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Therapeutic Induction of Altered States of Consciousness: Investigation of 1-20Hz Neurofeedback

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Abstract

Positive outcomes linked to experiences of altered states of consciousness (ASC) have been linked to various brain wave patterns, as well as both positive and negative personality traits and affective disorders. Various innovative neurofeedback (NFB) technologies are being developed in an attempt to create adjunctive therapeutic treatments. The current study investigated 1-20 Hz NFB to induce ASC and examine associations between NFB, ASC, mood changes, and trait predictors. 23 students completed trait measures of emotionality, openness and extroversion from the HEXACO test of personality and a measure of trait absorption. Participants then completed 15min of NFB. The Profile of Mood States (POMS) was administered before and after the NFB session and the Altered States of Consciousness Questionnaire (OAV) at the end of session. Elevated levels of trait emotionality and absorption were associated with the subscale of disembodiment on the OAV. POMS scores indicated significant reductions in vigor and a significant increase in fatigue and confusion from pre-to post NFB. An overall decrease in 1-20Hz was seen pre-vs post intervention globally, with an increase in 1-20Hz during the intervention as measured at the NFB training site. Positive correlations were seen between EEG and OAV scores for the subscale disembodiment, with global changes between time one and time five during the intervention. EEG readings taken at the active training site demonstrated a positive correlation with trait emotionality and with the subscale spirituality. Qualitative feedback indicated that 70% of participants reported a positive response to neurofeedback, with 17% reporting negative effects, including feeling tired; often associated with over training, 14% reported having no response. 1-20Hz evidenced potentially therapeutic effects and warrants further investigation.

Key Words: Neurofeedback, PTSD, Altered States, Mindfulness, Default Mode Network, Therapy

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PTG	Post Traumatic Growth	1
NDA	Non-Dual Awareness	3
EEG	Electroencephalogram	6
ACT	Action and Commitment Therapy	7
ICN	Intrinsic Connectivity Network	9
DMN	Default Mode Network	9
CEN	Central Executive Network	9
SN	Salience Network	9
PCC	Posterior Cingulate Cortex	11
MDMA	Methylenedioxy-methamphetamine	12
LSD	Lysergic acid diethylamide	12
MM	Mindfulness Meditation	12
DMT	N,N-Dimethyltryptamine	13
ASC	Altered States of Consciousness	13
ADHD	Attention Deficit Disorder	15
NFB	Neurofeedback	16
fMRI	Functional magnetic resonance imaging	16
MEG	Magnetoencephalography	17
Pz	Posterior Midline Electrode Placement	17
OAV	Altered States of Consciousness Rating Scale	21
HEXACO	Model of Personality and associated Inventory	23
MODTAS	Modified Trait Absorption Scale	24
POMS	Profile of Mood States	24

Introduction

The Current State of Psychotherapeutic Outcomes for PTSD

Epidemiological studies suggest that about 70% of Canadians will experience a traumatic life event sometime in their lives. Examples include being sexually assaulted (3% Male, 19% Female) or molested (10% M, 33% F), involvement in a life threatening motor vehicle accident (23% M, 13%), or the sudden unexpected death of a loved one (40% M, 42% F; Van Ameringen, Mancini, Patterson, & Boyle, 2008). Although most will not develop some form of psychopathology, approximately 10% will develop significant psychological problems such as posttraumatic stress disorder (PTSD). Even the best current evidence-based psychotherapies are ineffective for up to 50% of persons with PTSD (Bradely, Greene, Russ, Datura, & Westen, 2014). Most common populations include survivors of domestic abuse, first responders, Canadian military veterans, and victims of occupational harassment, among others.

Traditional theories about Post-Traumatic Stress Disorder have followed a bio-psycho-social model and, as such, have been focused on how prolonged exposure to acute and long-term trauma can lead to fear conditioning and anxiety. The diagnostic criteria for PTSD reflect this focus, including a history of exposure to a traumatic event that meet specific criteria and the presence of symptoms from four different clusters, namely: intrusiveness, avoidance, negative changes in cognition and mood, and an alteration in how the individual reacts to situations (DSM-5, 2013).

While treatment outcomes are unfavourable for half of those who experience PTSD, the process of recovery for others will culminate in post-traumatic growth (PTG). PTG is defined as the recovery from an existential crisis that transforms a person's perception of self, relationships with others, and leads to a general shift in life's philosophy in a positive way (Calhoun &

Tedeschi, 2014). Understanding the processes that lead to resilience and PTG, as opposed to psychopathology, are therefore critical if we are to support trauma survivors in making a full recovery.

Mindfulness Meditation

Research has suggested that one way to foster the meaning-making necessary to facilitate PTG in traumatized persons is through the cultivation of mindful insight through meditation practice, which can impact self-referential thought processes and meaning in life. Whilst the majority of the mindfulness research literature has been devoted to investigating the basic cognitive processes of mindful attention, including our own work (e.g., Frewen, Hargraves, Depierro, D'Andrea & Flodorowski, 2016), new lines of research are beginning to explore higher states of transcendence and enlightenment (i.e. non-dual states) that are thought to be the ultimate goal of meditation practice (Berkovich-Ohaana, 2015; Josipovic, 2014).

Within such research, toward a deeper understanding of non-dual states, Tzu, Bannerman & McCallum (2015) identified the main features of non-dual states to include an awakening on three metaphorical levels: mental/mind, emotional/heart, existential/guts. Within the context of this thesis, a non-dual state is best understood as a state of resilience wherein an individual can adjust cognitive, emotional and physiological levels of arousal to meet the needs of that particular moment and then return to baseline following both positive and negative experiences. A dual state is representative of a state of division or dissonance that interferes with an individual's ability to respond to and recover from various life stressors. Arousal flexibility will be discussed in more detail within the arousal model developed by Yerkes and Dodson (1908).

At the mental level a practitioner begins to see the mind as a 'tool' instead of seeing thoughts as reality. At the level of the heart, the sense of self is no longer tied to emotions and feelings and, rather, is viewed as a sign to be heeded and addressed. Finally, at the existential level (i.e., gut feelings) “grasping toward the future” ceases, and acceptance of what is arises, thus paving the way for responsiveness toward intuitive gut feelings.

Therapeutically, an understanding of these regulatory states underlying mindfulness is becoming viewed as increasingly important for therapists. Zoran Josipovic is an adjunct assistant professor within the psychology department of NYU. Whose research has focused on consciousness, meditation and nonduality. Josipovic’s most recent articles are entitled “Love and compassion meditation: a non-dual perspective (2013), Neural correlates of nondual awareness in meditation (2016) and an editorial entitled “What can neuroscience learn from contemplative practices” (2015). The thread through these articles is tied to the arguments that have been made thus far and are highlighted here:

> “the results of the non dual awareness (NDA) meditation support the intuitive, but speculative, idea that the typical anticorrelations between the intrinsic and extrinsic networks might reflect the duality of internal self-related and external other-related mentation, and that the higher degree of functional integration between these two networks observed during NDA meditation may be related to the reported decrease in fragmentation of experience into subjective vs objective, or self vs other, poles encountered in mystical states of union or non-duality” (p.8).

Fragmentation of self in response to trauma is well documented (Frewen & Lanius, 2015; van Der Kolk, 2014), and therefore representative of a dual form of consciousness. In addition, Josipovic (2016) further proposed “that the disconnect from an embodied experience of dimensions and qualities, as can occur due to various traumas, is at the root of neurosis” (p. 5), further highlighting the need for therapies that help clients achieve an inner, embodied awareness, culminating in the experience of a non-dual state, as a potential a spark toward a resilient state of non-dual awareness. Therefore, Josipovic’s (2015, 2016) overall message to clinicians is that non-dual approaches are warranted for existential crisis, wherein a client’s “being” has been lost or called into question, whereas non-dual therapies, namely those that cultivate an “increasing intimacy within, and openness without, co-occur simultaneously through the attunement to the ground of being” (p.5) may be most efficacious. Further highlighting the underlying embodiment, and self-awareness that it is key to foster, prior to engaging in cognitive or narrative therapies.

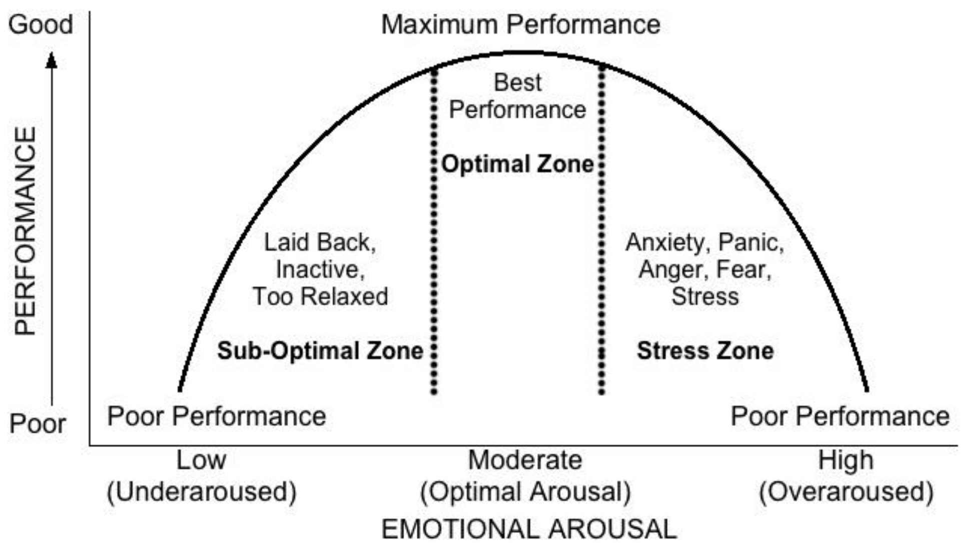
Philosophically the shift from a dual to a non-dual state is best understood by unpacking how an individual’s sense of self changes with each state. In a dualistic state, the self is defined in an autobiographical way (i.e.,“me”), represented by a clinging to illusory thoughts and emotions that are often associated with a denial, suppression, or unawareness of gut feelings (i.e., intuition). Therefore, the sense of self is split and viewed as a separate force often causing discomfort and inner turmoil. A non-dualistic sense of self is, however, defined by an embodied and attuned sense of self (i.e., “I”), in tune and responsive to gut emotions, while maintaining a non-judgemental acceptance toward the inward dance of emotion and thought, representative of a highly adaptive and resilient state. While addressing the shift from dual to non-dual states from a philosophical model is fascinating and informative, it also highlights and mirrors a part of arousal theory identified by Yerkes and Dodson in 1908, namely the theory of arousal related to the autonomic nervous system (ANS; As cited in Hamlin, 2016, p. 8-22; Menon, 2011).

Arousal Theory

Arousal theory of the ANS was originally developed as a learning theory. However, it has been adapted into various models including emotional regulation, motivation, sexual arousal, memory, perception, decision making, personality and peak performance, etc., (Schacter, Stanley, Singer and Jerome, 1962; Steinmetz, Schmidt, Zucker, Kensinger, 2012; Yerkes & Dodson, 1908). A common element to these theories is a belief in an ‘optimal’ level of arousal.

This perspective is highlighted in the Yerkes-Dodson (1908) performance curve, with the peak of the curve representing optimal arousal (See figure 1 below).

