When five artists' identities seem as one

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In general the production and appreciation of visual art has been considered to be a cultural phenomenon, but lately the possibility of a biological, leading on to a neuroscientific basis, for making art has been considered. This article investigates the brain wave activity of five prominent Pretoria artists, during the act of making art. In this study data was captured using electroencephalogram featuring the brain wave clusters of delta, theta, alpha, beta and gamma. Receptors were placed on the artists' heads at four sites representing the frontal, parietal, left and right areas. A rise or decline in brain wave activity during art making indicates the activation (or deactivation) of significant cognitive and neural function. Whilst artists' individual brain waves are idiosyncratic, clearly indicative of highly personal visual and perceptual interpretations, when compared with each other overall they present similar brain wave patterns. It is indeed as if the five artists' identities seem as one.
Key words: identity, art making, brain wave activity

Vyf kunstenaars se gelykvormige identiteit
Oor die algemeen word die maak en waarderding van visuele kuns as 'n kulturele uiting beskou. Deesdae word die moontlikheid van 'n biologiese, inleidend tot 'n neurologiese, basis tot kunsskepping wel oorweeg. Hierdie artikel gee verslag oor 'n ondersoek aangaande die brein golf aktiwiteit van vyf gerespekteerde kunstenaars woonagtig in Pretoria, ten tye van kunsskepping. Brein golf inligting was deur middel van elektroenkefalografie met betrekking tot delta, theta, alpha, beta en gamma groepe verkry. Reseptore was op die kunstenaars se koppe op vier verskillende plekke geplaas, naamlik frontaal, pariëtaal, links en regs. Die styg of daal van die brein golf aktiwiteit gedurende kunsskepping dui aktivering (of deaktivering) van beduidende kognitiewe en neurologiese funksies aan. Alhoewel die individuele kunstenaars se brein golf aktiwiteite uniek is, bestaan daar oorkoepelend gelykvorminge brein golf patrone. Dit wil inderdaad voorkom asof die vyf individuele kunstenaars 'n neurologiese identiteit ten tye van kunsskepping deel.
Sleutelwoorde: identiteit, kunsmaak, brein golf aktiwiteit

One can assume that artists, like all human beings, value their identity highly, as this provides a sense of being self-situated within a socio-cultural environment (Noland 2009). However, following Noland (2009) as well as Stets and Burke (2000) one can assume that for the artist, there exists a continuous flux/tension between the idiosyncratic or unique and the artist community. So why are we, in a sense, reducing the utterly incomparable uniqueness of five visual artists by suggesting that they have a shared identity? In deference to the artists who are the focus of this article, we do not propose that their private, poetic or artistic identities are shared. The focus here is on similar neuroscientific patterns which create a 'shared' identity.

In a previous article (van Heerden & Munro 2012:295), we referred to the debate that C.P. Snow initiated in the 1960s when he compared the two cultures, best understood as art (in particularly the literary) versus science (the physical sciences). We mentioned Snow, amongst others, to prepare the reader for what followed in that article - reporting on art making and the physiological data that was captured of the same art-making events. The empirical methods that we employed were skin conductance, peripheral skin temperature, respiration and heart rate. We

have expanded on those methods and previous findings and now report on salient aspects of art making and brain-wave activity.

Objectivity and subjectivity in research on art making

Berteletti, Hubbard and Zorzi (2010) refer to a fundamental question in the study of consciousness as being the connection between subjective reporting and the objective measures thereof. Similarly, if art making is considered to be in the domain of consciousness (or possibly altered consciousness), the fundamental question in the study of art is the subjective experience and objective measures thereof. Studies in art making, consequently, require the same rigorous inquiry (as do studies in consciousness), yet there is a paucity of studies combining the artist's subjective experiences with objective measures of the same art making events. Liu and Miller (2008:472), when cautioning against potential subjectivity involved in interpreting studies of art making and the brain, refer to no less than 150 physicians and art historians who retrospectively diagnosed Vincent van Gogh (1853-1890) with temporal lobe epilepsy, Ménière's disease, porphyria, depression, bipolar illness and absinthe poisoning, to name a few.

It thus seems that the difficulties surrounding inquiry about visual art *per se* have their roots in the difference between objectivity and subjectivity, which is often due to the exclusive use of either quantitative or qualitative measures of inquiry. Van Heerden and Munro (2012: 296-297) add:

> Thus, the notion is not new that research as to the lived experience (such as art making) expressed as science, is viewed with circumspection. Ernst Heinrich Weber and Gustav Theodor Fechner were the first to measure how sensations vary systematically as a function of physical stimulation, and could thus be viewed as the founding fathers of experimental psychology.

Experimental psychology can thus be viewed as first attempts to quantify a human experience that could be regarded as essentially qualitative in nature (Hergenhahn 2009: 251). In this regard studies about *responses* to art preceded studies of *art making*. Up until the 1950s experimental psychologists had shown very little interest in the study of aesthetics – "with such noteworthy exceptions as Arnheim, Farnsworth, [T] Munro, and Schoen" (Wallach 1959). Aesthetics, in this article, refer not to philosophical concepts of beauty, as such, but rather to visual art and responses thereto. Munro, T (1948: 226) referred to 'the psychology of art' as a branch of 'applied psychology', which in turn was considered to be an outgrowth "…of the older subject known as "aesthetics", which in turn was derived from philosophical speculations on beauty and art". According to Munro, T (1948: 226), it was the German psychologist Fechner, who, in 1876, first proposed a scientific approach to aesthetics with empirical studies of observable data, and a procedure based on experimentation and quantitative measurement. These included, for example, studies on geometric shapes and individuals' aesthetic preferences. Chandler (1928) was one of the first psychologists of art to publish in English on 'experimental aesthetics' which included statistical and laboratory experiments involving quantitative measurement, which included methods such as skin conductance.

