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Articles

Conducting Art Therapy Research Using Quantitative EEG Measures

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Abstract

This study presents a modified, single subject design that measured the patterns of electrical activity of a participant's brain following an hour spent painting and drawing. Paired t *tests were used to compare pre and post art-making electroencephalograph (EEG) data. The results indicated that neurobiological activity after drawing and painting was statistically different (*$p < .05$*) from activity measured at a state of rest. In general, the higher frequency bands (alpha and beta) were characterized by increases in brain activity, whereas the lower frequency bands (delta and theta) showed decreases. This study suggests that the EEG is a useful and innovative tool for conducting art therapy research.*

Introduction

Given the remarkable advancements in imaging technology, neuroscience offers unique observational methods for investigating art therapy practices that do not rely on interpretive frameworks. This article presents a study that expands upon the view that "science will be central to understanding and defining how art therapy actually works" (Malchiodi, 2003, p. 17) and argues that brain imaging techniques may help bridge the gap between art therapy and its foundation in traditional empirical research. In an attempt to work toward a neurological understanding of art therapy, a single subject pilot study was conducted in the biological psychiatry lab at Hines Veteran's Hospital in Hines, Illinois. Using quantitative electroencephalograph (EEG) measures, the authors hypothesized that the EEG would reflect differences in the patterns of electrical activity of a participant's brain following one hour of painting and drawing.

Review of the Literature

Although art therapy has historically been slow to embrace scientific approaches to treatment, theory, and research (Gantt, 1998), there is "a growing awareness of the need to incorporate the findings of neuroscience in the conduct of our profession" (Kaplan, 2004, p. 123). Current art therapy literature has countered earlier beliefs that empirical, science-based models of research are antithetical to art therapy research and clinical methods (Burt, 1995; Junge & Linesch, 1992).

With increased reference to the value of neuroscience in art therapy (see, for example, Kaplan, 2000; McNamee, 2004; Riley, 2004; Stewart, 2004), there is greater understanding of the neurobiological underpinnings inherent in the act of making images. For example, Lusebrink (2004) described the underlying features of the visual information processing systems of the brain and outlined parallels between the various qualities of artistic expression and the brain's organizational structures. Klorer (2005) utilized findings in neuroscience to support her observation that client-centered, non-directive interventions were most effective in her work with traumatized children and their imagery.

The Language of Images and the Grammar of the Brain

Even though "common sense tells us that images do have an impact on how we feel and react," as Malchiodi asserted (2003, p. 18), a greater understanding of how visual images are processed in the brain and ultimately translated into emotional events can provide art therapists with a foundation for assessing, explaining, and refining their work (Lusebrink, 2004). Although art therapy literature has established that images are powerful, there is little evidence to explain why. Within the field of art therapy, "the mechanism of how we actually observe objects visually has not been of major concern" (Riley, 2004, p. 184).

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Neuroscience provides the art therapist an opportunity to experience a new framework to address the most basic tenets of the field.

What is "the language of images" (McNiff, 1998, p. 27)? What does it mean to agree that a shade of blue is "soothing," the lines in a drawing are "aggressive," or a photograph is "honest"? Why does making images help us feel better? Where do artistic images come from? How an image looks is at least partially dependent upon the physical and perceptual properties and laws of the brain's visual system (Livingstone, 2002). Whether the experience of creating or viewing an image makes one happy, sad, excited, or overwhelmed, the emotional impact of an artwork is dependent upon specific neural pathways in the brain, the activation of certain cells and parts of the body, and perceptual cues of the visual cortex (Lusebrink, 2004; Zeki & Lamb, 1994). One cannot speak the language of images without referencing the grammar of the brain. Color theory, depth perception, negative space, and the like are not simply abstract rules; these perceptual phenomena address the means by which the human brain receives, processes, and stores visual stimuli. "All visual art must obey the laws of the visual system" (Zeki & Lamb, 1994, p. 607). Clearly, science and art are intertwined in the process of sensation and perception (Lusebrink, 2004).

Not only does art have a neurological foundation in its perceptual properties, but the emotions evoked from making and viewing art have a neurological component as well. Neuroscientist Daniel Siegel (1999) explained that emotions do not exist in the way we usually think of them. They are not "some kind of packets of something that can be experienced, identified, and expressed, as implied in the statement 'Just get your feelings out.'…Emotions represent dynamic processes created within the socially influenced, value appraising process of the brain" (p. 123).