Figure 1: The Arousal Model



Prior to the peak, the spectrum ranges from sleep to mild-alertness, while after the peak the spectrum ranges from stress to panic. In sports, the peak is described as the ‘optimal energy zone’ and for cognitive tasks the “highest efficiency requires maintaining greater than average arousal” (Hamlin, 2017, p.8-4). For example, with a simple task like hitting a nail with a hammer, arousal that is slightly higher than normal is needed; failure to obtain such arousal leads to missing the nail or inefficient work, whereas, a complex task such as playing chess requires a lower arousal level to help sustain attention. If arousal becomes too high, then the player is likely to make careless mistake or become restless or bored.

From a therapeutic perspective, and within the context of neurofeedback therapies, dysregulated arousal has been linked to various mental health concerns and is best understood within the context of four types of arousal: 1) *over*, seen in anxiety, anger, impatience, hyperactivity, muscle tension and headaches; 2) *under,* depression, low motivation, attention problems, overly sensitive, shy, sleep problems; 3) *unstable*, emotional regulation difficulties, nightmares, relationship problems and migraines; 4) *disordered*, implicated in developmental trauma, autism, deregulated attachment, substance abuse, explosive anger. Table 1 highlights the various brainwave states and their relationship to arousal. An important point to consider with respect to understanding the relationship between the dominant electroencephalogram (EEG) activity and arousal is that the activity should be matched by a supportive brainwave state for optimal functioning. For example, if someone wishes to sleep, but have too much Beta (12-32Hz) activity they will likely experience insomnia because their mental and physical state is tense and does not allow for rest.

Table 1: The Arousal model and Brain Oscillations (Demos, 2005)

	Too Little	**Normal**	**Too Much**
Delta (0-4Hz)	Poor Sleep	Restful Sleep	Depressed/Sluggish
Theta (4-8Hz)	Robotic	Intuitive	Foggy/daydreaming
Alpha (8-12Hz)	Exhaustion	Calm/relaxed	Anxiety/hypervigilant
SMR (12-15Hz)	Scattered Tired	Present/ready Focused	Depressed Mind Chatter
Beta (15-32Hz)	Depressed Unmotivated	Engaged	Unable to relax Tense

Individuals who are locked into one pattern of arousal lack the flexibility required to address life events in a resilient way, instead they are locked into a pattern of behaviour that is represented in their dominant EEG patterns. With respect to disordered arousal, which is directly associated with developmental trauma, a delay in the development and regulation of both the limbic or the cortical areas may be observed. Thus, when clinicians work with these individuals, they are essentially working with a mind that has lost the subtle capacity for regulation and therefore governed by the lower, more primal centres of the brainstem. Therefore, therapies like neurofeedback that target and train the underlying lack of functional connectivity and arousal flexibility, required as prerequisite prior to engagement in cognitive based therapies, may be warranted. For example, Hamlin and van der Kolk (2016) demonstrated a significant drop in PTSD symptoms in a group of 34 participants between the ages of 32-64. The pilot study investigated a neurofeedback protocol described as T4 - P4, which aims to address a disordered arousal pattern and enhance the connection (i.e., functional connectivity) between the limbic system and the prefrontal cortex (EEG training manual, 2016; Vander Kolk and Hamlin, 2017). In other words, individuals locked in any of the aforementioned arousal patterns have lost their resiliency and lack the capacity to develop a healing narrative due to the rigid, subconscious, arousal loop, in which, they are essentially stuck.

Post Traumatic Growth and Resiliency

Fredrich Nietzsche [2003] said “he who has a why, can bear almost any how”. Current literature suggests that the creation of a narrative that allows persons to discover meaning in their suffering is integral to trauma recovery (Burton, Cooper, Feeny, & Zoellner, 2015). From a theoretical perspective, the capacity to engage in a narrative and move toward post traumatic growth requires a degree of resiliency for the process to begin (Calhoun and Tedeschi, 2014). However, at this time, an agreed upon operational definition of resiliency has yet to be developed (Bradley et al., 2014; Windle, Bennett & Noyes, 2011).

Resiliency is best understood as the ability to recover from trauma without developing psychopathology; a relative absence of resiliency in the face of trauma is related to psychological vulnerability and can lead to symptoms consistent with PTSD (Calhoun et al., 2014). One potential mediator in various mental health disorders is the ability to decenter from difficult thoughts and emotions. In Action and Commitment (ACT) therapy this is described as a diffusion, whereby the client learns to “distance” themselves from their emotions and take a more objective stance: a stance that requires the development of the "observer" within, which underlies the mindful state of being (Harris, 2009). Interestingly, this overlaps with the process outlined by Tzu et al., (2015), describing the process by which individuals move from dual (i.e., rigid) toward non-dual (i.e., resilient states).

Bishop (2004) defined mindfulness as both a state and a trait. In general, mindfulness is understood as the process away from dual states, wherein an individual is governed by their thoughts and feelings toward an embodied state of presence, where the mind, heart and gut are embraced and seen as tools and informants for awareness/self, as an individual develops the observer state of mind and moves toward a non-dual awareness. Bishop (2004) outlines three observable traits that hallmark this shift, namely; acceptance, curiosity and openness toward their moment to moment experiences.

Case studies within Tedeschi and Calhoun's (1999) book "*Facilitating Posttraumatic Growth"* outline that a shift toward mindfulness is a clear, although perhaps overlooked aspect of the reported experiences. For example, Diane's story started following the traumatic death of her six-year-old daughter. During a discussion with her therapist, one in which she was demonstrating PTG; the key traits of mindfulness are woven into the fabric of her movement toward post traumatic growth: 1) openness, "I want to do more and see more. Get involved with things… There's a whole world out there to see and I haven't seen a lot of it."; 2) curiosity, "I'm intellectually more curious about things"; 3) acceptance "I can let go of things from the past better…I'm getting a lot stronger in realizing that life goes on…you can't hold onto the past forever (p. 29-30).

Stories like Diana's are compelling and heart warming, and the work of Bishop (2004) and Tzu et al. (2015) pull at a thread of resiliency, one which assumes the premise concerning what underlying neural mechanisms hallmark the embodied and physiological side of these changes. Recent studies investigating the neurological underpinnings, of individuals underserved by current evidence-based psychotherapeutic treatments, have revealed that the ability to engage trauma in a cognitive manner (i.e. a small degree of resiliency is present), as well as re-establishing a level of self regulation and arousal as evidenced in EEG dominant frequencies (i.e., resiliency), is potentially dependent on the regulation of three intrinsic connectivity networks (ICN) in the brain (Lanius, Frewen, Tursich, Jetley & McKinnon, 2015).

Intrinsic Connectivity Networks

The ICNs are defined as strong patterns of activity that remain active and measurable across a variety of mental states, including sleep and unconsciousness (Lanius et al., 2015; Menon, 2011). These three networks are: 1) Default Mode Network (DMN), tied to self-referential thought processes, memory, social engagement and emotion regulation (i.e., internal awareness); 2) the Central Executive Network (CEN), implicated in processing information in working memory, problem solving and goal-directed behaviour and (i.e., external awareness); 3) the Salience Network (SN), linked to a sensitivity toward signals in the environment, and tied to how the mind and body connect, both externally and internally (i.e., interoceptive awareness). The SN also orients both the DMN and the CEN toward which external and internal stimuli should be attended (Menon, 2011). The DMN and the CEN are understood as anticorrelated, individuals are either focused internally or externally in normal waking consciousness (Menon, 2011). Disorders of this ability to “toggle” between internal and external awareness are increasingly implicated in various disorders including schizophrenia, wherein the networks’ degree of anticorrelation is hindered and the networks’ fuse together,’ causing individuals to attribute personal meaning to external events, because their brain is functionally incapable of identifying the differences (McFarlane, Williamson, & Lanius, 2010; Whitfield-Gabrieli & Ford 2012).

Notably, in the case of trauma, McFarlane et al., (2010) discovered that dissociative individuals are essentially locked in the DMN and lack the ability to engage the CEN during a demanding cognitive task. This is akin to being locked inside of your mind, without the ability to distance yourself from angry and upsetting thoughts, or as Tzu et al., (2015) would define it, the individual is trapped in their mind and has yet to learn to use it as a tool and their heart is tied to emotions, unable to see them as messengers and guides, but instead as abusive and punitive, which can be tied to disordered patterns of arousal, as evidenced in the state of resiliency or rigidity within their ICN's.

There is still another element at play here, namely the SN, which is potentially akin to the veil that the DMN and the CEN toggle through each time they switch. One way to conceptualize this is to imagine two hands with their fingers intertwined (one representing the DMN and one representing the CEN). Metaphorically, the SN is like a waterfall that the DMN and CEN constantly pass through, as attention and focus switch between inner (DMN) and outer (CEN) states. The temperature of the water can be understood as akin to the level of physiological arousal an individual is experiencing in that moment. For example, if someone is hypervigilant it is like the water being too hot, also associated with high Beta activity. However, is in a dissociative state (excessive theta and possibly delta), then it is similar to the water being too cold. Therefore, every time attention switches between inner and outer perspectives, it is either given a message that reinforces a negative loop of either hyper arousal or hypo arousal. If the water is just right, then this is similar to experiencing the 'window of tolerance' whereby an individual is in a more resilient and responsive state. As Tzu et al., (2015) might express, the SN is potentially tied to the regulation of physiological arousal (i.e., heart and the gut) and without a comfortable temperature, then it will be difficult for awareness to self-regulate and enter into a mindfulness state of openness, curiosity and acceptance. This highlights the importance of our mind/body connection; a connection that appears to be of paramount importance to consider when working with individuals struggling with trauma (Menon, 2011; Whitfield-Gabrieli, & Ford, 2012).

Default Mode Network and Alpha Rhythm

Of the three ICNs, the DMN is of central focus to this study because of its strong connection with the temporal lobes, the amygdala and hippocampus, which are related to the processing of emotion, memory and sense of self (Carhart-Harris, et al., 2012a, 2014; Daniels, Bluhm & Lanius, 2013). Several lines of research support the view that the DMN organizes the activity and interplay of other networks (Duncan, Enzi, Wiebking, & Northoff, 2011; Daniels et al., 2012). Fox and Greicius (2010) conducted a review of DMN research and found that the changes in functioning of the DMN is often implicated in a variety of mental health disorders, including PTSD, social anxiety, autism, bipolar and depression. The DMN is also the home of the posterior dominant rhythm, which emerges as the Alpha rhythm (8-12 Hz), a brainwave that can be metaphorically understood as the ‘rhythm section’ in the brain.

Regulation of Alpha has been associated with relaxed awareness, whereas deregulation in the DMN/Alpha rhythm has been linked to PTSD, anxiety and depression, dementia, schizophrenia, epilepsy, autism and attention deficit/hyperactivity disorder (Broyd et al., 2009; Hamlin, 2016). It is important to note that deregulation in the DMN has also been noted in meditation practitioners fully engaged in deep mindfulness, as evidenced by a deactivation of the Posterior Cingulate Cortex (PCC) in particular. The PCC is considered the main hub of the

DMN. Within mindfulness practice this deregulation is thought to reflect a state of nondual, present, effortless awareness (Brewer et al., 2011; van Lutterveld et al., 2016). In addition, deregulation of the DMN has also been shown to occur in individuals under the influence of psychedelics, including psilocybin (magic mushrooms), Methylenedioxy-methylamphetamine (MDMA) and Lysergic acid diethylamide (LSD; Carhart-Harris et al., 2012b, 2015, 2016). Pharmacological deregulation resulting from these psychedelic substances are associated with reduction in Alpha band activity (Knyazev, Slobodskoj-Plusnin, Bocharov, &Pylkova, 2011).

