pleasure in deciphering ambiguous imagery and that “ambiguity itself can be a source of pleasure” (Gooch, 2002, p. 11). An example of (7) problem-solving in aesthetics relates to Ernst Gombrich’s (1973), question of the distaste of a completely bare nude in favor of the allure from a veiled nude. The idea in this instance is the visuals system’s interest in problem-solving what is extracted from the elements and imagined possibilities. The torso of the marked mannequin in ‘still walk’ has been loosely covered in fabric. In congruence with aesthetic problem-solving the covering is partially draped on the torso, with a profiled exposure of the mannequin's form, especially the side breast.

(8) Visual metaphors, more specifically art as metaphors, are discussed in the seventh law of aesthetic experience. Ramachandran (1999) states that a metaphor, “is a mental tunnel between two concepts or percepts that appear grossly dissimilar on the surface” (p. 31). And much like the pleasurable effect of grouping on a viewer, understanding a metaphor, or analogy, in art can be rewarding (Ramachandran & Hirstein, 1999). This is a rhetorical effect which illuminates a reference in art whether that is visual or otherwise. The visual metaphor in ‘still walk’ is between the disjointed immobile mannequin forms and the lively contrast of light, and composition. It then allows the eye to play within the frame to create a story of senses to activate the imagination. The title adds a context scaffold to view the photograph. ‘Still’, being a
motionless quiet and also adverb of timely action. ‘Walk’, is considered as the movement and in, around and out the frame while the senses create a story unique to the viewer. Together ‘still walk’ is the combination of visual movement in the static frame that creates a personal story of a dynamic time and place.

In the present study, our directive art making task, “make a picture of how you’re feeling, using lines, shapes, and colors”, employs this law of visual metaphor as participants make connections between internal emotional states and external art productions. These principles offer logical, biological, and neurophysiological foundations for considering aesthetics. C. P. Snow (1959) talked about two severed cultures of the sciences and humanities. Ramachandran and Hirstein (1999) propose that in the interface of the brain, and perhaps through art these two cultures do meet. Neuroaesthetics, a science of art, offers progressive integration, especially when implemented through the clinical field of art therapy.
Appendix K
Expressive Therapies Continuum

Figure K1. The Expressive Therapies Continuum (ETC) adapted from Hinz (2009). Each component of the ETC lies on a continuum with the Creative Level integrated throughout each level.
Appendix L

Art, Movement, and EEG Flyer

Figure L1. This figure was distributed on a university campus and within the surrounding community of a capital city in the Midwest.
Appendix M

Art Therapy & Neuroscience Logo

*Figure M1.* This logo was created using subject ARP005’s art making response to replicate common brain mapping imagery.
Appendix N

Indiana University Informed Consent Statement: IRB Approval #150739860

PROTOCOL TITLE: Cortical Activity Patterns in Art Making versus Fine Motor Movement as Measured by EEG

Sponsor: Juliet King, Dragos Sabau, Leisha Osburn

Principal Investigator: Juliet King, MA, ATR-BC, LPC

Research Site Address: Neuroscience Center of Excellence
355 West 16th Street
Indianapolis, IN 46202-2267

Daytime Telephone #: 317-963-7382
Emergency #: 317-944-5000 and ask the operator to page Dr. King. After business hours, ask the operator to page the neurologist on call.

Coordinator: Sandy Guingrich, LPN, CCRC
Phone #: 317-963-7382
Emergency #: 317-312-1539; after the tone, enter your phone number & press the # key

You are invited to participate in a research study of the effects of art therapy in cortical function. We ask that you read this form and ask any questions you may have before agreeing to be in the study. The study is being conducted by Juliet King, Director of Art Therapy, Herron School of Art & Design, Dr. Dragos Sabau, Department of Neurology, Leisha Osburn, and graduate assistants Alex Shaikh and Kaitlin Knapp.