Munro, T (1948) offers a comprehensive discourse on American, British and German philosophic and scientific approaches to aesthetics and the psychology of art, inclusive of the various data capturing methods used from 1918 onwards. The methods included, amongst others, questionnaires, self-observation and case studies.

Studies of emotional responses to art (which did not include recorded responses of art *making*) became noteworthy with Daniel Berlyne's 'new experimental aesthetics' in the 1960s

and 1970s. This led to the development of a tradition in research on art which emphasized controlled laboratory research. In a review of developments vis-à-vis emotional *responses* to art (but not of art *making*), Silvia (2005) explains that both art and emotion resurfaced in psychology more or less simultaneously during the 1960s and 1970s, when psychologists began developing theories of basic emotions where experimental studies were conducted focusing on hedonic qualities of art (Silvia 2005: 342). Silvia (2005) refers to appraisal theories (where the central assumption is that subjective evaluation of events, not events themselves, is the local cause of emotional experience). With reference to emotional aspects of aesthetics, *interest* seems to be the emotion most central to the aesthetic experience, however, typically, interest increases with training and knowledge.

The experimental studies referred to above focused on the emotional aspects of aesthetics. Empirical studies in neurocognitive approaches to the psychology of aesthetics (Chatterjee *et al.* 2008; Höfel & Jacobsen 2008; Brandt 2009); reviews of studies of comparative neurology involved in aesthetic appreciation (Nadal & Peters 2008); neurocognitive approaches to art observation (Fairhall & Ishai 2008) and neurobiological approaches to aesthetics (Zeki & Lamb 1994; Zeki & Marini 1998; Zeki 1998, 2001, 2002; Ramachandran & Hirstein 1999) have expanded the context for explaining responses to art. However, studies of art by neuroscientists are not always readily accepted – an example is the art historian Gombrich's (2000) disagreement with the neuroscientists Ramachandran and Hirstein's (1999) theory of human artistic experience and the neural mechanisms that mediate it. Recently Hyman (2010) responded with a scathing philosophical critique of both Zeki and Ramachandran's understanding and explanation of visual art.

Responses to art may have expanded the context for understanding art, but do not equate to responses whilst *making* art. Bhattacharya and Petsche (2002, 2005) conducted EEG studies on 'healthy' artists and non-artists and posit that

> art and cognition are deeply interrelated, acting like two convex mirrors each reflecting and amplifying the other; yet, despite numerous research developments in both aesthetics and cognitive science, the connection between the two has not been studied systematically except for some preliminary investigation (2002: 179-180).

Studies on the connection between art and the brain in healthy artists are few compared with studies by neurologists, psychologists, psychiatrists and cognitive scientists who report on cases of artists and non-artists who suffer from localised brain injury or disease (Liu & Miller 2008; Liu *et al.* 2009). Such studies do not necessarily demonstrate a decline in artistic ability of the artist – on the contrary, some studies demonstrate a newfound interest in the visual arts following left frontal or temporally predominant brain degeneration, whereas other studies demonstrate marked changes in the artists' preference of subject matter or use of colour (Liu & Miller 2008). Liu and Miller (2008: 472) report that "[S]ome [researchers] argue that following the natural history of established artists provides a richer understanding of the neurological substrate of art-making…" – this is particularly edifying when studying changes in art making that occurred when 'healthy' artists experience dementia or lesions, compared with their prior work.

Cognisance is taken of the above. However, the focus of this article is not to *analyse* the art produced by artists, nor is this study about longitudinal studies of artists and changes in their art making over the span of a career. This is a non-laboratory study about a non-clinical population (healthy artists), reporting on objective measures of some art making events. In general, information could be gained through 1) neurophysiology (anatomical structure related to mental functions); and 2) neural and cognitive processes (how complex properties of the brain

allow behaviour to occur and information processing in the brain). In this study data-collection was done through electroencephalographic (EEG) recordings to learn more about brain activity during art making.

Data capture using electroencephalography (EEG)

Teixeira *et al.* (2008: 506) refer to invasive, precise (and even dangerous) methods used to analyse biometric data where emotions and physiological responses are coupled in experiments. The same authors suggest non-invasive methods such as EEG, fMRI, galvanic skin response (GSR) and oximeter. Teixeira *et al.* (2008: 506), who tested emotional responses by using EEG, mention that EEG is considered by sceptics in the medical community of being a gross correlate of brain activity. Fink *et al.* (2007: 69) report that "[W]hile fMRI enables insights into the neuroanatomical bases of creative cognition with high spatial accuracy, the primary advantage of EEG lies in its high temporal resolution (in the range of milliseconds) and the availability of different parameters". Dietrich (2003: 243) refers to EEG as a crude method that measures summed postsynaptic electrical activity of a large area of the cortex. Bekhtereva *et al.* (2001), in a creative task-related experiment comparing EEG with PET, found both methods to be generally adequate, yet they suggest that the spatial resolution of the standard EEG and its sensitivity to deep brain processes are insufficient for adequate detection of the area of the predominant activation. EEG does, however, offer good temporal resolution (Croft *et al.* 2002: 101), has the advantage of being relatively inexpensive as a method, and furthermore, can be used in a non-medical environment.

Since the discovery of the EEG by Hans Berger in 1929, oscillatory patterns can be observed in the electrical activity of the brain (Herrmann & Demiralp 2005). Berger considered the basic rhythm in the frequency band of 8–12 Hertz (Hz), and named it a- (alpha) rhythm. The next chronological identified frequency range between 12 and 30 Hz was b- (beta) rhythm. Faster oscillations in the human EEG, between 30 and 80 Hz were later identified and named g (gamma) activity. Slower waves below the a range were named 'd', and were later divided into delta (0-4 Hz) and theta (4-8 Hz) ranges. Decreased oscillations with increased frequencies, such as the omega range, were later identified (Herrmann & Demiralp 2005:2719).