Alpha activity is associated with a sense of calm and inner peace, states often cultivated by mindfulness training (Demos, 2005). It is therefore important to consider all areas of research that have been shown to influence positive changes within the DMN. Such changes are evidenced through various brainwave states, with a focus on Theta, Alpha and Gamma activity, including mindfulness meditation (MM; Berkovich-Ohana, 2015; Berkovich-Ohana et al., 2012; Cahn, Delorme & Polich, 2010; Fell, Axmacher & Haupt, 2010; Lutz, Greischar, Rawlings, Ricard & Davidson, 2004; Taylor et al., 2012) and psychedelic therapies (Carhart-Harris et al.,2012a, 2014; Don et al., 1998; Stuckey, 2005; Riba et al., 2002). Understanding of these changes potentially facilitates a more thorough understanding of the neurological underpinnings related to resiliency and post traumatic growth.

Psychedelics

A burgeoning field of psychiatric research into the potential of psychedelic drug use for positive therapeutic outcomes has recently re-emerged (Bogenschutz & Pommy, 2012; Carhart-Harris et al., 2012a; Pollan, 2015; Vollenweider & Kometer, 2010). A recent study by Hendricks, Thorne, Clark, Coombs & Johnson (2015) investigated suicide rates in the US by surveying 191,382 respondents for classic psychedelic use (i.e., Ayahuasca (N,N-Dimethyltryptamine, DMT), LSD, mescaline, peyote, psilocybin). Hendricks et al., (2015) reported a significant negative correlation between psychedelic use and suicide risk. The opposite effect was found regarding use of illicit substances; i.e., cocaine, heroin, PCP and illegal use of pain killers. In addition, “such drugs have occasioned highly valued altered states of consciousness (ASC) including ‘mystical’ experiences that strikingly, for a majority of research participants, were considered one of the top five ‘most personally meaningful’ and ‘most spiritually significant’ experiences of their lives’ (Griffiths, Richards, McCann, & Jesse, 2006; Griffiths, Richards, Johnson, & McCann, 2008).

Positive outcomes related to psychedelic experiences tied to a participant’s mystical experience offer personal insight through what users describe as access to their unconscious mind. Such experiences correlate with subjective improvements in self-reported measures of inner peace, patience, good-natured humor/playfulness, interpersonal regard, anger, compassion, mood disorders and addictions (Griffiths et al., 2006, 2008, 2011). Beneficial long term psychological outcomes including increased trait openness to experience (MacLean, Johnson, & Griffiths, 2011), mindfulness (Soler et al., 2016), and creative problem solving (Harman, McKim, Mogar, Fadiman, & Stolaroff, 1966; Kuypers et al., 2016). Overall, psychedelics are not known to be additive (Bogenschutz and Pommy, 2012) and when used therapeutically 80% of the participants in clinical trials continue to report positive changes at a 6-month follow-up (Carhart-Harris et al., 2016; Mithoefer, Grob & Brewerton, 2016). Thus, as positive outcomes emerge, with respect to the use of psychedelics to treat a variety of mental health conditions, a resurgence in interest toward developing a deeper understanding of the healing potential of psychedelics continues.

From a neurological perspective, the positive impact of psychedelics is believed to lie in the alterations of consciousness they facilitate (i.e., nondual). In general, consciousness is the unique ability of the human mind to engage in metacognition (i.e. the ability to reflect upon thought and behaviour; Lutz, 2007). Motivated by a desire to create a framework for further understanding this capacity, Carhart-Harris et al. (2014) proposed a theory of consciousness based on the differentiation of primary vs. secondary states, as indicated by differential amounts of entropy exhibited between states. Entropy is best understood as the quantification of disorder, or the uncertainty, of a given system in a given state (Ben-Naim, 2012). Secondary states are represented by normal waking consciousness, and have lower levels of entropy (i.e. our awareness and ability to process concepts and experience is relatively organized). Primary states are incurring increased levels of entropy in which our consciousness enters into a more expansive state with fewer restrictions on how we process concepts and sensory input. Essentially the difference between a secondary and primary state is the amount of information brought into conscious awareness, as well as the equality of importance all concepts are given in a primary state. In secondary states cognitions are more controlled or “gated” by our regular thought patterns and schemas.

Experiences with primary states, as induced by psychedelics, have been shown to increase cognitive flexibility, leading to enhancements in our capacity for creativity, novel thinking and imagination. Yet, they do come at the cost of reducing functionality and inhibiting attention and cognitive control while within a primary state (Gallimore, 2015). However, when an optimal degree of entropy is reached, there is the potential for secondary states to facilitate a break in “inflexible and circular modes of thinking” as evidenced in the rigid dual states those with trauma face, which when broken can have the potential to facilitate positive outcomes related to psychotherapeutic treatments (Carhart-Harris et al., 2014; Gallimore, 2015; Kuypers et al., 2016).

Current Limitations for Mindfulness and Psychedelics as Therapies

The main limitation for MM is related to regular practice, time commitment and required focus, especially for those struggling with PTSD where this commitment may go beyond their current ability. With respect to psychedelics, despite the increase in literature supporting the potential applications of psychedelic therapies, they remain illegal as a treatment substance. Use of psychedelics is currently restricted to; research use, end of life therapies conducted at New York University, John Hopkins, and under the jurisdiction of labs within countries that have decriminalized illicit drugs or have approved their use for experimental purposes, including Portugal and Germany (Pollan, 2015). However, recent research by Carhart-Harris et al., (2016) has continued to demonstrate the extent of their therapeutic potential, especially with respect to treatment resistant depression. With these findings in mind, it may be possible to augment a third treatment, utilizing MEG findings related to brain wave activity, as informed by psychedelic and MM research, specifically, EEG neurofeedback.

Neurofeedback

EEG Neurofeedback is an empirically-based method for regulating physiological arousal. Its efficacy has been shown to assist individuals with regulating arousal thereby relieving symptoms related to disorders such as attention deficit disorder (ADHD; Arns, Kleinnijenhuis, Fallahpour & Breteler, 2008; Lofthouse, Arnold, Herschl, Hurt & DeBeus, 2012), depression and anxiety (Hammond, 2005) and addiction (Scott, Kaiser, Othmer & Sideeroff, 2005; Unterrainer, Chen & Gruzelier, 2013). While some early evidence suggests EEG neurofeedback may be an effective treatment option in PTSD, research is lacking. Lanius et al., (2015) have argued that neuroscientically-informed treatment interventions will be integral to the development of future treatments for PTSD and related mental health concerns. Interest in neurofeedback has increased due to negative side effects associated with of other modern treatments such as pharmacological interventions (Fraser, O'Carroll, & Ebmeier, 2008; Rosa, Picarelli, Rosa & Marcolin, 2006), as well as the large number of individuals that go largely unserved by current psychotherapeutic interventions (Van Ameringen et al., 2008).

Current pharmacological interventions indirectly influence electrical activity in the brain, whereas neurofeedback (NFB) directly influences these oscillations. Importantly NFB has been associated with long term changes with little to no known side effects when properly administered (Ros, Baars, Lanius & Vuilleumier, 2014). In general, NFB includes real-time performance feedback, usually through visual or auditory rewards, that signal a shift in brain oscillations in the direction of the assigned protocol, which allows the participant to learn the difference between their baseline and new state and attempt to self-regulate their neurophysiological state via continually responding to the feedback.

One protocol currently showing potential with respect to PTSD is EEG-alpha down NFB (8-12Hz). In EEG alpha desynchronization, as little as one session has demonstrated improvements in subjective emotional state as well as modulated fMRI resting-state neural networks critical to cognition-emotional reactions (Kluetsch et al., 2014). Further pilot studies by Frewen and Lanius found: 1) participants engaged in long term MM treatment demonstrated an additional 30% reduction in PTSD severity after the introduction of 15-20 sessions of EEG-alpha NFB, 2) a decrease in PTSD symptoms of 67% was demonstrated using a combined MM+NFB, which has been maintained at 3-month follow-up. Therefore, pilot findings strongly suggest the feasibility and potential for further improving clinical outcomes associated with MM therapy, for

PTSD through NFB augmentation, however this has never been investigated in a randomized controlled trial.

Frewen and Hargraves (2016, in preparation) developed an interest in placebo-controlled trials using functional neuroimaging (fMRI, EEG/MEG) demonstrated a reduction of brain wave oscillations up to ~ 20Hz, reflected in a reduction of activity in the midline-posterior cortex (i.e., DMN, including the PCC, precuneus; Carhart-Harris et al., 2016; Kometer, Pokorny, Seifritz, & Volleinweider, 2015; Kometer, Schmidt, Jäncke, &Vollenweider, 2013; Muthukumaraswamy et al., 2013; Riba et al., 2002, 2004). One area of continued investigation focuses on how reductions in slow frequency oscillations contribute toward alterations in consciousness experienced by individuals who consume psychedelic substances. Positive correlations have been reported between variability of alpha (8-11Hz), theta (4-7Hz), and delta (1-4Hz) amplitude reduction achieved in midline-posterior cortex, on the one hand, and individual differences in the intensity of ASC experienced across participants, on the other (Carhart-Harris et al., 2016; Kometer, Pokorny et al., 2015; Muthukumaraswamy et al., 2013).

Considering these findings, Frewen et al., (2016, in preparation) propose that with respect to reduction in neural oscillations up to 20Hz it may be possible to self-induce an altered state of consciousness, via neurofeedback, by rewarding a participant to reduce these oscillations. Training will focus on the midline structures of the brain associated with the DMN, in particular , the posterior midline electrode placement (Pz), found at the back of the head, over the parietal cortex and above the occipital regions.

NFB is an intervention by which real-time EEG or fMRI recording and participant feedback acts as a means by which a participant can learn to self-regulate the state of their own nervous system, for example, by modulation of attention and arousal as in meditation practice. In a previous study, Ros et al., (2013) demonstrated that down-regulation of the amplitude of EEG alpha oscillations recorded from midline posterior cortex (Pz electrode) is possible in healthy volunteers via EEG-NFB, with correlated effects observed for fMRI in the precuneus as well as with the experience of mind-wandering. Further research demonstrated that EEG NFB training the up-regulation of EEG alpha amplitude at Pz tended to mimic the effects of mindfulness meditation practice in healthy volunteers (Chow, Javan, Ros, &Frewen, 2016).

Additionally, reduction of high-frequency (Gamma) EEG amplitude (van Lutterveld et al., 2016) and FMRI activity (Garrison et al., 2013a, b) in PCC are also achievable through NFB. This training was associated with an increased meditation-related experience of "effortless awareness", defined as a state of mindful concentration whereby sensory experience is observed with a sense of contentment, devoid of any effort to change it (Garrison et al., 2013a). Furthermore, correlations between gamma-band amplitudes and slower frequency oscillations were also reported as frequently significant. These recent studies, together with the long history of research into the role of EEG alpha NFB for anxiety reduction and relaxation Kamiya (1969) suggest the potential therapeutic efficacy of EEG NFB protocols that target the modulation of slow frequency oscillations within the medial parietal lobe (PCC, precuneus) as a translational neuroscience intervention informed by psychedelic medicine.