STUDY PURPOSE:

The purpose of this study is to explore the differences in cortical (cerebral cortex), the part of the brain that plays an important role in our consciousness, function between art making and rote fine motor tasks. Using the quantitative electroencephalogram (qEEG). Electroencephalography (EEG) is the measurement of electrical patterns at the surface of the scalp which reflect brain activity, and are commonly referred to as “brainwaves”. Quantitative EEG (qEEG) is the analysis of the digitized EEG, and is sometimes called “Brain Mapping”. The qEEG is an extension of the analysis of the visual EEG interpretation which may assist and aid our understanding of the EEG and brain function. This information will contribute to current literature on the neuroscience of art making and further provide a framework for the understanding and application of clinical art therapy interventions.

NUMBER OF PEOPLE TAKING PART IN THE STUDY:
If you agree to participate, you will be one of 10 subjects who will be participating in this research.
INCLUSION/EXCLUSION CRITERIA

Participants must be 18 years or older and able to consent for themselves. If you have a prior history of major head injury, stroke, seizure disorder, brain or skull surgery or are taking psychotropic medications or other medications that can affect EEG recording, you will be excluded from participation in this study.

PROCEDURES FOR THE STUDY:

If you agree to be in the study, you will do the following things:

Electrical impulses in the brain are evaluated using an EEG. The test measures the electrical activity through several electrodes placed on your scalp. An electrode is a conductor through which an electric current can pass safely. The electrodes transfer information from your brain through wires to an amplifier and a machine that measures and records the data.

The test involves the following steps:

To obtain a baseline control, rest measurements will be taken by asking the participant to remain still, close their eyes, and open their eyes. Electrical impulses in the brain are evaluated using an EEG. The test measures the electrical activity through several electrodes placed on a participant’s scalp. An electrode is a conductor through which an electric current can pass safely. The electrodes transfer information from the brain through wires to an amplifier and a machine that measures and records the data. The test involves the following steps:

- The participant will be asked to sit in a chair at a table
- The technician will measure the participant’s head and use a pencil to mark where electrodes will be attached to the scalp. These spots are then scrubbed with a special cream that helps the electrodes get a high-quality reading.
- The technician will put a sticky gel adhesive on 16 to 25 electrodes and will place these electrodes at various spots on the scalp. The electrodes look like flat metal disks.

Once the test begins, the electrodes send electrical impulse data from the brain to the recording machine. This machine converts the electrical impulses into visual patterns that can be seen on a screen and are saved to a computer. On the screen, the electrical impulses look like wavy lines with peaks and valleys. The participants may be directed by the technician to do certain things while the test is in progress, such as remain still and to open or close your eyes. In this study, the technician will prepare the subject and either the PI or the graduate research assistants will provide the directives in the presence of the technician, who will consistently monitor to ensure ease of data collection and control for artifact. Artifact in EEG is electrical data gathered from areas other than the cerebral cortex such as from other body parts or elements in the environment. After the directives are complete, the technician will remove the electrodes. During the directives, very little electricity is passed between the electrodes and the participant’s skin. The electrodes do not send any sensations, and the participants will feel little to no discomfort.

The directives include:
1. To sit still with electrodes on long enough to gather a baseline measure
2. To engage in a directive drawing task; for example: “Draw a picture of how you feel using lines, shapes and colors.”
3. A rote motor task, such as flipping a coin and rotating a pen in hand.

*Note: It is not necessary to have artistic ability to participate!

Each task will be no longer than 15 minutes in duration, for a total of 1 hour and approximately 15 minutes to set up the electrodes and clean up afterwards for a total of 1.5 hours of time, at most.

RISKS OF TAKING PART IN THE STUDY:

You might experience some mild discomfort from the electrode adhesive, similar to a Band-Aid, but since the recording is passive, you will not experience any additional feeling or discomfort. There is a potential risk of loss of confidentiality.

BENEFITS OF TAKING PART IN THE STUDY:

There are no immediate benefits to you as an individual from taking part in this study. We anticipate that the information acquired from your participation (and that of other subjects) will provide foundational evidence for the further exploration of how, and why, art therapy is an effective form of therapy and will help to assess and refine the clinical treatment therein.

ALTERNATIVES TO TAKING PART IN THE STUDY:

Instead of being in this study, you have the option not to participate.