The conspicuous presence of various brain wave phases is typically associated with certain neural and cognitive states, or behaviours, a few of which are summarised as follows:

•Delta: 1-4 Hz – sleep (Belkofer & Konopka 2008:57), deeper levels of meditation and awareness (Stinton & Arthur 2013:4);
•Theta: 4-8 Hz – creativity, spontaneity, daydreaming (Demos 2005:113); memories, visualising, peak performance, associations (Thompson & Thompson, 2003:38); cognition, depression. (Egner, Zech & Gruzelier 2004).
•Alpha: 8-12 Hz – alert awake (Thompson & Thompson, 2003:10); meditation, inner calm, peacefulness (Demos, 2005:115); viewed as 'cortical idling', preventing internal information processing to be disturbed by external input (Fink *et al.* 2007); relaxed concentration, resting state, open awareness; deeper creativity, visualisation, meditation, relaxation (Stinton & Arthur 2013:4); shifts in consciousness, relaxed yet alert mental states (Belkofer & Konopka 2008:57).
•SensoriMotor-RhythmStrip (SMR): 12-16 Hz – internal orientation, decreases with movement (Demos, 2005:117); calm mental state, internal orientation, decreased movement and impulsivity (Thompson & Thompson 2003:248).
•Beta 1, 2, 3, 4: 16-34 Hz – focused, analytic, problem solving, alert, logical, externally oriented, relaxed thinking (Demos 2005:118); anxiety, emotional intensity, ruminating (Thompson & Thompson 2003:10); increased alertness, concentration (Stinton & Arthur 2013:4).
•Gamma: 34-42 Hz – Near 40Hz may have unique role of 'event binding rhythm', feelings of satisfaction, gratitude, love and compassion (Rubik, 2011:109-110); problem-solving, promotes

learning, mental sharpness, brain organising (Demos 2005: 120); peak performance (Thompson & Thompson 2003: 40).

The EEG can track the way in which the brain functions through the energy- consuming activation of neurons. The brain does not have inherent brain waves – electrical activity is produced by the underlying neurons or nerve cells in the brain. "The EEG picks up this flow of electrical activity through electrodes strategically attached to the scalp…Each electrode connects to a wire that conducts the electrical activity from the head to a designated connection on an electrode board" (Belkofer & Konopka 2008: 57), where the signal is amplified. Such electrodes act as sensors and are made conducive by using an electrode paste between the electrode and the surface of the scalp.

In principle the electrodes comprise a positive (+ve) lead (active lead) which is usually placed over the area to be recorded and measured, a negative (-ve) lead (reference electrode) which is usually placed over an area that is relatively inactive electrically, and a ground. The EEG instrument measures the potential difference between the positive and the negative leads. More than one active electrode site can be measured on the scalp – up to 20 leads at active sites are referred to as a 'full cap assessment'. Figure 1 indicates the standard placement of electrodes during EEG recording, where electrodes over the left hemisphere are labelled with odd numbers, those over the right with even numbers and those on the midline with a 'z'. The uppercase abbreviation indicates the location of the electrode: A, auriole; C, central; F, frontal; Fp, frontal pole; O, occipital; P, parietal; and T, temporal.
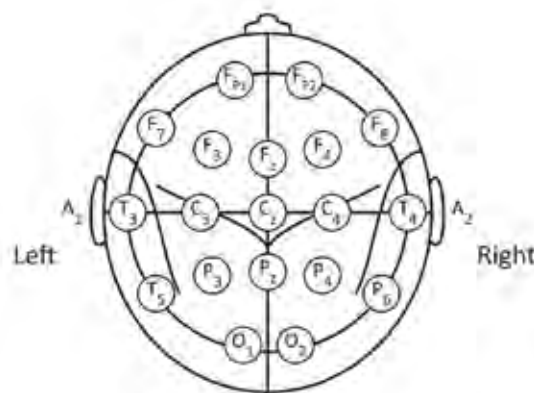

Figure 1
Standard placement of electrodes during EEG recording – also known as the International 10-20 System (source: Banich, 2004: 87).

"The raw EEG shows the morphology (shape) of the waves, the amplitude (how high the waves are from peak to trough) and the frequency (how many waves there are in one second)" (Thompson & Thompson 2003: 4). The QEEG, in addition to recording the EEG, transforms the raw EEG into quantitative displays by using computer algorithms. The QEEG quantifies data with regard to the amount of electrical activity occurring at particular frequencies or across defined frequency bands. "The electrical activity is usually expressed either as amplitude, measured as microvolts (μV) or millionth of a volt, or as power, measured as picawatts (pW) (Thompson & Thompson 2003: 4). Raw EEG data, transcribed into numeric data, can further be transcribed to a 2- or 3-dimensional graph and is referred to as the compressed spectral

array (CSA) (Demos 2005: 90). The CSA provides an overview of frequency band distribution acquired from a single channel of EEG.
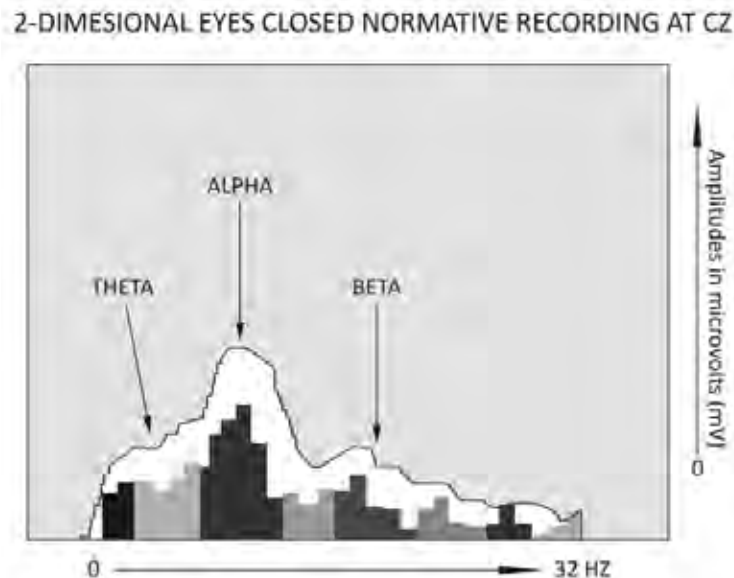

Figure 2
Example of compressed spectral array (CSA) - 2-dimensional eyes closed recording at receptor site Cz
(source: Demos (2005, figure 5.1).