1-20Hz De-Synchronization NFB

1-20 Hz De-regulation neurofeedback can be classified as a "squash" protocol among neurofeedback practitioners, as it seeks to take several bandwidths and lower their frequency simultaneously, wherein no single bandwidth becomes the focus of the training. Collura (2014) describes a squash protocol as akin to a "bench press" for the mind (p. 137). Traditionally, a squash protocol is used in a "trail" oriented approach, with a 4-20Hz frequency range, wherein the client practices decreasing and then releasing the suppression of bandwidths. Electrode placement will determine which area of the brain the focus of lower EEG amplitude, with a by-product of activating the related area (Collura, 2014). One well known squash protocol is the "sharp" protocol, with an electrode placement at Cz, which rests at the top of the head, over the sensorimotor rhythm area (SMR), with inhibits placed on four bands, spanning from 4-20 Hz, with the goal of obtaining a positive mood and improving mental fitness through "a state of overall EEG quietude…physiologically associated with a neuronal state of readiness, acuity in response, and being poised for action" (Collura, 2003, p. 4). The traditional squash protocol teaches an individual to achieve EEG quietude (i.e., a reduction in brain oscillations) similar to the quietude observed in individuals who require focus right before an action, as is the case with skilled archers who will quiet their EEG prior to executing a successful action. Training of this nature "emphasizes entering a state of optimal readiness" (Collura, 2003, p.4).

Although, Collura (2016) discusses squash protocols within his book *Technical Foundations of Neurofeedback.*This thesis is the first to formally investigate 1-20Hz down-regulation neurofeedback. In addition, electrode placement for squash protocols is traditionally used with frontal or sensorimotor (central) electrode placements. At this time, this is the only study the author is aware of that sought to use a squash protocol at the Pz location, with a focus on the PCC and precuneus, thus focusing on the DMN network.

Our decision to focus on Pz, in addition to the already reviewed meditation and psychedelic literature that emphasize the importance of the DMN was also linked to Tarrant (2016) overview of how to entrain a variety of mindfulness states via neurofeedback, including 1) Focused Attention, wherein the individual increases their ability to shift their awareness and attention away from inner and outer distractors, and remain focused on a meditative object (i.e., breath, candle flame, mantra); 2) Open monitoring, wherein the meditator is able to sit in the moment openly observing their inner and outer awareness without becoming caught up in any thought and or sensation; 3) Automatic self-transcending, wherein the meditator attempts to move from an object of meditation, as practiced with focused attention, as well as beyond observing toward a state of mental quietude.

Interestingly, Tarrant (2016) suggests rewarding Alpha at the Pz site as part of the training protocol for each form of meditation. Both focused attention and open monitoring also reward a secondary site, but for automatic self-transcending, rewarding Alpha at Pz is the only protocol to encourage a quiet mind. Although counterintuitive as our protocol seeks to inhibit a broad range of bandwidths by including Alpha, we keep with Kluetsch et al., (2014) observation that a single session of alpha suppression offered therapeutic outcomes, in part associated with an Alpha rebound that helped stabilize and increase Alpha oscillations. In addition to this, traditional squash training focuses on short bursts of squash and then rest, often 30 seconds to 1 minute in duration, with an increase in alpha often observed between active training, which is described as a form of "post-reward synchronization" during relaxation. It is believed this will help an individual learn to move between concentration and relaxation, and therefore successfully execute difficult tasks faster, and with more precision (Collura, 2014). At this point we can observe two significant departures with respect to our current protocol and traditional protocols as outlined by Collura (2014). Our protocol, based on Carhart-Harris et al., (2014) MEG study with psilocybin expanded the bandwidth to include Delta (1-4Hz), whereas this bandwidth is traditionally not included. In addition, our intervention was a total of 15 minutes in duration and the participant was encouraged to continually down-train the 1-20Hz signal over time. This duration was chosen to allow for a block design of measurement, breaking the EEG recordings up into five, three-minute time epochs to allow us to consider therapeutic length and optimal training.

In response to the need for randomized controlled trials of various forms of NFB, this pilot study investigated an innovative NFB protocol based on Carhart-Harris et al., (2012b) discovery that participants under the influence of psilocybin demonstrated a global decrease in cortical activation between 1-20 Hz (Muthukumaraswamy et al., 2013). The pilot study included 40 volunteers from Dr. Paul Frewen's Trauma course at Western University. Participants received a single 15-minute session of NFB targeting the inhibition of 1-20Hz EEG amplitude over midline posterior cortex (Pz electrode site; medial parietal lobe) and evaluated the degree to which participants might also report experiences of ASC relative to questionnaire norms established for the response to psilocybin, ketamine, and MDMA by a previous meta-analysis (OAV scale; Studerus). We investigated outcomes of this form of NFB on EEG amplitudes of both slow and fast (gamma, >35) frequencies, where the latter was of theoretical interest in so far as increased EEG gamma amplitudes have been observed in advanced meditative practice (Lutz et al., 2004), as well because of psychedelics (Riba et al., 2002; Kometer et al., 2015).

Hypothesis

It is predicted that participants might experience an altered state of consciousness following NFB to the extent that they successfully learn to self-regulate their EEG in the intended direction of reducing the amplitude across the 1-20Hz frequency band, with potential emergent effects on higher (gamma, 35-55Hz) frequencies. In addition, it is predicted that outcomes to vary with respect to individual differences in pre-morbid psychological characteristics, including trait openness to experience, absorption and neuroticism. We also predict a similar pattern of self report measures of altered states of consciousness, in comparison to psilocybin as measured by the altered states of consciousness scale developed by Studerus (2010).

Methods

Participants

The 23 participants, 21 females and 2 males, aged 21-28 (M=22, SD=1.6) were student recruits from a major Ontario university where participation with the study was for partial course credit. 74% were Caucasian, 20% were Asian and 5% included Punjab and South African.

Materials

Brief Demographics

Demographic questions included, age, gender, ethnicity and meditation experience (e.g., duration and frequency of practice).

Altered States of Consciousness Rating Scale (OAV; Bodmer, Dittrich, Lamparter, 1994; Studerus, Gamma & Vollenweider, 2012). The primary study outcome measured the extent to which participants would experience ASC in response to NFB as measured by a 42-item short form version of the OAV, a 66-item scale describing the phenomenology of ASC typically within trials of psychedelic drugs using a 0-100 visual analogue scale measured in millimeters ranging from 'No, not more than usually' to 'Yes, much more than usually'. We scored only the 42 items identified by Studerus et al., (2010) to form 11 factorially-invariant subscales across a meta-analysis of 591 psychedelic sessions across three drug classes (327 psilocybin, 162 ketamine, and 102 MDMA) and 43 experimental studies using structural equation modeling, hierarchical item clustering, and multiple indicators multiple causes methodology: 1) experience of unity (5 items; e.g., "Conflicts and contradictions seemed to dissolve"), 2) spiritual experience (3 items, e.g., "My experience had religious aspects"), 3) blissful state (3 items, e.g., "I experienced an all-embracing love"), 4) insightfulness (3 items, e.g., "I gained clarity into connections that puzzled me before"), 5) disembodiment (3 items, e.g., "It seemed to me as though I did not have a body any more"), 6) impaired control and cognition (7 items, e.g., "I had difficulty in distinguishing important from unimportant things"), 7) anxiety (6 items, e.g., I was afraid without being able to say exactly why"), 8) complex imagery (3 items, e.g., "I saw scenes rolling by in total darkness or with my eyes closed"), 9) elementary imagery (3 items, e.g., "I saw colors before me in total darkness or with closed eyes"), 10) audio-visual synesthesia (3 items, e.g., "The shapes of things seemed to change by sounds and noises"), and 11) changed meaning of percepts (3 items, e.g., "Things around me had a new strange meaning for me"). Studerus et al., (2010) found that subscale scores differed significantly as a response to the 3 drugs where, for example, psilocybin was associated with particularly high scores for complex and elemental imagery and audio-visual synesthesia, ketamine was associated with particularly high scores for disembodiment, and MDMA was associated with the highest scores for blissful state, and particularly low scores for complex and elemental imagery and audio-visual synesthesia; meta-analytic means and standard deviations referring to response to each drug were obtained directly from the author.

HEXACO Personality Inventory (Lee & Ashton, 2004). As a broad measure of personality characteristics, participants completed the 10-item *Openness*, *Extraversion*, and *Emotionality* (i.e., Neuroticism) subscales of the 60-item short-form version of the 6-factor on 5-point Likert-Scales 1 (‘Strongly Disagree’) to 5 (‘Strongly Agree’). Questions from each subscale include “I like people who have unconventional views” (Openness), “I think most people like some aspects of my personality” (Extraversion), and “I sometimes can’t help worrying about the little things” (Emotionality-Neuroticism).

Modified Trait Absorption Scale (MODTAS; Jamieson, 2005; Tellegen & Atkinson, 1974). Participants also completed the 34-item MODTAS, which measures openness to cognitive, perceptual, and imagistic experiences as well as vivid imagery, synesthesia, and intense involvement in aesthetics and nature. The same 5-point scale used for the HEXACO questionnaire was used to ensure comparability. Example questions include “I can be greatly moved by eloquent or poetic language” and “I often know what someone is going to say before he or she says it.”

Profile of Mood State (POMS-SF; McNair, Lorr, & Droppleman, 1989; Curran et al., 1995) is a 37-item instrument that evaluates six transient distinct mood states: depression, tension-anxiety, vigor-energy, fatigue, anger-hostility, and confusion-bewilderment. Participants responded on a five-point Likert scale ranging from 0 (‘not at all’) to 4 (‘extremely’). Items include single words such as “unhappy,” “sad,” “active,” and “fatigued.”

Adjective Word List (EWL-K; Janke & Debus (1978). Following Struderus et al., (2012) four items from this list were used to assess a participant’s level of excitement prior to an intervention. Participants responded on a five-point Likert scale ranging from 0 (‘not at all’) to 4 (‘extremely’). Items include single words such as “go-getting,” “avid,” “active,” and “energetic.”

Procedure

Upon arrival at the testing site, participants completed a consent form, demographics questionnaire, drug history questionnaire, brief symptom inventory, HEXACO and Tellegan absorption scale via Qualtrics online survey software in a separate room. The neurofeedback session was completed within the study using the EEGer NFB software version 4.3 (EEG Spectrum Systems, CA) and its associated "formation game" connected to a dual channel Spectrum4 amplifier (J&J Engineering, United States) in a single-channel referential montage (ground and reference were the left and right earlobes), while a Emotiv Epoch+ EEG headset (14-channel covering primarily lateral frontotemporal cortex, San Francisco, United States) recorded raw signal from untrained electrode sites.

Participants were then brought into the treatment room where they sat in a comfortable chair facing a 31" computer monitor that was fitted with EEG and NFB hardware. The EEG hardware was worn throughout the study allowing for continuous EEG recordings for all conditions. Participants were verbally administered the POMS and EWL-K prior to a pre-intervention baseline EEG measurement. Participants were then asked to close their eyes and allow their minds to naturally wander allowing for a three-minute baseline EEG measurement recorded with both Epoch and EEGer. Upon the completion of baseline measures, each participant received instructions for each respective 15-minute NFB intervention.