CONFIDENTIALITY:

Efforts will be made to keep your personal information confidential. We cannot guarantee absolute confidentiality. Your personal information may be disclosed if required by law. Your identity will be held in confidence in reports in which the study may be published and in databases in which the results may be stored.

Organizations that may inspect and/or copy your research records for quality assurance and data analysis include groups such as the study investigator and his/her research associates, the Indiana University Institutional Review Board or its designees, the study sponsors and (as allowed by law) state or federal agencies, specifically the Office for Human Research Protections (OHRP) who may need to access your medical and/or research records.

By signing this informed consent form, you will be giving permission for the following productions created during this session to be used for the purposes of scientific research. I understand that this consent may include possible references to my art and/or the process of art making in scientific publications and/or presentations pertaining to art therapy.
COSTS:

The costs of the study will be covered by the sponsor of the study. You and your insurance company will not be charged for the testing done as a part of this study.

PAYMENT:

You will not receive payment for taking part in this study.

CONTACTS FOR QUESTIONS OR PROBLEMS:

For questions about the study, contact the researcher Dr. King at (317) 963-7404 (the phone is answered 24 hours a day). This number may also be used in case of emergencies.

If you cannot reach the researcher during regular business hours (i.e. 8:00AM-5:00PM), please call the IU Human Subjects Office at (317) 278-3458.

For questions about your rights as a research participant or to discuss problems, complaints or concerns about a research study, or to obtain information, or offer input, contact the IU Human Subjects Office at (317) 278-3458 or (800) 696-2949.

VOLUNTARY NATURE OF STUDY:

Taking part in this study is voluntary. You may choose not to take part or may leave the study at any time. Leaving the study will not result in any penalty or loss of benefits to which you are entitled. Your decision whether or not to participate in this study will not affect your current or future relations with IU Health, Indiana University or Herron Art School & Design.

SUBJECT'S CONSENT:

In consideration of all of the above, I give my consent to participate in this research study.

I will be given a copy of this informed consent document to keep for my records. I agree to take part in this study.

Subject’s Printed Name: ____________________________________________

Subject’s Signature: ___________________________ Date: ____________

(Printed Name of Person Obtaining Consent: ____________________________)

Signature of Person Obtaining Consent: ________________ Date: ____________
Appendix O

Indiana University Demographics Survey

PROTOCOL TITLE: Cortical Activity Patterns in Art Making versus Fine Motor Movement as Measured by EEG

CONFIDENTIALITY NOTICE:

Efforts will be made to keep your personal information confidential. We cannot guarantee absolute confidentiality. Your personal information may be disclosed if required by law. Your identity will be held in confidence in reports in which the study may be published and in databases in which the results may be stored.

Organizations that may inspect and/or copy your research records for quality assurance and data analysis include groups such as the study investigator and his/her research associates, the Indiana University Institutional Review Board or its designees, the study sponsors and (as allowed by law) state or federal agencies, specifically the Office for Human Research Protections (OHRP) who may need to access your medical and/or research records.

Name: _______________________________  Subject ID: _______________________________
Age: _______________________________  Gender: _______________________________

Level of artistic training (please circle the one, which most applies):

No experience  Some experience  Formal training

By signing below, I certify that all information listed above is true and correct to the best of my knowledge.

Signature: ____________________________________  Date: ___________________________
Appendix P

Script for Data Collection

Please have a seat. For the next 2 hours you will be participating in a study that helps us learn about brain function and art. First, we will have you read and sign the informed consent form. Please let either of the graduate research assistants know if you have any questions.

Next, Bonnie, the technician will place the EEG electrodes on your scalp. This process will take approximately 30 minutes. First, Bonnie will measure your head with a pencil to mark where electrodes will be placed. These spots will be scrubbed with a special cream, which helps the electrodes obtain a high-quality reading. Finally, she will apply a sticky gel adhesive on the electrodes and place them on the previously marked areas.

The electrodes will send electrical impulse data from your brain to the recording machine, which converts this data into visual patterns on a computer. We expect the data to change over time from the requested tasks you will be asked to complete. There should be no discomfort during the recording.