Human interactions, learning, and the performance of certain activities can all alter the patterns of brain activity as well as a person's emotions (Restak, 2003). "By altering both the activity and the structure of the connections between neurons, experience directly shapes the circuits responsible for such processes as memory, emotion, and self-awareness" (Siegel, 1999, p. 2). It follows that if art therapy affects our emotions, it alters the circuitry and activity of the brain. Conversely, if art therapy alters our brain, one can expect it to affect our emotions. To more fully understand the benefits of the creative act, it is essential to study how the creative experience may shape consciousness and emotions through the alteration of neurological activity.

Electroencephalograph (EEG) Basics

The electroencephalograph (EEG) tracks "the way in which the brain functions through the energy-consuming activation of neurons. The degree and localization of this arousal and activation within the brain—this flow of energy—directly create our mental processes" (Siegel, 1999, p. 3). The EEG picks up this flow of electrical activity through electrodes strategically attached to the scalp (Hughes, 1994). The electrodes are held in place by a tightly fitting headpiece called an EEG net that is strapped firmly to the head and chin. Each electrode connects to a wire that conducts the electrical activity from the head to a designated connection on an electrode board. Brain wave frequencies are measured in Hertz units (numbers of cycles per second) and divided into four kinds of brain waves, which are designated alpha, beta, theta, and delta (Hughes, 1994). These terms describe four different wave speeds (Lawrence, 1972):

1. Delta brain waves are the slowest and are most prominent in states of deep, dreamless sleep;
2. Theta brain waves occur in states of drowsiness, creativity, and the dream portion of the sleep cycle;
3. Alpha brain waves are generally found in relaxed yet alert mental states or shifts of consciousness; and
4. Beta brain waves are the fastest and are linked to attending, orienting, and coping skills applied to everyday concerns as well as with states of anxiety.

In addition to describing electrical activity as frequency bands, the EEG also measures the amplitude of brain activity (expressed in micro volts [µV] or percentages at each electrode) in terms of absolute and relative power respectively. *Absolute power* refers to the amplitude of electrical activity measure at each electrode (Thatcher, 1998). It identifies the cumulative amount of brain activity recorded for that site. *Relative power* is expressed as a percentage to indicate the portion of brain activity generated on each frequency band at a single electrode location.

Method

The participant was the first author (Belkofer), who was a 29-year-old Caucasian male graduate art therapy student at the time of the study. Art-making sessions and EEG readings were conducted on a single day in the biological psychiatry lab of Hines Veterans Hospital in Hines, Illinois.

Two 22-minute EEG readings were administered by a lab technician. One baseline reading was taken before art making and another reading was recorded after art making, which functioned as the experimental variable. Movement during an EEG recording must be restricted to minimize artifact. "Artifacts refer to any disturbance in the recording that does not arise from the brain" such as muscle activity, eye movement, sweating, and shifting electrodes (Hughes, 1994, p. 41). Both pre- and post-experiment readings were taken in stillness with closed eyes. In addition, no EEG readings were conducted concurrently with the art making.

Because of the limited space of the EEG booth, the researchers decided that the art-making portion of the study would be conducted in an adjacent office. Furthermore, to diminish the amount of time between art making and EEG readings, the EEG net was worn (with the electrode wires unplugged from the board and bundled ponytail style) during the art making. Following the art-making phase, the cables were quickly reconnected by a technician for a 20-minute follow-up reading. The estimated time between art making and the start of the second reading was 10 minutes.

The art-making session lasted 1 hour. Art materials consisted of watercolor paints and brushes, charcoal sticks, an 11" x 8.5" pad of white drawing paper, and two graphite pencils. These materials were chosen for their ease of use and common availability in art therapy settings. No stimulus or topic was provided; the images were spontaneously created.

EEG Data Acquisition and Analysis

In an eyes closed, resting state, EEG data were collected from the 19 monopolar electrode sites of the International 10/20 System (Figure 3), using linked ears as a reference (Hughes, 1994). (Because ears do not generate electrical activity they are used as a neutral reference point; "linked ears montage" refers to active electrodes from the skull when linked to both ears). The sampling rate for quantitative electroencephalograph (QEEG) acquisition was set at 500Hz, and the filters were set at 0.01 and 70 Hz, a standard setting for clinical data collection.