The protocol was such that participants were rewarded when they decreased their absolute 1-20Hz amplitude below threshold. Thresholds in NFB are typically set in such a way that the participant achieves a certain level of success that is challenging without becoming too easy or difficult. (Demos, 2005). As such, a moving threshold was calculated continuously over the first three-minutes of training such that EEG-alpha amplitudes could be expected to continue to exceed the moving threshold 65% of the time. EEGer delivered 15-minutes of continuous NFB training the inhibition of 1-20Hz amplitude exclusively at the Pz electrode site (midline/medial posterior/parietal).

Feedback was delivered by revealing images, hidden under grey boxes (about 8-12 per image). While participants' 1-20Hz amplitudes were above threshold, the images would remain covered, or the removal of grey boxes would pause. While participants' 1-20Hz amplitudes were below the determined threshold, the images below a screen of grey boxes would slowly be revealed one grey box at a time. The images used are generally described as non-threatening psychedelic imagery (e.g., fractal, kaleidoscopic symbols and landscapes). Participants were instructed to become sensitive to their own inner state and intuitively discover a method for removing the grey boxes to reveal the image behind them. Upon completion of the intervention participants were asked to close their eyes again for a post-intervention EEG baseline measurement. Participants also listened to relaxing ambient music throughout the 15-minute intervention through fitted, noise-cancelling headphones to remove any background noise.

Participants were again asked to verbally answer the POMS and EWL-K and were given a computer to complete the OAV scale. After debriefing, participants were informed that a follow up email will be sent to them that evening requesting they answer the question “what might you have noticed since completing the study today” to assess any further subjective changes that may have occurred following the intervention.

Results

Self report measures of participants’ traits (HEXACO) and absorption were correlated with the altered states scale (OAV) that was administered following the neurofeedback intervention. Difference between the profile of mood state pre-and post-intervention were assessed using t-tests, corrected for multiple comparisons. The OAV scale was also compared with the original validation by Studerus et al., (2010) with MDMA and psilocybin to offer a snapshot of similarities in reports.

A general linear model (GLM), ANOVA, test of within subject effects and post hoc t-test was conducted across all EEG analyses to assess the differences, and direction of the differences, pre-and post and across time for both the full head EEG recording from the Emotive Epoch. In addition, the single training electrode for EEGer, at the PZ location, was also analyzed to assess the differences between hemispheres and across electrode clusters, including frontal and temporal parietal changes. Finally, self report measures were correlated with EEG findings.

Self-Report Measures

HEXACO (N = 23) was limited to three subscales for this study, including emotionality (M = 3.2, SD = .22), openness (M = 3.2, SD = .26) and extraversion (M = 3.2, = .24). Emotionality was positively correlated with absorption $r(21) = .52$, $p < .005$. Comparisons of mood (POMS) pre and post measures demonstrated a significant decrease in vigor post intervention $t(22) = 2.299$, $p = 0.031$, and an increase in fatigue following the intervention $t(22) = -2.168$, $p = 0.041$. Overall, a significant change was demonstrated in POMS ratings from pre-to post, $t(22) = 2.274$, $p < 0.05$, as shown in figure 2.

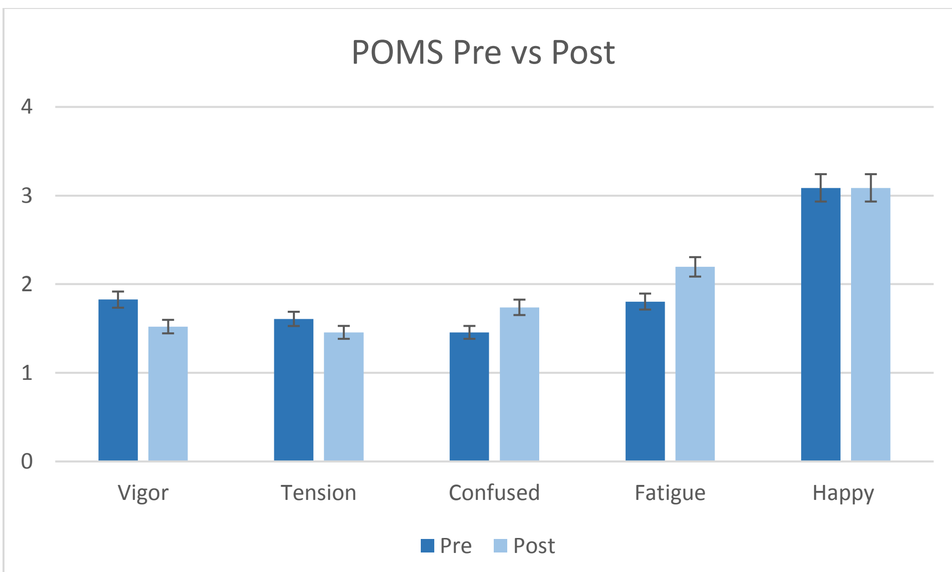


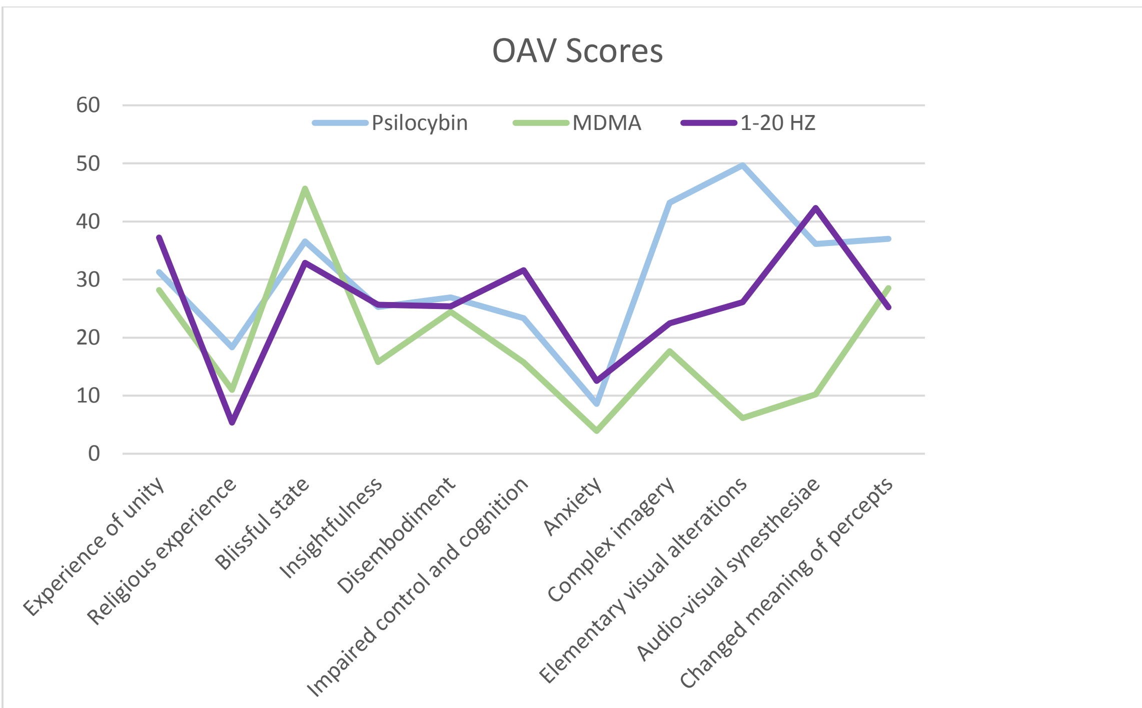
Figure 2 changes in Profile of Mood State (POMS) pre-vs. post intervention.

Self-Report Altered States of Consciousness Rating Scale

The OAV consists of 11 subscales, including an experience of unity (M = 37.2, SD = 17.18), spiritual experience (M = 5.36, SD = 6.25), blissful state (M = 32.90, SD = 26.48), insight (M = 26.70, SD = 24.75), disembodiment (M = 25.36, SD = 17.57), impaired cognition and control (M = 31.61, SD = 12.45), anxiety (M = 12. 54, SD = 9.09), complex imagery (M = 22.46, SD = 21.54), elementary imagery (M = 26.09, SD = 19.63), audio-visual synesthesia (M = 42.32, SD = 25.11), changed meaning of percepts (M = 25.21, SD = 15,73).

Disembodiment was positively correlated with emotionality $r(21) = .60$ $p < .001$ and absorption $r(21) = .55$, $p < .003$. Figure 3 illustrates a snap shot of similarities and differences with respect to self reported altered states between 1-20 De-synchronization neurofeedback, MDMA and psilocybin as reported by Studerus et al., (2010).

Figure 3, OAV profiles for various interventions, including 1-20Hz Studerus (2010).



Pre-and Post analysis of EEG

Participants were included in the analysis of EEG baselines if the data retained >60% of the one second epochs within the total 3-minute EEG recording pre- and post-intervention after artifact rejection and EEG pre-processing. Thus, three participants were excluded from analysis (Subject 1 and 2 were excluded prior to the analysis due to issues during recording that rendered the data unfit for analysis. Subject 18 retained 26% at pre-intervention, 14% retained at post-intervention). Table 2 and 3 report results for the EEG 1-20Hz amplitude before vs after the intervention.

1-20Hz Training: Epoch

As shown in Table 2, a main effect was found for both location (lobe) and time (pre-vs post). A one-way repeated measures ANOVA revealed significant 1-20Hz amplitude changes between the two locations (frontal and temporal parietal), $F(1, 18) = 21.84$, $\eta^2 = 0.535$, $p < 0.001$ and between pre-and post measures, $F(1, 18) = 16.85$, $\eta^2 = 0.470$, $p < 0.001$. A non-significant interaction was demonstrated for time, hemisphere and lobe. Post-hoc test indicates that 1-20Hz amplitudes decreased for left frontal, $t(18) = 3.38$, $p = 0.003$, right frontal, $t(18) = 3.39$, $p = 0.003$, left temporal parietal (TP), $t(18) = 3.96$, $p = 0.007$, right TP, $t(18) = 3.04$$p = 0.007$ pre vs post intervention. Significant changes were also observed pre-and post for global measures (i.e., all amplitudes for electrodes in the defined region were combined), including right frontal global $t(18) = 3.743$, $p = 0.001$, left frontal global $t(18) = 3.698$, $p = 0.002$, frontal global $t(18) = 3.812$, $p = 0.001$, and temporal parietal global $t(18) = 3.470$, $p = 0.003$. Changes in amplitude pre-vs post for the frontal electrodes can be seen in figure 4, while changes in the temporal parietal can be seen in figure 5.