The CSA makes it easier to observe which brain wave frequencies are at high or low amplitudes during mental activities at a particular receptor site, or during EEG recording segmentation. Thompson and Thompson (2003: 36-37) describe the spectral array as "…a histogram showing the amplitude for each frequency usually from 2 to 32 Hz or more". The rise and fall in amplitude is the key descriptor of the spectral array, or histogram, and generally has recognisable patterns, such as that "…amplitudes usually decrease fairly uniformly as you move from 2 Hz to 62 Hz in part because the skull attenuates the faster frequencies more than slower frequencies". In short, the raw EEG data is transcribed to numerical data, where after it is transcribed into a histogram in the form of a bar graph. The bar graph (or chart) provides an overview of frequency band distribution acquired from a single channel of EEG and also facilitates the reading of patterns in the data.

Artists and art making

The artists who participated in the study are practicing or professional artists with a 'tried-and-true' *modus operandi* of fine art painting and/or drawing, conversant with disciplined and focused habits that result in sustainable practice and expertise. This points to a certain maturity, or chronological age. The authors are in agreement with Sheldon and Kasser (2001: 492) that chronological age is an imperfect indicator of a person's position within his or her unique life course – however, chronological age has cultural meaning and also provides an unambiguous temporal metric upon which to compare different individuals, or, as pertains to this study, a group of artists. As artists do not generally peak during their career formative years, maturity is considered to be an advantage, rather than the converse (Gardner 1993; Sawyer 2006: 51-53).

The research population was initially guided by information sourced from a reputable, professional art website of long standing, of South African artists. In Pretoria environs, where the research was conducted, 25 male artists were identified who potentially reflected the homogeneous profile – aged 50 to 70, skilled, practicing, professional artists who work two-dimensionally. In order to minimise variables in the data, sculptors were excluded as they generally use electrical equipment and heft weight in the execution of their work (and would thus be more prone to producing measurement artefacts). As a small team of practitioners performed the time-consuming EEG experiments and sensitive equipment had to be transported and set up in artists' studios, the sample was further reduced to artists who have studios within a radius of five to ten kilometres of the researchers' residences, predominantly in the Eastern part of Pretoria. Five healthy (no history of prior neurological or psychiatric diseases), right-handed male artists, mean age 61 years, with no less than 35 years of professional art making experience, were considered appropriate to meet the full complement of participants.

In order to further limit variability, all five artists were required to produce a drawing or painting whilst sitting or standing at an easel. Thus the body movements would be typical of, and limited to, those resulting from the artist using a tool such as a pencil, pastels or a brush dipped in paint. The artwork produced during the study differed in size from approximately 30 cm to 120 cm, with drawings on paper tending to be smaller compared with paintings on canvas. Some artists at times used one or more fingers as a tool to smudge or rub the medium on the surface of the 'ground'. If the artist was sitting during the first session of the main study, the artist was requested to sit during the remaining sessions. The same applied to artists who stood during the first session. Each participant completed three sessions. A studio of personal choice was used for each artist. The same studio initially chosen by the artist was used for all three of his sessions. Each participant's sessions took place during more or less the same time of day (all artists preferred a morning session) in order to limit the variability of cortisol secretion throughout the day – Huppert (2009: 141) refers to a healthy pattern involving a post-awakening peak and a 20-fold decrease later in the day. The investigations were conducted in a real-life (natural) setting – in this case a studio of the artists' choosing.

EEG data capture and art making

The objective for the use of EEG data collection was to gain insight into of brain wave activity of the artist whilst the artist is making art. This was achieved by observing idiosyncratic brain wave activity of the artist in delta, theta, alpha, SMR, beta and gamma brain wave ranges during five recording segments, over three recording sessions. This was facilitated by placement of gold electrodes (9mm in diameter) placed at recording sites C3, C4, Fz and Pz, representative of left, right, frontal and parietal regions of the cerebral cortex, according to the international 10-20 system (see figure 1). Idiosyncratic data for each artist over the three recording sessions were pared down to averages and then all five artists' results were compared with each other. The overview of the brain wave activity facilitated the establishment of patterns in the brain wave activity of all five artists which could lead to generalisations.

In Figure 3 below, a participating artist can be seen with the four gold electrodes correctly positioned at the chosen receptor sites on the scalp. He is connected to electronic devices that transform the raw data into algorithms that are presented as data.

Figure 3
Placement of electrodes at receptor sites C3, C4, Fz and Pz during EEG recording.

Artefacts may result due to technical factors (cable movements or electrode paste variations) as well as artists' physiological uniqueness (skull thickness, body temperature or bodily movements). A way of minimising the production of artefacts is to check and limit the impediment to the flow of alternating current, which is measured in ohms at a given frequency. In this study recordings only commenced when impedance was below, or as close to 5 kΩ. Impedance checks could not be carried out after the recording sessions had commenced, however the raw EEG data was continuously monitored during recording sessions so that any aberrations could be identified. Belkofer and Konopka (2008) refer to a pilot study in which they did not include multiple baseline measures over more than one recording session, as having no significant reliability and validity. In this study the replication of recording sessions (three per artist) contributed to the reliability and validity of data capture. The replication also served as a cautionary measure to observe whether recordings (and thus also impedance), inclusive of bodily movements during art making, were within a similar range. What is meant by a similar range is that somatic movements during art making were observed to be similar per artist, per recording session. The occurrence of impedance differences between the individual receptor sites, as well as across the three recording sessions, required the analysis of the data to be based on the identification of patterns in the data, rather than the use of inferential statistical analysis.