Utilizing a method reported by Lapointe, Crayton, deVito, Fichtner, and Konopka (2006), QEEG data were analyzed with NeuroGuide 1.74. QEEG files generated in NeuroScan were imported into NeuroGuide and viewed with a linked ears montage (Rybak, Crayton, Young, Herba, & Konopka, 2006). In order to select artifact-free data, EEG records were visually screened for eye movement, muscle movement, and other sources of artifact; data containing artifacts were rejected.

Results

The participant created two images on blank sheets of paper. The first image (Figure 1) is a charcoal drawing of an angel in a rural landscape. The second image (Figure 2) is a barren and stark winter landscape, created with watercolor paints and pencil. Figure 3 is a map that shows an overhead view of the head that identifies the electrodes and their placement. To help orient the viewer, EEG maps also depict a nose and two ears. Therefore, the side to the left of the nose corresponds to the left side of the brain, and the side to the right of the nose corresponds to the right side of the brain. The small round circles on the head maps depict the reference points and the electrodes used to record electrical activity.

Paired student *t* tests with a level of significance $p < .05$ were utilized to determine differences between the pre and post art-making EEG readings. Figure 4 (absolute power, or the total amount of brain activity at each electrode) and Figure 5 (relative power, or the percentage of overall brain activity within each frequency band at each electrode) show these results in the form of topographic maps of the brain. Shaded areas indicate where statistically significant ($p < .05$) differences occurred with each map indicating the four brainwave frequencies. Absolute power maps (Figure 4) show differences in delta, theta, and beta frequencies. Relative power maps (Figure 5) show differences in delta, alpha, and beta frequencies. In addition to the maps of the brain, the numerical *p* values reported by the *t* tests are presented in Table 1 (absolute power) and Table 2 (relative power) with significant differences shown in bold.

Figure 1

Figure 2

Because the *p* values do not reflect directional differences, *z* scores were computed to determine whether post art-making EEG readings were characterized by increases or decreases in electrical activity. Tables 3 and 4 show the *z* values for the statistically significant electrodes in brainwave activity for absolute power and relative power respectively. Negative values indicate a decrease in brain activity and positive values indicate an increase. Columns on the

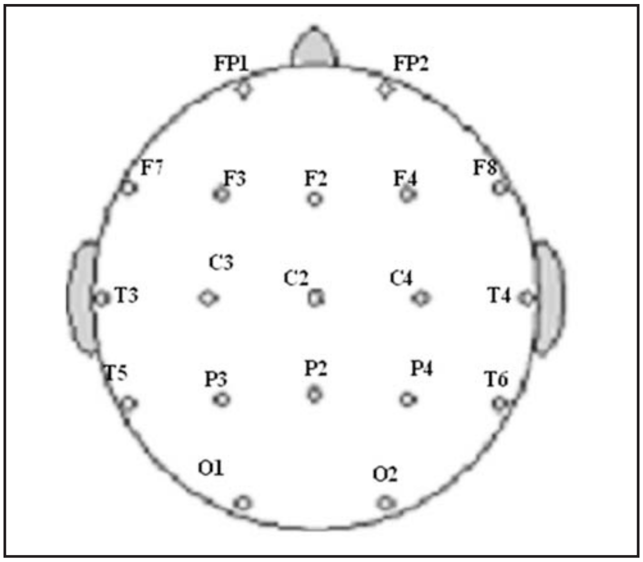

Figure 3

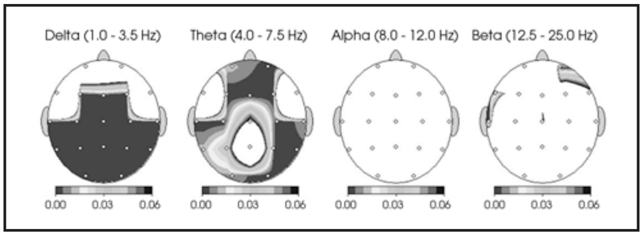

Figure 4 FFT Absolute Power Paired t-Test (P-Value)

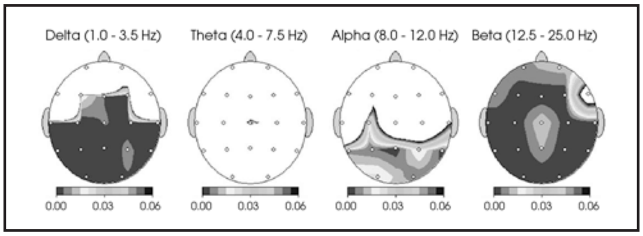

Figure 5 FFT Relative Power Paired t-Test (P-Value)

table that are left blank indicate that no statistically significant changes were recorded.