During the EEG recording, you will be asked to complete a baseline measure three times, which will last 12 minutes and take place between each of our interventions. During the baseline measure, we will ask you to open and close your eyes for 3 minutes at a time.

Let’s begin with the first baseline measure. We ask that you keep your eyes open for the next 3 minutes, please blink normally during this time. Now close your eyes. I’m going to ask that you open your eyes again. Now please close your eyes once more.

We will now begin the art making intervention. Use the 12 pack of chalk pastels and 12” x 18” sheet of white paper with the pre-drawn circle provided to explore “how you’re feeling using lines, shapes, and colors in the circle.” You will have 12 minutes to complete this task,
please continue to make art for the duration of this task. You will not be judged based on the artwork created, there is no right or wrong way to complete this task. This concludes the art making intervention.

We will now begin the second baseline measure. Again, we ask that you keep your eyes open for the next 3 minutes, please blink normally during this time. Now close your eyes. Please open your eyes. Once more, please close your eyes.

We will now begin the movement intervention. This intervention will be divided into two 6 minute tasks. For the first 6 minutes we will ask you to continually flip a coin. Next, we will ask that you rotate a pencil between your fingers using your dominate hand for the remaining 6 minutes. You may begin flipping the coin. Now you may begin rotating the pencil between your fingers using your dominate hand. This concludes the movement intervention.

We will now begin the last baseline measure. Again, we ask that you keep your eyes open for the next 3 minutes, please blink normally during this time. Now close your eyes. Please open your eyes. Once more, please close your eyes.

This concludes our study. Thank you for your participation. We will now begin removing the EEG electrodes.
Appendix Q

Subjects’ Artwork

*Figure Q1*: Subjects’ Artwork. Created with the directive, “explore how you feel using lines, shapes, and colors” within 12 minutes.

Of the ten subjects, self-reported artistic experience: six no experience (NE), three some experience (SE), one formal training (FT).

Top left to right, subject and self-reported level of artistic training: ARP001, NE; ARP002, SE; ARP003, NE; ARP004, NE; ARP005, FT; ARP006, NE; ARP007, NE; ARP008, SE; ARP009, NE; ARP010, SE.
Table R1. Recordings of the EEG data were performed for epochs and subsets of time, as detailed here. Control data were obtained through comparison of Epoch 1 Subset 4 to Epoch 1 Subset 2. Epoch 1, Subsets 2 and 4 were combined to form the Baseline (Eyes Closed) data set. Epoch 3, Subsets 2 and 4 were combined to form the After Art Making (Eyes Closed) data set. Epoch 5, Subsets 2-4 were combined to form the After Motor Tasks (Eyes Closed) data set.
Appendix S

Table S1: Channel Groupings of Electrodes for Quantitative EEG Analysis

<table>
<thead>
<tr>
<th>Left Hemisphere</th>
<th>F7-aF7, T3-aT3, T5-aT5, O1-aO1, F3-aF3, C3-aC3, P3-aP3</th>
<th>Right Hemisphere</th>
<th>F8-aF8, T4-aT4, T6-aT6, O2-aO2, F4-aF4, C4-aC4, P4-aP4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left Frontal</td>
<td>F7-aF7, F3-aF3</td>
<td>Right Frontal</td>
<td>F8-aF8, F4-aF4</td>
</tr>
<tr>
<td>Left Temporal</td>
<td>T3-aT3, T5-aT5</td>
<td>Right Temporal</td>
<td>T4-aT4, T6-aT6</td>
</tr>
<tr>
<td>Left Central-Parietal</td>
<td>C3-aC3, P3-aP3</td>
<td>Right Central-Parietal</td>
<td>C4-aC4, P4-aP4</td>
</tr>
<tr>
<td>Left Posterior Temporal-Occipital</td>
<td>T5-aT5, O1-aO1</td>
<td>Right Posterior Temporal-Occipital</td>
<td>T6-aT6, O2-aO2</td>
</tr>
</tbody>
</table>