Raw EEG signals were recorded in 1-Hz bins using two 2-channel EEG amplifiers (ProComp Thought Technology Ltd. Encoder, Montreal, Quebec). Data was captured at 256 samples per second – up to a maximum of 64 Hz. The channel sets accommodated the bandwidth frequencies (or groupings) as delta (1 – 4 Hz); theta (4 – 8 Hz); alpha (8 – 13 Hz); sensorimotor rhythm (SMR) (13 – 15 Hz); beta (15 – 24 Hz) and gamma (34 – 41 Hz). The brain wave phases were recorded concurrently, whereas five segments were recorded and followed after each other sequentially:

- Segment 1 – 3 minutes of eyes closed and inactive (referred to as 'eyes closed before' [ECB]);
- Segment 2 – 3 minutes of eyes open and inactive (referred to as 'eyes open before [EOB]);
- Segment 3 – 30 minutes of eyes open and drawing or painting (referred to as 'active' [A]);
- Segment 4 – 3 minutes of eyes open and inactive (referred to as 'eyes open after' [EOA]);
- Segment 5 – 3 minutes of eyes closed and inactive (referred to as 'eyes closed after' [ECA]).

The raw EEG data expressed in microvolts (μV) was captured by an EEG amplifier and transcribed algorithmically as numerical 'means'. The transcribed numerical data was then

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transferred to MS Excel© (version 2010) into histograms in the form of spreadsheets and bar graphs. The bar graph (or chart) provides an overview of frequency band distribution acquired from a single channel of EEG and also facilitates the reading of patterns in the data. The pattern constitutes the spectral array of the various brain wave phases for the predetermined duration of each recording segment. Interpreting such data allows one options to assess (or zoom in to) artists' brain wave activity during a particular brain wave phase or recording segment.

Figure 4 indicates a pattern of delta phase activity of artist AA in 1-Hz bins (2-3 Hz and 3-4 Hz) at receptor sites C3, C4, Fz and Pz of one recording session.

The bar chart indicates the five sequential recording segments that are demarcated in different shades of grey from left to right of each Hertz bin:

- ECB, left, is pale grey;
- EOB is slightly darker;
- A is black;
- EOA, to the right of the black bar, is slightly darker; and
- ECA, on the right, is slightly lighter.

Brain wave activity is thus considered as a change from one recording segment compared with the next segment.

Data readings were thus done by way of patterns indicated by the bar graphs (or charts) and not the numerical data as such. These could be referred to as spectrographic readings of the mean peaks and troughs of the brain wave activity at particular receptor sites, representing the duration of a particular segment, over the three recording sessions. From these spectrographic readings patterns and emerging themes or trends were identified. The particular area of interest to us was what transpired during the art-making segment of the recordings.
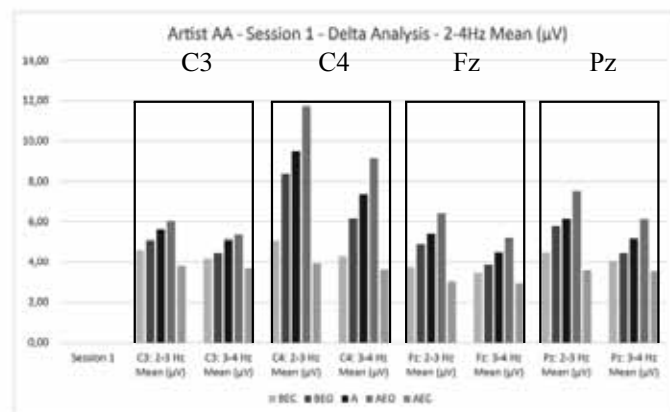

Figure 4
2-Dimensional display of EEG of artist AA in 1-Hz bins (2-3 Hz and 3-4 Hz) at C3, C4, Fz and Pz.

Data analysis

In order to analyse the data, means (averages) of the three recording sessions were obtained. In deference to limitations of space in this article, an example is offered in Figure 5, representing the means (averages) of artist AA's delta brain phase profile, representing the four receptor

sites of C3 (right), C4 (left), Fz (top) and Pz (bottom). The five recording segments can be distinguished by their colour and order: from the left, blue represents the artist's brain wave activity during 3 minutes of eyes closed (and inactive), at the start of the recording session. Next to blue, moving to the right the red bar represents three minutes of eyes open (inactive). The middle bar (green) represents thirty minutes of art making activity (with eyes open). The purple bar to the right of the green bar represents eyes open for three minutes (inactive), followed by a turquoise bar representing eyes closed (inactive). Note that even though the green bar is the only recording segment that captured art-making activity, there is clearly brain wave activity occurring during the inactive recording segments. Such bar charts were created of each artist, of each of the recording sessions, representing delta, theta, alpha, SMR, beta and gamma. Comparing artist AA's bar chart with artist AB's (figure 6) it is evident that each artist's spectral array is highly individualistic.
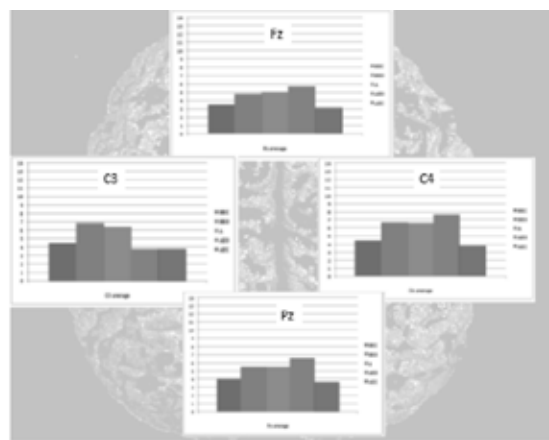

Figure 5
This bar chart represents the means (averages) of artist AA's delta brain phase profile over three recording sessions. The four receptor sites of C3 (right), C4 (left), Fz (top and Pz (bottom) are represented, as well as the five recording segments.