For delta frequency, decreases in activity occurred in both absolute and relative power at all statistically significant electrode sites. Although no differences were found between pre and post EEG readings for theta band in relative power, a similar "across the board" decrease of brain activity occurred in terms of absolute power. A closer look at both delta and theta frequencies (Table 3) indicates bilateral decreases in absolute power for the occipital, parietal, and temporal lobe regions of the brain.

Alpha band frequencies, associated with relaxed yet alert mental states, showed no differences in absolute power (Table 4). However, there are bilateral relative power increases in the occipital, parietal, and temporal lobes; no decreases were seen. Beta frequency was found to be characterized by both absolute and relative power increases in the left medial temporal and left frontal lobes paired with

Table 1
Absolute Power (µV)^2, Paired *t* tests ($p < .05$)

Electrodes	Delta	Theta	Alpha	Beta
FP1	0.149	0.012	0.275	0.646
FP2	0.123	**0.001**	0.306	**0.000**
FZ	**0.000**	**0.000**	0.073	0.086
F3	**0.000**	**0.000**	0.093	0.153
F4	**0.000**	**0.000**	0.133	0.115
F7	0.854	0.488	0.507	**0.005**
F8	0.652	0.564	0.182	0.070
CZ	**0.000**	0.067	0.141	0.046
C3	**0.000**	**0.001**	0.390	0.653
C4	**0.000**	**0.000**	0.070	0.232
T3	**0.000**	**0.001**	0.622	**0.002**
T4	**0.000**	**0.007**	0.548	0.929
T5	**0.000**	**0.012**	0.347	0.274
T6	**0.000**	**0.004**	0.314	0.142
PZ	**0.000**	0.166	0.174	0.816
P3	**0.000**	**0.034**	0.588	0.631
P4	**0.000**	**0.001**	0.306	0.826
O1	**0.000**	**0.008**	0.719	0.310
O2	**0.000**	**0.001**	0.371	0.063

Table 2
Relative Power (%), Paired *t* tests ($p < .05$)

Electrodes	Delta	Theta	Alpha	Beta
FP1	0.918	0.766	0.737	0.009
FP2	0.115	0.334	0.100	0.012
FZ	**0.005**	0.230	**0.002**	**0.001**
F3	**0.019**	0.623	0.074	0.000
F4	**0.002**	0.692	0.069	0.000
F7	0.928	0.590	0.571	0.010
F8	0.563	0.497	0.190	0.090
CZ	**0.006**	0.026	0.148	0.016
C3	**0.000**	0.237	**0.017**	**0.000**
C4	**0.002**	0.115	0.147	0.000
T3	**0.000**	0.421	0.253	0.000
T4	**0.000**	0.377	0.061	0.000
T5	**0.000**	0.434	**0.008**	**0.000**
T6	**0.000**	0.230	**0.002**	**0.001**
PZ	**0.000**	0.648	**0.001**	**0.011**
P3	**0.000**	0.533	**0.006**	**0.000**
P4	**0.007**	0.997	**0.022**	**0.00**
O1	**0.001**	0.729	**0.022**	**0.000**
O2	**0.005**	0.067	**0.006**	**0.000**

Table 3
Absolute Power (µV)^2, *z* Scores

Electrodes	Delta	Theta	Alpha	Beta
FP1		**- 0.34**		
FP2		**- 0.40**		**-1.40**
FZ	**- 5.68**	**- 1.61**		
F3	**- 4.76**	**- 1.45**		
F4	**- 4.73**	**- 1.22**		
F7				***+ 0.10***
F8				
CZ	**- 7.71**			
C3	**- 6.36**	**- 1.18**		
C4	**- 6.11**	**- 1.11**		
T3	**- 3.83**	**- 0.74**		***+ 0.63***
T4	**- 3.22**	**- 0.52**		
T5	**- 5.29**	**- 0.91**		
T6	**- 7.53**	**- 1.74**		
PZ	**- 7.91**			
P3	**- 6.36**	**- 1.02**		
P4	**- 6.78**	**- 1.11**		
O1	**- 8.93**	**- 2.46**		
O2	**- 7.47**	**- 3.11**		