Table 2: Group differences in full-band EEG 1-20Hz amplitudes pre -vs- post intervention

EEG Scalp Region	Epoch EEG 1-20Hz	
	Before	After
Left Frontal	17.82 (0.51)	17.60 (0.35)
Right Frontal	17.90 (0.43)	17.60 (0.33)
Left Temporal + Parietal	18.20 (0.69)	17.90 (0.51)
Right Temporal + Parietal	18.16 (0.60)	17.91 (0.46)
Left Global	17.98 (0.55)	17.70 (0.38)
Right Global	17.99 (0.46)	17.71 (0.32)
Frontal Global	17.86 (0.45)	17.58 (0.31)
Temporal Parietal (TP) Global	18.19 (0.60)	17.91 (0.45)

Epoch EEG 1-20Hz, reported as Means (SD)

Main and Interaction Effects	Statistics
Lobe	$F(1, 18) = 21.84$, $\eta^2 = 0.535$, $p < 0.001$**
Hemisphere	$F(1, 18) = 0.020$, $\eta^2 = 0.001$, $p = 0.890$
Time	$F(1, 18) = 16.85$, $\eta^2 = 0.470$, $p < 0.001$**
Lobe x Hemisphere	$F(1, 18) = 0.580$, $\eta^2 = 0.029$, $p = 0.460$
Lobe x Time	$F(1, 18) = 0.001$, $\eta^2 = 0.000$, $p = 0.975$
Hemisphere x Time	$F(1, 18) = 0.050$, $\eta^2 = 0.003$, $p = 0.826$
Lobe x Hemisphere x Time	$F(2, 18) = 1.028$, $\eta^2 = 0.051$, $p = 0.323$

Epoch EEG 1-20Hz, Mixed Between Within ANOVA Statistics

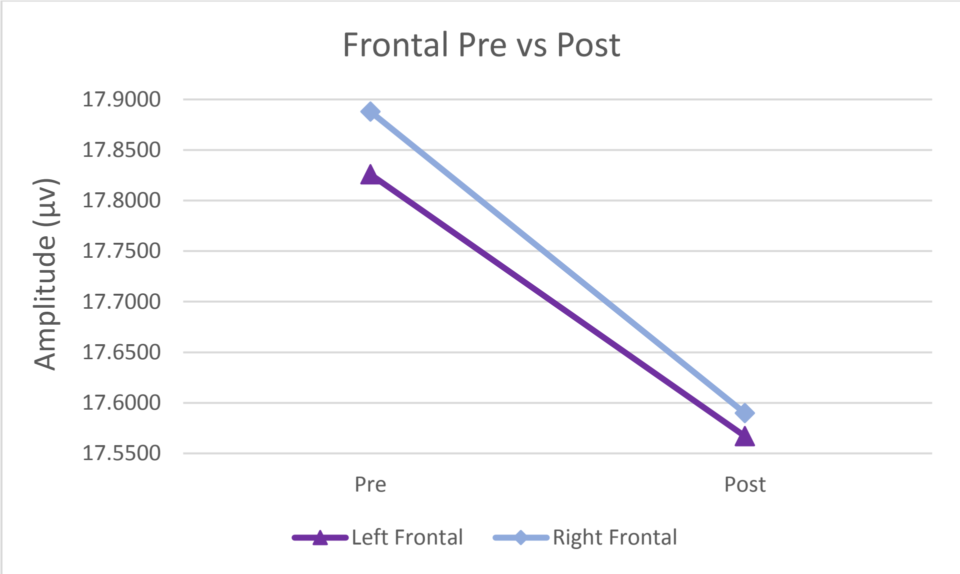


Figure 4: Changes in amplitude pre-vs. post for Epoch Frontal electrodes

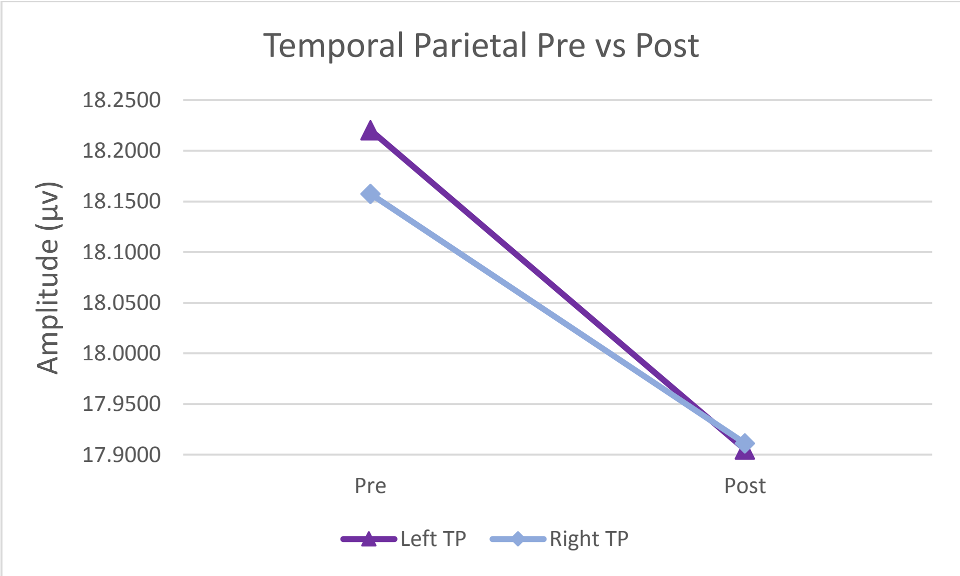


Figure 5: Changes in amplitude pre-vs. post for Epoch Temporal and Parietal electrodes

1-20 Hz Training: Pre-vs Post

A single recording was also taken at the training size for the Pz electrode: Pre (M= 17.35, SD = 0.70), Post (M = 18.57, SD =0.36). Participants were included in analysis of EEGer Pz electrode baselines if the data retained >60% of the one second epochs within the total 3-minute EEG recording at either pre- or post-intervention after artifact rejection and EEG pre-processing. Eight participants were excluded from analysis based on this criterion. Post-hoc test show a reverse effect compared to Epoch findings, with an increase in 1-20Hz amplitude, $t(15) = -6.516$, $p< 0.001$.

EEG Change During 15-Minute Intervention: Epoch

Participants were included in the final analysis if EEG changes retained during the intervention were greater than 60% of their total 15-mintue data set during the intervention period and after artifact rejection and EEG pre-processing. Only one subject was removed due to a 57% loss of data during the fourth segment of the intervention.

Table 3 reports all results for 1-20Hz Epoch EEG amplitudes during the 15-minute intervention. The intervention was divided into five separate time windows, each three minutes in duration. A one-way repeated measures ANOVA of the 1-20Hz training revealed a main effect of *timepoint* $F(4, 15) = 3.590$, $\eta^2 = 0.490$, $p < 0.05$ and an interaction between *timepoint, lobe and hemisphere* $F(8, 15) = 3.560$, $\eta^2 = 0.487$, $p < 0.05$, as seen in table 2. Overall, amplitudes increased across *timepoints* $F(4, 18)$, $\eta^2= 0.396$, $p < 0.01$ and *lobe* and in a linear fashion $F(1, 18)$, $\eta^2= 0.245$, $p < 0.05$. Changes in amplitude over time for the frontal electrodes can be seen in figure 6, while changes in the temporal parietal can be seen in figure 7.

Table 3: Differences across 1-20Hz amplitudes during 15-minute intervention: Epoch

Intervention	Left-Frontal		Right – Frontal		Left TP		Right TP	
	M	SD	M	SD	M	SD	M	SD
First (0-3min)	.1689	.0038	.1701	.0032	.1694	.0048	.1696	.0032
Second (4-6 min)	.1695	.0051	.1703	.0031	.1707	.0046	.1715	.0032
Third (7-9 min)	.1692	.0044	.1701	.0030	.1711	.0042	.1711	.0029
Fourth (10-12 min)	.1703	.0047	.1710	.0036	.1717	.0053	.1722	.0038
Fifth (13-15min)	.1709	.0051	.1703	.0041	.1726	.0045	.1724	.0031

Main and Interaction Effects	Statistics
Timepoint	$F(4, 15) = 3.590$, $\eta^2 = 0.490$, $p = 0.030$
Lobe	$F(1, 15) = 5.845$, $\eta^2 = 0.245$, $p = 0.026$
Hemisphere	$F(1, 15) = 0.595$, $\eta^2 = 0.032$, $p = 0.451$
Timepoint x Lobe	$F(4, 15) = 1.639$, $\eta^2 = 0.304$, $p = 0.216$
Timepoint x Hemisphere	$F(4, 15) = 2.822$, $\eta^2 = 0.429$, $p = 0.063$
Lobe x Hemisphere	$F(4, 15) = 0.256$, $\eta^2 = 0.014$, $p = 0.619$
Timepoint x Lobe x Hemisphere	$F(8, 15) = 3.560$, $\eta^2 = 0.487$, $p = 0.031$

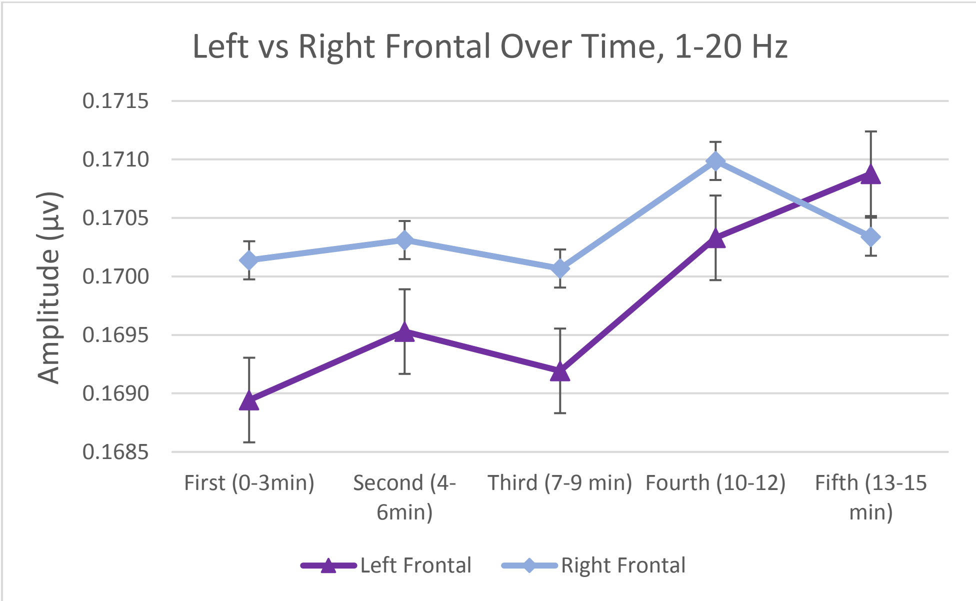


Figure 6: Changes in amplitude, left vs. right during intervention for Epoch Frontal electrodes

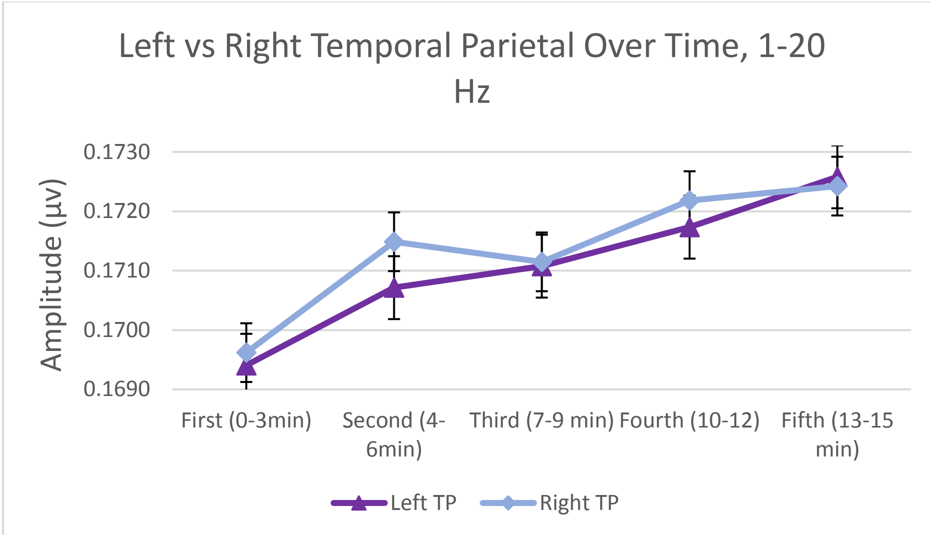


Figure 7: Changes in amplitude, left vs right during intervention for Epoch Temporal and Parietal electrodes

Individual bandwidths were also analyzed to clarify how each bandwidth was affected individually by the 1-20Hz de-synchronization protocol. Due to a limitation in sampling frequency, at a fixed rate of 128Hz per channel, low Gamma (35-55Hz) were not recorded. See figure 9 for an overview of the changes across all bandwidths.