Figure 6
This bar chart represents the means (averages) of artist AB's delta brain phase profile over three recording sessions. The four receptor sites of C3 (right), C4 (left), Fz (top and Pz (bottom) are represented, as well as the five recording segments.
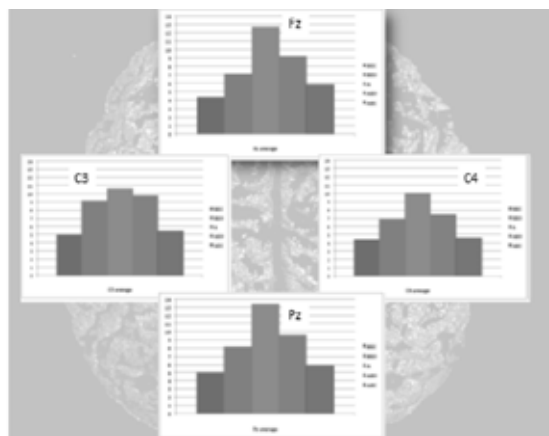
Themes in the data

Once we had compared all five artists' spectral arrays, a few very distinct overlaps started to emerge from the data. Figure 7 summarises brain wave activity before, during and after the art-making recording segment of all five artists.

Artist AA

Recording segments	BEC Before eyes closed	BEO Before eyes open	A Active	AEO After eyes open	AEC After eyes closed
Wave phase delta	Increase ↑		Stable ⇔	Increase ↑	
Wave phase theta	Increase ↑		Increase ↑	Increase ↑	
Wave phase alpha	Increase ↑		Increase ↑	Increase ↑	
Wave phase SMR	Decline ↓		Decline ↓	Increase ↑	
Wave phase beta	Decline ↓		Decline ↓	Increase ↑	
Wave phase gamma	Decline ↓		Increase ↑	Increase ↑	

Artist AB

Recording segments	BEC Before eyes closed	BEO Before eyes open	A Active	AEO After eyes open	AEC After eyes closed
Wave phase delta	Increase ↑		Increase ↑	Decline ↓	
Wave phase theta	Increase ↑		Increase ↑	Decline ↓	
Wave phase alpha	Decline ↓		Increase ↑	Decline ↓	
Wave phase SMR	Increase ↑		Increase ↑	Decline ↓	
Wave phase beta	Increase ↑		Increase ↑	Decline ↓	
Wave phase gamma	Increase ↑		Increase ↑	Decline ↓	

Artist AC

Recording segments	BEC Before eyes closed	BEO Before eyes open	A Active	AEO After eyes open	AEC After eyes closed
Wave phase delta	Increase ↑		Decline ↓	Increase ↑	
Wave phase theta	Increase ↑		Stable ⇔	Decline ↓	
Wave phase alpha	Decline ↓		Increase ↑	Increase ↑	
Wave phase SMR	Decline ↓		Increase ↑	Increase ↑	
Wave phase beta	Stable ⇔		Stable ⇔	Stable ⇔	
Wave phase gamma	Increase ↑		Increase ↑	Decline ↓	

Artist AD

Recording segments	BEC Before eyes closed	BEO Before eyes open	A Active	AEO After eyes open	AEC After eyes closed
Wave phase delta	Increase ↑		Stable ⇔	Decline ↓	
Wave phase theta	Decline ↓		Increase ↑	Decline ↓	
Wave phase alpha	Decline ↓		Increase ↑	Decline ↓	
Wave phase SMR	Decline ↓		Increase ↑	Decline ↓	
Wave phase beta	Decline ↓		Increase ↑	Decline ↓	
Wave phase gamma	Increase ↑		Increase ↑	Decline ↓	

Artist AE

Recording segments	BEC Before eyes closed	BEO Before eyes open	A Active	AEO After eyes open	AEC After eyes closed
Wave phase delta	Increase ↑		Stable ⇔	Decline ↓	
Wave phase theta	Decline ↓		Increase ↑	Decline ↓	
Wave phase alpha	Decline ↓		Increase ↑	Decline ↓	
Wave phase SMR	Decline ↓		Increase ↑	Decline ↓	
Wave phase beta	Decline ↓		Increase ↑	Decline ↓	
Wave phase gamma	Increase ↑		Increase ↑	Decline ↓	

Figure 7
A summary of brain wave activity of artists AA, AB, AC, AD and AE indicating increased or decreased brain wave activity during recording segments and brain wave phases.

The themes that emerged can be described in terms of similarities observed of all five artists. During the art-making segment all five artists experienced an increase in alpha (8-13Hz) brain wave activity as well as gamma (34-41Hz). A propensity for increase was observed in delta and theta (2-8Hz), as well as SMR (13-15 Hz) and beta (15-24 Hz). In deference to limitations of space, only the significance of the complete overlaps will be discussed.

Increased alpha brain wave activity

An increase in alpha is associated with meditation, relaxation, lack of cognitive processing, contemplation, visualisation, problem-solving, deeper creativity (Stinson & Arthur 2013: 4). Increased activity in alpha provides sensory input and illustrates the content through imagery and sensualisation; it links the conscious mind to the subconscious (Wise 2002: 140). Increased alpha denotes a resting or reflecting state, creative state, daydreaming (Thompson & Thompson 2003: 38). It is generally found in relaxed yet alert mental states or shifts of consciousness (Belkofer & Konopka 2008: 57). Increased alpha is associated with a cortical 'idling' phenomenon; also an active inhibition of task-irrelevant brain regions – preventing internal information processing to be disturbed by external input or conflicting operations (Fink *et al*. 2007).