Table 4
Relative Power (%), *z* Scores

Electrodes	Delta	Theta	Alpha	Beta
FP1				***+ 0.54***
FP2				***- 3.21***
FZ	**- 6.76**			***+ 1.05***
F3	**- 4.65**			***+ 0.79***
F4	**- 6.30**			***+ 1.89***
F7				***+ 0.93***
F8				
CZ	**- 6.41**			***+ 1.12***
C3	**- 7.15**		***+ 1.84***	***+ 2.65***
C4	**- 5.98**			***+ 2.58***
T3	**- 7.46**			***+ 4.96***
T4	**- 4.48**			***+ 2.53***
T5	**- 6.02**		***+ 1.94***	***+ 1.94***
T6	**- 4.99**		***+ 3.67***	***+ 1.18***
PZ	**- 7.49**		***+ 4.97***	***+ 0.85***
P3	**- 6.53**		***+ 2.78***	***+ 2.20***
P4	**- 4.64**		***+ 1.18***	***+ 1.85***
O1	**- 5.21**		***+ 3.86***	***+ 1.83***
O2	**- 4.84**		***+ 4.53***	***+ 1.74***

decreases in the right prefrontal region. Relative power showed further left frontal and prefrontal increases as well as bilateral occipital, parietal, and posterior temporal gains.

In summary, the results indicate that the higher frequency alpha and beta brain waves were characterized by increased activity primarily in the occipital, parietal, and temporal lobes. Conversely, the lower frequency delta and theta brain waves showed decreases in these same regions. In addition, beta frequency showed a decrease in right prefrontal activity paired with an increase in the left medial temporal, left frontal, and left prefrontal lobes.

Discussion

Due to the use of a modified single subject design that did not include multiple baseline measures over more than one session or treatment phase, the results of this pilot study are limited in that they have no significant reliability and validity. Therefore, all inferences made from this data are speculative. Financial and time constraints prevented the application of the method with multiple subjects. Rather than generalizing the results to larger populations, this paper is an attempt to create an introductory framework for utilizing the EEG as a method for conducting art therapy research.

Another limitation is that the participant also designed the experiment. Therefore, it is possible that any differences presented in the data are a result of an expectancy effect rather than the behavior involved in producing an art image. In addition, the data may have measured the subject's response to leaving the EEG booth as opposed to the experience of making art. 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.

Taking these limitations into account, the results suggest that painting and drawing for 1 hour may have led to statistically significant changes in neurological activity before and after art making. Although no major conclusions from this study are fully realized, there are several findings worth discussing.

Decrease in Delta and Increase in Beta Activity

The overall decrease in delta activity found in this study is inconsistent with previous research by Bhattacharya and Petsche (2005) that used EEG measures to explore whether artists (participants who had earned a master of art degree from the Academy of Fine Arts in Vienna) utilized different brain functions than their non-trained counterparts when mentally composing a drawing of their own choice. According to their results, the artists exhibited increases in the lower frequency delta band, decreases in alpha band, and right hemisphere dominance. Conversely, the non-artists were characterized by an increase in the higher frequency beta band and an increased activity in the frontal lobes.

In our study, the subject (first author) has a bachelor's degree in fine art and extensive exhibition experience, but the increase in beta and decreases in delta activity that characterized his post art-making EEG readings are incompatible with the results of the Bhattacharya and Petsche study.

Although it is difficult to determine precisely why these results are different, it is possible that his art training is not as substantial as the Vienna group and therefore utilized brain functioning more consistent with their non-trained counterparts. A second and more likely explanation is that the different methods of the two studies (physically making an image and recording the brain activity versus recording their brain activity while imagining making an image) led to different results.

On the other hand, an earlier study by Bhattacharya and Petsche (2002) that compared EEG recordings of artists to non-artists while they looked at slides of various paintings resulted in data that are more consistent with the findings of our current study. Bhattacharya and Petsche found that viewing a painting resulted in increases in beta frequency primarily in the central and parietal regions. In our study, drawing and painting for an hour also led to central and parietal increases in beta frequency.

Thus, for artists the faster brainwave beta frequency seems to be enhanced during viewing a painting, "whereas low frequency bands (especially delta) were found to be involved during imagination" (Bhattacharya & Petsche, 2002, p. 185). These findings, combined with our results, indicate that further analysis of beta and delta frequencies would be a profitable area for EEG-based art therapy research. In addition, future studies need to examine the neurobiological functions of drawing from observation as opposed to drawing from memory. It is possible that these different tasks impact brain functioning in a manner that would ultimately influence the client's response to art therapy treatment.