*Table S1.* Indicates the channel groupings used for the Quantitative EEG Analysis, separated into left and right hemispheres; left and right frontal regions; left and right temporal regions; left and right central-parietal regions; left and right temporal-occipital regions. For this preliminary data analysis, only the channel groupings of Left and Right Hemisphere were analyzed. All channel groupings will undergo analysis in future studies.
Appendix T

Table T1: Pairwise Comparison by Subject Frequency, Location

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Estimate</th>
<th>StdErr</th>
<th>DF</th>
<th>t-value</th>
<th>Probt</th>
<th>Adjustment</th>
<th>Adjp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left Hemisphere</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-2 HZ</td>
<td>-0.01422</td>
<td>0.02072</td>
<td>115</td>
<td>-0.69</td>
<td>0.494</td>
<td>Tukey-Kramer</td>
<td>0.772</td>
</tr>
<tr>
<td>2-4 HZ</td>
<td>-0.02298</td>
<td>0.02409</td>
<td>135</td>
<td>-0.95</td>
<td>0.3418</td>
<td>Tukey-Kramer</td>
<td>0.6073</td>
</tr>
<tr>
<td>4-6 HZ</td>
<td>-0.003183</td>
<td>0.01836</td>
<td>180</td>
<td>-0.17</td>
<td>0.8625</td>
<td>Tukey-Kramer</td>
<td>0.9836</td>
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<tr>
<td>6-8 HZ</td>
<td>0.05006**</td>
<td>0.0114</td>
<td>237</td>
<td>4.39</td>
<td>&lt;.0001</td>
<td>Tukey-Kramer</td>
<td>&lt;.0001</td>
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<tr>
<td>8-10 HZ</td>
<td>0.1082**</td>
<td>0.01664</td>
<td>181</td>
<td>6.5</td>
<td>&lt;.0001</td>
<td>Tukey-Kramer</td>
<td>&lt;.0001</td>
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<tr>
<td>10-12 HZ</td>
<td>0.1319**</td>
<td>0.02012</td>
<td>165</td>
<td>6.55</td>
<td>&lt;.0001</td>
<td>Tukey-Kramer</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>12-14 HZ</td>
<td>0.1167**</td>
<td>0.0166</td>
<td>166</td>
<td>7.03</td>
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<td>Tukey-Kramer</td>
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<tr>
<td>14-16 HZ</td>
<td>0.08742**</td>
<td>0.01203</td>
<td>173</td>
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<tr>
<td>16-18 HZ</td>
<td>0.0506**</td>
<td>0.008826</td>
<td>122</td>
<td>5.73</td>
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<tr>
<td>18-20 HZ</td>
<td>0.02398*</td>
<td>0.009734</td>
<td>107</td>
<td>2.46</td>
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<td>20-22 HZ</td>
<td>0.01424</td>
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<td>26-28 HZ</td>
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<td>0.01527</td>
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<td>1.1</td>
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<td>28-30 HZ</td>
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<td>0.01677</td>
<td>69.6</td>
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<td>30-32 HZ</td>
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<table>
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<th>t-value</th>
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<th>Adjustment</th>
<th>Adjp</th>
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<tbody>
<tr>
<td>Right Hemisphere</td>
<td></td>
<td></td>
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Subject ARP003 After Art Making Task to Baseline

**Left Hemisphere**

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Subject ARP003 After Art Making Task to Baseline

**Right Hemisphere**

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Subject ARP005 After Motor Tasks to Baseline

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### Subject ARP006 After Art Making Task to Baseline

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### Subject ARP007 After Art Making Task to Baseline

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Subject ARP007 After Motor Tasks to After Art Making

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### Subject ARP008 After Motor Tasks to After Art Making

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### Subject ARP009 After Motor Tasks to After Art Making

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Subject ARP010 After Art Making Task to Baseline

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Subject ARP010 After Art Making Task to Baseline