It implies that during art making alpha waves could be activated because they are related to the unconscious and the sub-conscious; they could be activated because of the act of visualisation. Alpha could also be activated because the artist's past, or collective memories are 'tweaked' during art making. Artists have related feeling relaxed yet alert when making art, focusing on the task at hand – such observations concur with prior research. Some artists note that during art making it seems as if they experience shifts in consciousness, even feeling 'high'. This observation also concurs with prior research on increased alpha brain wave activity.

Increased gamma brain wave activity

Higher phase synchrony (occurring in both hemispheres) in gamma bands indicates focused creativity (Demos 2005). Increased gamma activity denotes enhanced binding ability (Bhattacharya & Petsche 2002) This can be explained as a rather unique role that gamma plays as the "event binding rhythm" – binding together neural representations of simultaneous events in a unified whole. Demiralp et al. (2007) concur when they refer to gamma being associated with multiple sensory and cognitive processes, especially memory functions. Thompson and Thompson (2003) associate enhanced gamma with peak performance. In addition, increased gamma activity is associated with feelings of satisfaction, gratitude, compassion and love (Rubik 2011: 109-110).

It implies that during art making, one can assume that increases in gamma indicate focused creativity (Demos 2005). Enhanced binding ability (Bhattacharya & Petsche 2002) indicates that a person is able to distinguish patterns from an array of information and are able to recognise representations of simultaneous events in a unified whole - artists have reported that they seem to go into 'big picture' mode, where one can act beyond, yet on, what you see. Perhaps because the artists who participated in this study are all highly experienced, they reported working 'intuitively', which could be explained as the brain engaging implicitly, rather than in the explicit mode.

Conclusion

It must be noted that despite conducting a comprehensive literature review on previous studies on EEG experiments and art (broadly speaking), which included studies on creativity and insight, no previous studies recorded artists or focused on art-related activities of artists in 'real-time', whilst engaged in the act of art making (recall the brief discussion on the potential creation of artefacts in the data when somatic movement is involved). For example, Belkofer and Konopka (2008) used EEG to measure patterns of brain activity of a single participant pre and post an hour spent drawing and painting, but not during art-making activities. This renders the study which is the topic of this article unique, but also makes comparisons difficult.

It must further be noted that three pilot studies were conducted prior to the series of main experiments. Following a heuristic trajectory, various components of the computer 'scripts' that were designed for the EEG data capture (such as the amount of recording segments, the duration of the recording segments and the placing of the scalp receptors) were interrogated and commensurately adapted to establish the most optimal and effective combination of components that would yield meaningful data. The script that was ultimately used during the main experiments is thus fit-for-purpose and unique; it could be regarded as a component for a future model for studies across various disciplines. As such, the study is ongoing and has not been tested with a similar sampling population, for example five female middle-aged artists, nor with covariate groups. Further areas of research could include an art critical study vis-à-vis the art produced by the artist-participants of this study and linking this with the EEG data. More than one group (for example artists producing art that is mimetic versus spontaneous) could participate to test whether neural and cognitive activity can be linked with the specific artistic output. Where EEG is concerned various possibilities for further research arise, for example the effect of art-making artefacts on the gamma range, or to ascertain the statistical significance of increases or decreases in brain wave activity.

As it was evident that there were shifts in brain wave activity between the various segments in the recording process (before, during and after) of this study, we were curious to observe the overall patterns of all the brain wave activity during the entire recording session, inclusive of all five the recording segments. We thus created bar charts of the three sessions of each artist's brain wave activity, at each receptor site, represented in single Hz bins from 2Hz through to 41 Hz. An agglomeration of all recorded brain wave activity per artist was created which offers an overall pattern of the data representing the brain wave activity during art making in the data. Figure 8 represents artists AA, AB, AC, AD and AE over three recording session, representing all four receptor sites. To facilitate the reading of patterns, such single Hertz bar charts were further grouped into averages of all three sessions recorded per artist, per receptor site and per brain wave from delta through to gamma (Figure 8).

In this article we have not suggested that the idiosyncratic and artistic identities of the five artists who participated in this study are shared. Observing the five artists attests to highly idiosyncratic art practice – the way that they individually prepare their studio environment (such as planning and arranging the tools of their trade); the way that they apply media to their chosen ground (such as applying small marks that build up to larger shapes on paper, or alternatively applying a large area of colour on canvas, upon which smaller areas of colour are added later); or the individualistic manner in which they activate the space between the art work and the body. Yet, there are similarities that identify them as a homogenous group in that they are all male, middle-aged, have at least 35 years of expertise and experience in art making and all happen to be right-handed. Furthermore, even though the art that they produce is highly individualistic