Higher Frequency Brain Activity in the Occipital and Parietal Lobes

The increased activity seen in the occipital and parietal lobes likely reflect the increased visual processing demands required of the participant. These results are consistent with research that has identified the occipital and parietal lobes as the brain regions primarily responsible for performing visual-spatial and perceptual tasks (Cohen, 1996; Newberg, D'Aquili, & Rause, 2001). In addition, previous research has identified increased beta frequency with active and attentive states of visual focus (Wrobel, 2000).

Higher Frequency Brain Activity in the Temporal Lobes

The large increases in temporal lobe activity observed in this study identify the "what pathway" of the visual system, that is, the part of the brain where images and meanings are associated (Ratey, 2002, p. 100). The temporal lobes also are concerned with language, emotion, memory, sense of time, and mystical states of consciousness (Obiols, 1996). Research has shown that temporal lobes play an important role in spiritual activities, such as experiencing a profound sense of meaning, connections to a higher power, deep feelings of peace, and a loss of time (Persinger, 1983; Newberg et al., 2001).

It is possible that the activation of the temporal lobes plays a role in the strong emotional and spiritual connection and in the transcendental states of consciousness that are frequently associated with making art. An increased sense of that which is true and important, and an overwhelming feeling of serenity and joy, have been "identified with total engrossment in an aesthetic experience" (Matthew, 1996, p. 159). Many approaches to art therapy treatment utilize the spiritual and transformative powers of art to reach new places of self-awareness (Rubin, 2001). The sacred character, the ritualistic method, and the loss of time and self-awareness are potentially therapeutic properties of the creative process (Allen, 2001). Research that examines the activation of the temporal lobes may reinforce the theory that art making can help individuals reach new kinds of spiritual awareness characterized by acute clarities of purpose and meaning, a sense of community and belonging, and a connection to a higher power.

Art and Memory

According to Restak (1988), "electrical stimulation delivered to the temporal area of the brain elicits images of events that occurred in the patient's past" (p. 243). Temporal lobe activation may be related to the bubbling up of suppressed or forgotten memories that occur in art making and often lead to therapeutic moments of insight (Rubin, 2001). These implicit memories, which are directly responsible for the formation of various emotional states, are primarily stored in the limbic regions deep within the temporal lobes (Siegel, 1999). Art making may activate the temporal lobes to elicit dormant memories, emotions, and sensations.

Left and Right Brained Functioning

The decreases in right prefrontal lobe activity for both absolute and relative power in beta frequency support the notion that it is simplistic to identify art making as a solely right brained activity given the complex roles that each hemisphere plays. For example, although the right hemisphere is important for many art-related perceptual and cognitive tasks (Lusebrink, 2004), art does not exclusively involve the right side of the brain (Solso, 1994). According to Obiols (1996), the first impressions of a visual image are a predominantly right hemisphere activity, whereas "the most sublime and pure artistic forms, particularly in the modern era, imply the use of analytical processes, heavily loaded with categorizations and linguistic formulations that require a fully functioning left hemisphere" (p. 39). Although right hemispheric functioning has profound clinical implications (Klorer, 2005), it is essential to take into account which regions of the brain (prefrontal, temporal, etc.) are activated within each hemisphere. For example, the left prefrontal lobes have been identified with positive emotions, whereas the right prefrontal lobes have been associated with depression (Ahern & Schwartz, 1985). Cela-Conde, et al. (2004) found correlations between left prefrontal lobe activation and aesthetic perception. Future research could explore whether art related tasks promote the experience of certain emotional states by creating variations in the inter- and intra-hemispheric flow of neurobiological activity in the brain.

Conclusion

The authors hope that the results of this study will encourage other researchers to attempt replication with a larger participant pool and with multiple baseline measures over a longer experimental phase. The results suggest that the effects of art therapy treatment may be assessed by comparing neurological activity before and after treatment. It is this capacity to directly observe an individual and to provide quantifiable data that makes brain-imaging an exciting tool for conducting research. 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 correlated with differences in mood and affect. In the future, one may be able to define art therapy treatment based on clients' histories as well as their baseline EEG patterns, and to use art therapy to modify or normalize the brain activity leading to improvement in their condition.

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