EEG Change During 15-Minute Intervention: EEGer PZ

Participants were included in the final analysis if EEG changes retained during the intervention were more than 60% of their total 15-mintue data set during the intervention period and after artifact rejection and EEG pre-processing. Five participants were excluded from the final analysis due to corrupted data prior to analysis. Participant 11 was removed due to a 62% loss of data during the third segment of the intervention.

EEGer electrode analysis (N=17) at time point one (M = 0.162, SD = 0.004), two (M = 0.162, SD = 0.005), three (M = 0.165, SD = 0.004), four (M = 0.167, SD = 0.003, and five (M = 0.167, SD = 0.004), demonstrating a significant change across time points $F(4, 16) = 23.137$, $\eta^2 =$

0.89, $p < 0.001$ that moved in a linear increase across time $F(4, 16) = 98.792$, $\eta^2 = 0.861$, $p < 0.001$. Changes in PZ electrode across time is shown in figure 8.

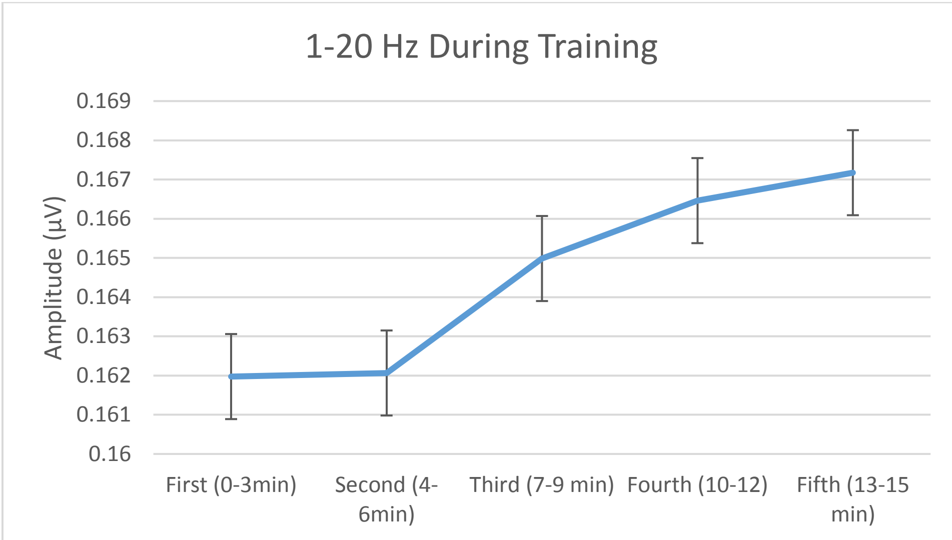


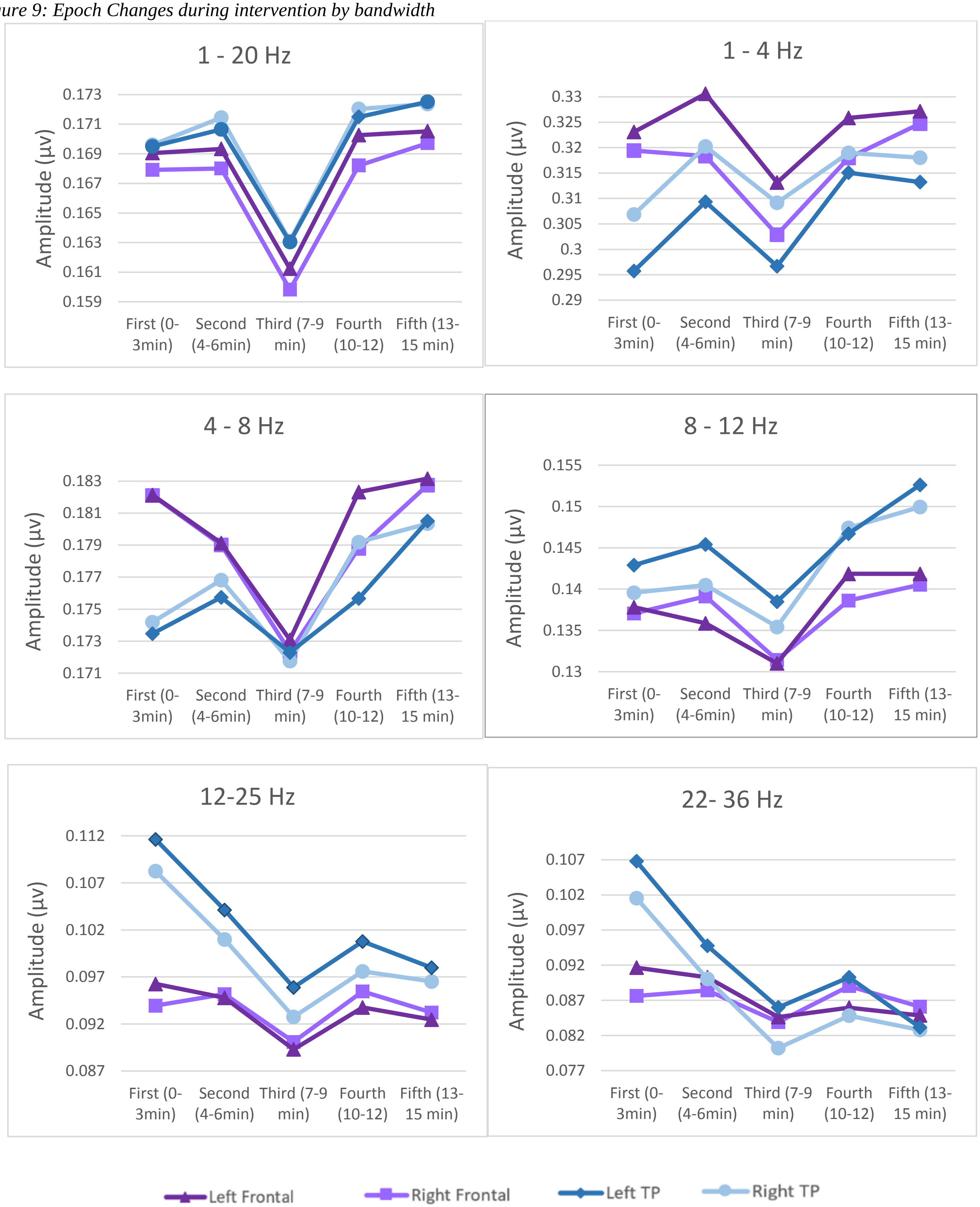
Figure 8, changes over time for Pz electrode, 1-20Hz

Overall, there was a negative correlation between the amount of change pre-vs post, compared to a global change between first and fifth session of the active 15-minute intervention $r(14) = -0.534$, $p = 0.01$. Therefore, the more negative or positive changes demonstrated pre-vs post, the less change in amplitude observed during the intervention (see figure 10). See figure 11 for an overview of the changes across all bandwidths recorded at Pz during the intervention.

Correlations Between OAV Scores and EEG Observations

Scores on four measures were significantly correlated with OAV scores, including global change in Epoch and PZ amplitudes pre-vs post, global change in Pz pre-vs post, as well as global change at time one vs five time for both Epoch and Pz amplitudes during the active condition. A significant correlation was shown for global change one vs five for Epoch for Disembodiment $r(19) = .523$, $p = 0.011$. Significant negative correlations were detected for change from one vs five for Pz electrode for both Spirituality $r(17) = -0.431$, $p < 0.05$ and Emotionality $r(17) = -0.514$, $p < 0.05$.

Figure 9: Epoch Changes during intervention by bandwidth



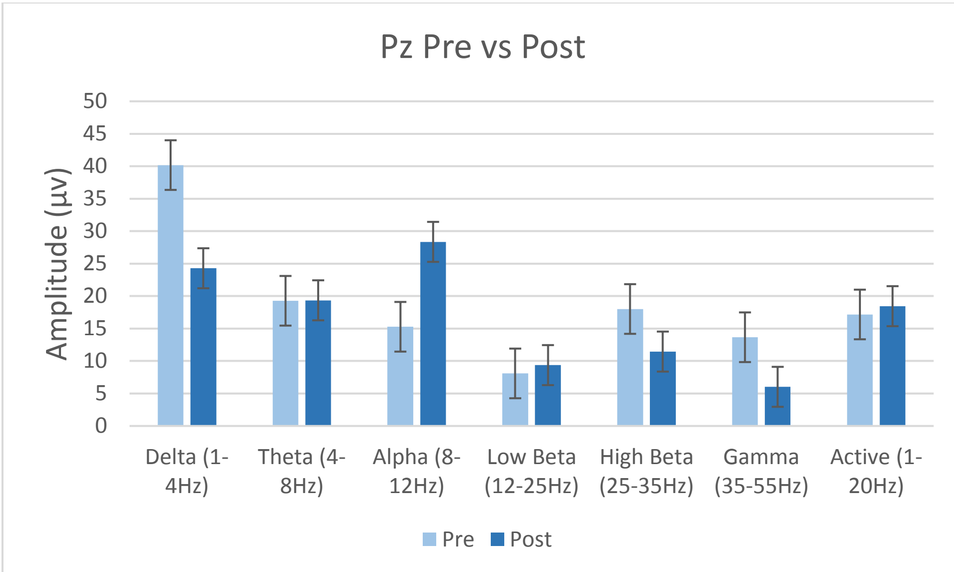


Figure 10: Pz Amplitudes Pre-vs Post

Qualitative Feedback

Participants in the study were emailed 24 hours following their neurofeedback session. They were asked to respond to the question "What have you noticed since the study?" Twenty one of twenty three participants responded, for a response rate of 91%. Sixteen participants (70%) reported a positive experience following the neurofeedback, including increased focus, increased energy, increased positive affect, and increased creativity. Statements of a positive response included:

> Participant 15: After the study, I started to realize that I was much more happier than usual and in a great mood. My stress faded away and the headache I had had for 2 days went away and has not come back. I was able to complete some school work and focus my thoughts in a much better way and I wasn't as prone to being distracted by my own thoughts as much and was able to complete more homework than I had planned for the day. I also finally came up with a clear idea for an essay that I had been stuck on forever beforehand. Finally, for about a few hours after time seemed to melt away and I was completely unaware of how much time went by until I cared to look at a clock.