(which speaks to their unique identity) they are all artists who transform their reference material for their paintings and drawings away from a mimetic representation of what they observe.
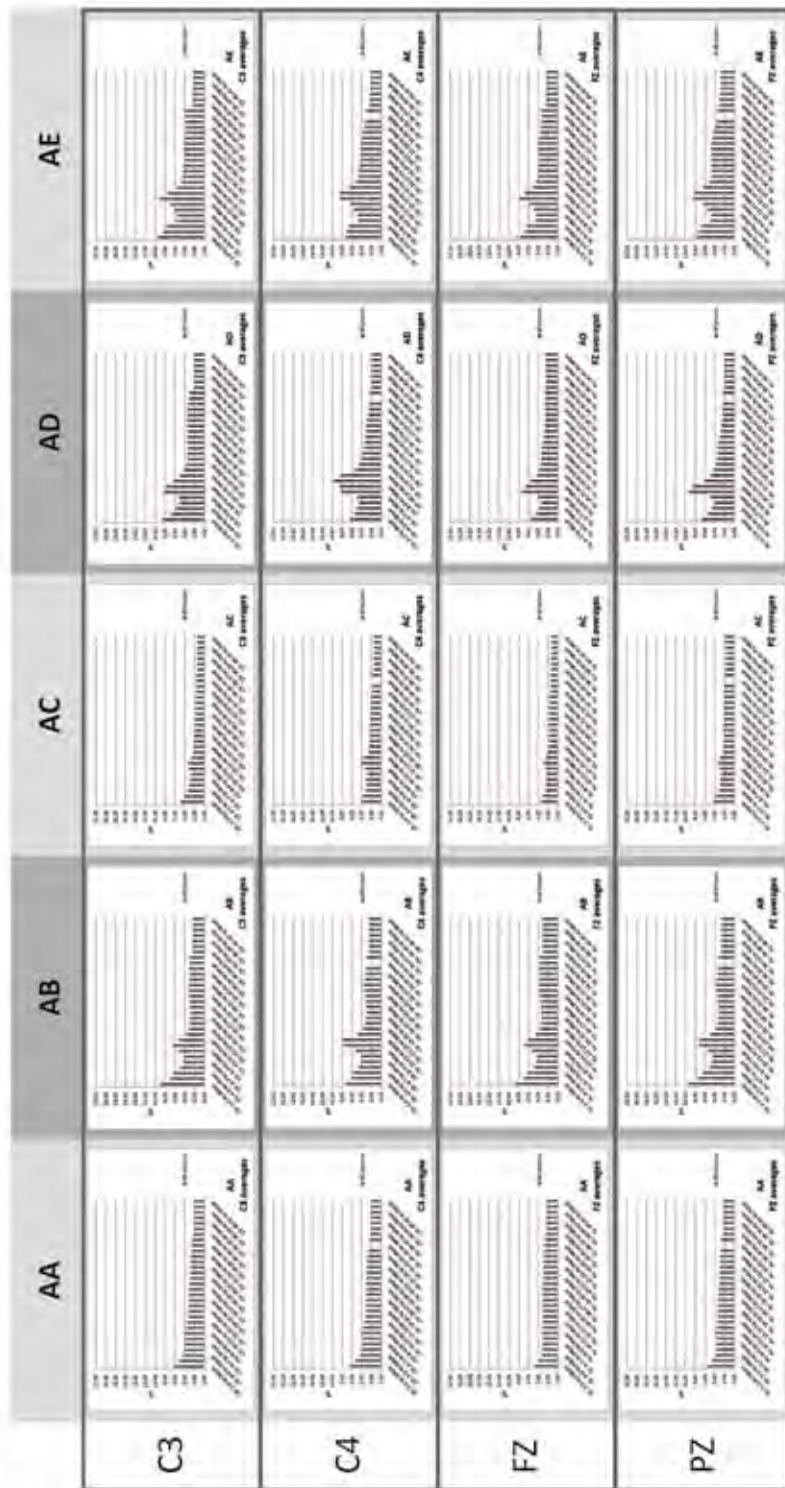

Figure 8
Patterns representing averaged 2 to 41 Hz brain wave activity of artists AA, AB, AC, AD and AE at C3, C4, Fz and Pz receptor sites.

However, the spectral array of the five artists' brain wave activity yields a type of template with a markedly comparable contour. The emergence of this recognisable contour, or pattern, may be as a result of art making, specifically, or due to the fact that it represents *means* of all aspects of the study (as yet not tested, or compared with five participants of another discipline such as music). The patterns, rather than the numerical data of cortical activity as read in μV, indicate that the five artists' cortical brain wave activity indicated an elevation at 2Hz (delta), which gently decreased at 7Hz (theta), rising again slightly at 9Hz, (alpha) then gently dipping and rising again at 17Hz (beta 1). Thereafter there was a gradual downwards sloping and rise, ending at around 41Hz (gamma). Thus, even though the actual cortical activity recording levels as measured in μV differ per artist attesting to their unique selves, the brain wave patterns are similar, attesting to a 'shared' identity of their socio-cultural environment (specifically the community of the five participating artists). The five artists' brain wave/neuroscientific identities during art making do, indeed, seem as one.

Notes

1   Strayer (2008) offers an overview of art and the aesthetic, and the debates surrounding contemporary philosophical aesthetics where art and the aesthetic are separated.

2   In particular, Munro, T (1948) discusses work done by Chandler, Müller-Freienfels and Plaut.

3   For more on experimental psychology and aesthetics see Dessoir, Fechner, Witmer, Legowski and Thorndike (Munro, 1948).

4   An alternative theory of emotional responses to art is a prototypical approach, which proposes that preference for a work of art is determined by the perceived typicality, and not by the work's collative features (Silvia, 2005).

5   Experience refers to "something that happens to somebody or an event that somebody is involved in" or "direct personal awareness of or contact with a particular thing" (Encarta, 2001). The sum total of an individual's experience is acquired through "thoughts and feelings" and knowledge acquired through "the senses rather than through abstract reasoning" (Encarta, 2001). Experience in art making or flow is thus both a noun and a verb. Schindehutte, Morris and Allen (2006:350) posit that the experiential mode is intuitive, automatic, natural and based on images to which positive and negative affective feelings are attached.

6   An example referred to by Teixeira *et al.* (2008) is electrocorticography (ECoG).

7   Hertz units refer to the numbers of cycles per second.

8   The pattern of electrode placement on the scalp is referred to as the International 10-20 System and is relatively standard in clinical practice (Zillmer & Spiers, 2001:203).

9   A segment refers to a demarcated time-related event (which can be of any time duration) during the EEG recording. For example, the first segment could require the participant to have eyes closed; the second segment could require eyes to be opened.

10 See http://www.art.co.za.

11 Linked earlobes served as reference and ground.

12 EEG recording times (in minutes) did not emulate the actual studio time that artists employed to make art, as these differed per artist and were dependent on individual artists' circumstances, work programmes and individual needs. For example, even though all five artists tended to have regular and disciplined working hours, these would change during the run-up to an exhibition, or when an artist was sourcing reference for a new body of work away from the studio environment.

13 The various experiments form part of an unpublished doctoral thesis by Ariana van

Heerden which focused on the brain state referred to as 'flow'.

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