### Right Hemisphere

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<td>0.00476</td>
<td>163</td>
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<td>0.0388</td>
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<td>0.00455</td>
<td>164</td>
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<td>0.6341</td>
<td>Tukey-Kramer</td>
<td>0.8823</td>
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Table T1. This table details a pairwise comparison by subject, frequency and location, showing estimated mean differences of power after art making task to the baseline, after motor tasks to the baseline, and after motor tasks to after art making task for each subject. Cells with * indicate p < 0.05; cells with ** indicate p < 0.05 and have an estimated mean difference above 0.045 threshold.
Table U1: Pairwise Comparison by Frequency, Location

<table>
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<tr>
<th>Frequency</th>
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<th>DF</th>
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<th>Probt</th>
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<th>Adjp</th>
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<tr>
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<tr>
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<td>4-6 HZ</td>
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<tr>
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<td>&lt;.0001</td>
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<td>&lt;.0001</td>
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<tr>
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### After Motor Tasks to Baseline

#### Left Hemisphere

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<th>t-value</th>
<th>Probt</th>
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#### Right Hemisphere

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<th>Adjustment</th>
<th>Adjp</th>
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Table U1. This table details a pairwise comparison by frequency and location, showing estimated mean differences of power after art making task to the baseline, after motor tasks to the baseline, and after motor tasks to after art making task. Cells with * indicate p < 0.05; cells with ** indicate p < 0.05 and have an estimated mean difference above the 0.045 threshold or below the -0.45 threshold.
Appendix V

Table V1: Pairwise Comparison Slice by Artistic Experience by Frequency, Location

<table>
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<tr>
<th>Frequency</th>
<th>Estimate</th>
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<th>DF</th>
<th>t-value</th>
<th>Probt</th>
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<th>Adjp</th>
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### After Motor Tasks to Baseline - Some Experience

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## After Motor Tasks to After Art Making Task - No Experience

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### After Motor Tasks to After Art Making Task - Some Experience

#### Left Hemisphere

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#### Right Hemisphere

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<th>DF</th>
<th>t-value</th>
<th>Probt</th>
<th>Adjustment</th>
<th>Adjp</th>
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### Table V1. Cells with * indicate p < 0.05; cells with ** indicate p < 0.05 and have an estimated mean difference above 0.045 threshold. This represents a pairwise comparison slice by level of artistic experience (no experience, some experience, and formal training).
Table W1: Baseline Difference Control

<table>
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<th>Frequency</th>
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<th>Right Hemisphere</th>
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<tr>
<td>10-12 HZ</td>
<td>-0.02767**</td>
<td>0.01068</td>
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<td>12-14 HZ</td>
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<td>22-24 HZ</td>
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<td>24-26 HZ</td>
<td>0.02055***</td>
<td>0.006174</td>
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<tr>
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<td>30-32 HZ</td>
<td>0.02948***</td>
<td>0.006113</td>
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*Table W1.* This table shows estimated mean differences of left and right hemisphere power by frequency and location, for the Baseline (Eyes Closed) epoch 1 subset 4 compared to the Baseline (Eyes Closed) epoch 1, subset 2 (see Table 1. Procedure Time with Epoch Notation). Cells with * indicate p < 0.05; cells with ** indicate p < 0.01; cells with *** indicate p < 0.001.
Appendix X

Table X1: Demographics

<table>
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<th>Subject Identification Number</th>
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<td>16-25</td>
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<td>Some Experience</td>
</tr>
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<td>No Experience</td>
</tr>
<tr>
<td>ARP004</td>
<td>56-65</td>
<td>Right</td>
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<tr>
<td>ARP005</td>
<td>16-25</td>
<td>Right</td>
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</table>

*Table X1.* Shows de-identified demographic information for all 10 subjects, handedness, and artistic experience (self-report of no experience, some experience, or formal training).
Appendix Y

Pairwise Comparison by Frequency, Location

Figure Y1. Shows a pairwise comparison of the EEG power for After Art Making to Baseline, and After Motor Tasks to Baseline, by frequency for the left hemisphere. Additionally, comparison of 2 separate pre-intervention data collections, is shown as Pre-Intervention Control, demonstrating variation in power that has been used to establish an estimated mean difference threshold of 0.045 and -0.045. Each data point from frequencies 0-2 HZ through 28-32 HZ is indicated. Points with a circle show that the estimated mean difference for that frequency was statistically significant (p < 0.05).
**Figure Y2.** Shows a pairwise comparison of the EEG power for After Art Making to Baseline, and After Motor Tasks to Baseline, by frequency for the right hemisphere. Additionally, comparison of 2 separate pre-intervention data collections, is shown as Pre-Intervention Control, demonstrating variation in power that has been used to establish an estimated mean difference threshold of 0.045 and -0.045. Each data point from frequencies 0-2 HZ through 28-32 HZ is indicated. Points with a circle show that the estimated mean difference for that frequency was statistically significant (p < 0.05).
Appendix Z

Pairwise Comparison Slice by Artistic Experience Frequency, Location

Figure Z1. Shows a pairwise comparison of the EEG power for After Art Making Tasks to Baseline by frequency for artistic experience (no experience, some experience, and formal training) in the left hemisphere. Additionally, comparison of 2 separate pre-intervention data collections, is shown as Pre-Intervention Control, demonstrating variation in power that has been used to establish an estimated mean difference threshold of 0.045 and -0.045. Each data point from frequencies 0-2 HZ through 28-32 HZ is indicated. Points with a circle show that the estimated mean difference for that frequency was statistically significant (p < 0.05).
Figure Z2. Shows a pairwise comparison of the EEG power for After Art Making Tasks to Baseline by frequency for artistic experience (no experience, some experience, and formal training) in the right hemisphere. Additionally, comparison of 2 separate pre-intervention data collections, is shown as Pre-Intervention Control, demonstrating variation in power that has been used to establish an estimated mean difference threshold of 0.045 and -0.045. Each data point from frequencies 0-2 HZ through 28-32 HZ is indicated. Points with a circle show that the estimated mean difference for that frequency was statistically significant (p < 0.05).
**Figure Z3.** Shows a pairwise comparison of the EEG power for After Motor Tasks to Baseline by frequency for artistic experience (no experience, some experience, and formal training) in the left hemisphere. Additionally, comparison of 2 separate pre-intervention data collections, is shown as Pre-Intervention Control, demonstrating variation in power that has been used to establish an estimated mean difference threshold of 0.045 and -0.045. Each data point from frequencies 0-2 HZ through 28-32 HZ is indicated. Points with a circle show that the estimated mean difference for that frequency was statistically significant (p < 0.05).
Figure Z4. Shows a pairwise comparison of the EEG power for After Motor Tasks to Baseline by frequency for artistic experience (no experience, some experience, and formal training) in the right hemisphere. Additionally, comparison of 2 separate pre-intervention data collections, is shown as Pre-Intervention Control, demonstrating variation in power that has been used to establish an estimated mean difference threshold of 0.045 and -0.045. Each data point from frequencies 0-2 HZ through 28-32 HZ is indicated. Points with a circle show that the estimated mean difference for that frequency was statistically significant (p < 0.05).
Figure Z5. Shows a pairwise comparison of the EEG power for After Motor Tasks to the After Art Making Task by frequency for artistic experience (no experience, some experience, and formal training) in the left hemisphere. Additionally, comparison of 2 separate pre-intervention data collections, is shown as Pre-Intervention Control, demonstrating variation in power that has been used to establish an estimated mean difference threshold of 0.045 and -0.045. Each data point from frequencies 0-2 HZ through 28-32 HZ is indicated. Points with a circle show that the estimated mean difference for that frequency was statistically significant (p < 0.05).
Figure Z6. Shows a pairwise comparison of the EEG power for After Motor Tasks to the After Art Making Task by frequency for artistic experience (no experience, some experience, and formal training) in the right hemisphere. Additionally, comparison of 2 separate pre-intervention data collections, is shown as Pre-Intervention Control, demonstrating variation in power that has been used to establish an estimated mean difference threshold of 0.045 and -0.045. Each data point from frequencies 0-2 HZ through 28-32 HZ is indicated. Points with a circle show that the estimated mean difference for that frequency was statistically significant (p < 0.05).