Participant 21: I noticed in the hours following the intervention that I had felt calm, relaxed and tranquil. These were qualities I did not feel prior to the study. Throughout the study, I felt lost in my own personal thoughts and my personal issues were being resolved subconsciously within my mind. With that being said, I believe I felt an immediate sense of relief after the study, due to this resolution of issues through my subconscious. Hours after the intervention I still felt this sense of relief and internal peace but I was not as relaxed as I was immediately after completing the study.

Four participants (17%) reported negative experiences including a headache, irritability and fatigue. These symptoms are within the normal range of possible unwanted side effects for someone beginning neurofeedback and indicate the possibility of over training (Demos, 2005; Collura, 2014). It is possible that these participants would have had a positive experience had they had a shorter session and worked their way up to the 15-minute duration as is commonly the practice with neurofeedback protocols. Feedback included, "Immediately to about an hour after participating I found myself kind of sad and very unmotivated about everything. By the time I got home though I made myself go to the gym and everything felt pretty normal after that." All participants who reported negative symptoms indicated that the symptoms only lasted for a few hours and they felt 'normal' again by morning. Three participants (14%) reported a neutral response to neurofeedback, with no reported changes in mood, energy of focus. Feedback included, "I actually did not notice any unusual feelings after the study. I went to a birthday party that evening and felt relatively content. I did not feel stressed, upset, or anything similar to that."

Summary of Primary Findings

Overall, the participants in this study were not suffering from general psychopathology or emotional distress. Self-report (POMS) measures taken following the study indicated that

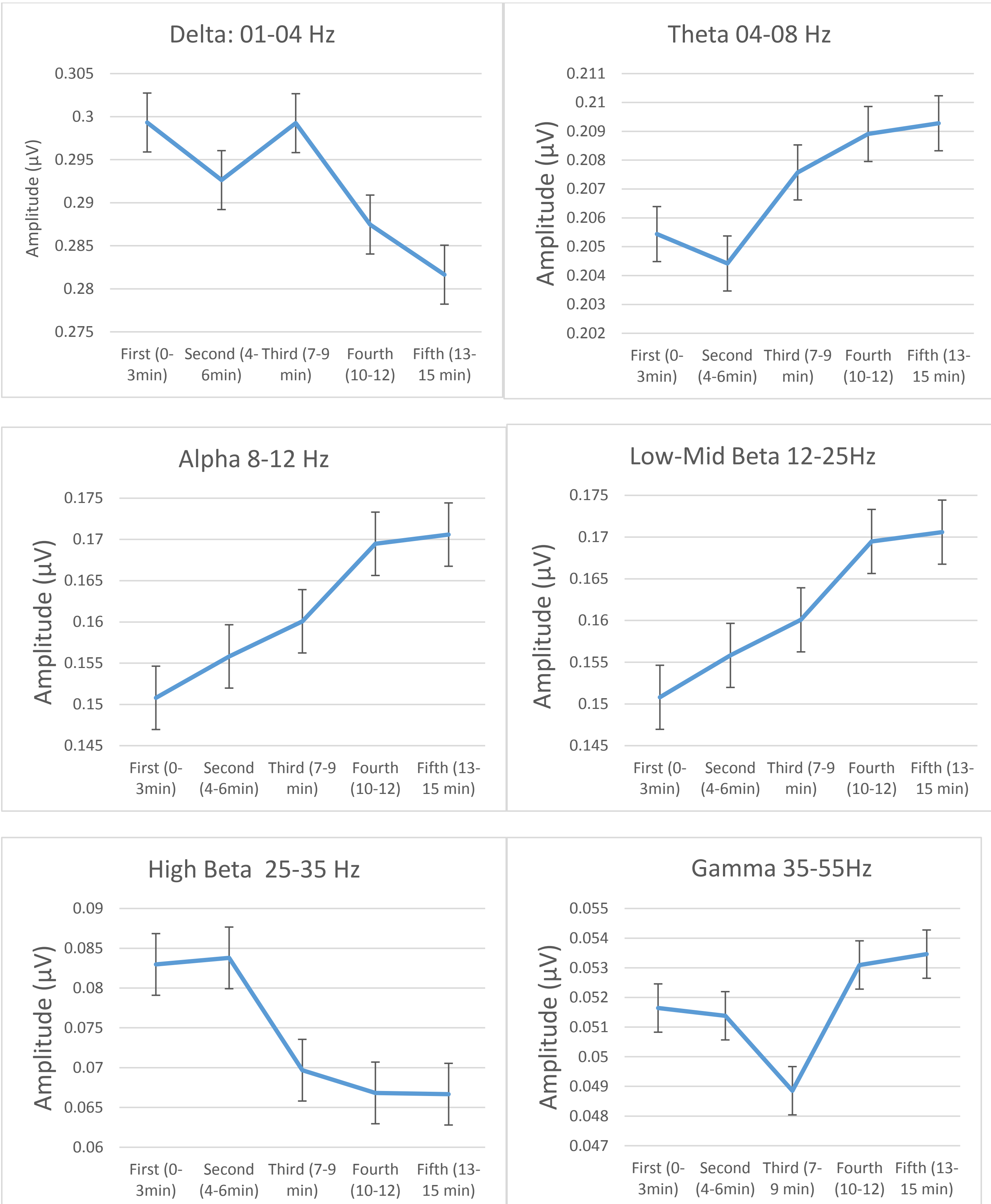


Figure 11: All Pz bandwidths, across the 15-minute intervention

participants reported feeling more relaxed and tired. On the altered states scale (OAV), those who endorsed a higher level of trait emotionality, associated with a higher need for emotional support and anxiety, as well as those scoring high on the absorption scale demonstrated a positive correlation with the subscale of disembodiment.

With respect to EEG findings, there was an overall (pre-vs post) decrease in 1-20 Hz amplitude in both the frontal and temporal/parietal measures, as opposed to the Pz electrode amplitude that was found to increase following the intervention. Over the course of the intervention there was a distinct V like pattern that occurred for the Epoch readings at the third epoch (7-9 minutes). The reduction in amplitudes at three minutes was evident across all brainwaves from Delta-Beta. Delta (1-4Hz) and high Beta (22-36Hz) demonstrated an overall reduction, while others evidenced an apparent rebound effect, with increased amplitudes for Theta (4-6Hz), Alpha (8-10Hz), as well as the 1-20Hz training bandwidth. Pz EEG recording demonstrated a similar reduction in Delta and High Beta, and a similar V like rebound within the Theta and Gamma and widths, occurring at the same third epoch (7-9 minutes). A steady decrease was observed in the high Beta bandwidths, while an opposite steady increase was shown for Theta, Alpha, Low Beta and the 1-20Hz active training bandwidths. For the EEG Epoch recordings, a significant interaction was seen between time point four and five for both the left and right temporal parietal measures, as well as for the left frontal and right frontal measures, with the left crossing over and increasing above the right on both locations.

Positive correlations were observed between EEG and OAV altered states scores for the subscale disembodiment with the global changed observed for Epoch readings between time one and time five of the intervention. Negative correlations were shown for changes between time one and five, for Pz electrode EEG readings with trait emotionality and the subscale spirituality.

Trends were also observed for change pre-vs post for Epoch EEG for complex imagery and openness, while change pre-vs. post for EEGer Pz electrode was seen with complex imagery.

Discussion

This is the first neurofeedback study to consider using current findings in psychedelic literature as a theoretical foundation toward the development of neurofeedback protocols. As mentioned, the recent increase in psychedelic research has offered profound new insights into underlying brain mechanisms (Carhart-Harris et al.,2012a, 2014; Don et al., 1998; Stuckey et al., 200; Riba et al., 2002). Therefore, there is the potential for this line of reasoning to foster insight toward the development of novel neurofeedback protocols by investigating the therapeutic potential associated with a reduction of ~20Hz oscillations that can be directed toward the attainment of the positive “afterglow” effects associated with these substances. The results of this pilot study contribute toward the growing literature on neurofeedback, while offering a novel method for utilizing MEG findings from psychedelic and meditation science.

Clinical Relevance of 1-20Hz Neurofeedback

As illustrated in figures four and five, the primary result of this study is the interaction between hemisphere amplitudes occurring between the fourth and fifth epoch for both the temporal/parietal amplitudes, as well as for the frontal amplitudes as measured by the Epoch EEG. This interaction may be representative of coherence between hemispheres. Collura (2014) said that the measurement and assessment of coherence in neurofeedback has a long and complicated history. Collura (2014) outlines several methods for both training and measuring coherence, including pure coherence, synchronicity metrics, spectral correlation coeffects, comodulation, phase and sum/difference channels. Further analysis is required to fully assess the type of coherence/synchronicity that the 1-20Hz protocol potentially elicited.

Coherence

Collura (2016) defines coherence as measuring the amount of information that is shared between two sites, while considering how stable a phase relationship is over time. Phase reflects the speed of information transfer between two sites. There are two types of coherence that reflect two types of phase: 1) low coherence/ low phase, which sends information quickly, but does not carry a lot of information, and 2) high coherence/high phase, which sends information slowly, but carries a large amount of information. The brain is dynamic in how it functions, and at any given moment a variety of coherence/phase interactions are occurring. In some instances, more differentiation is useful, while in others more connectivity is useful. The technical terms for each are hyper-coherence and hypo-coherence.

The level of coherence can be either adaptive or maladaptive depending on where it is occurring in the brain and within what bandwidths it is occurring. For example, hyper-coherence "may indicate excessive dependence between two sites and a lack of differentiation" (p.119). This may be seen in clients who have cognitive difficulties, as it indicates that a task is being well executed, however there is a lack of functional variation. Common associated difficulties include excessive rambling, difficulty converging on logical conclusions and issues with impulsivity. Alternatively, hypo-coherence indicates a "lack of collective functioning, and the inability to distribute processing in the brain" (p. 119), as is often the case in clients with attention difficulties or cognitive impairments, due to excessively tight coupling of brain areas. In essence, these individuals evidence an efficient speed of information transfer, yet they lack the ability to think critically about the information and may struggle with stuttering or a variety of language related difficulties (Collura, 2016). Overall, a client presenting with cognitive deficits could be either hypo or hyper in their coherence and EEG assessments can be a helpful tool when formulating a treatment plan.

There is also the possibility that a third site could be contributing to the coherence measure, and as mentioned in the introduction, the DMN and the alpha rhythm are viewed as a hub of information transfer and regulation of various processes (Demos, 2005), as well as reflecting the entropic theory of consciousness developed by Carhart-Harris, wherein too much rigidity (i.e., low entropy) is associated with mental health disorders like depression, OCD and anxiety, whereas as too much complexity (i.e., high entropy) is associated with dissociation, psychosis and certain forms of schizophrenia (Carhart-Harris, 2014, Broyd et al., 2009). In addition, the interaction seen in both the temporal/parietal, as well as the frontal lobes could also indicate a level of synchronicity, that would specifically consider if the peaks and valleys of the amplitudes lined up, as is often trained for ‘peak performance’ protocols, as synchronicity is considered an important modality for mental fitness and clinical interventions. Therefore, because the target training site was the DMN for the 1-20Hz protocol, and the potential interactions are seen in both the temporal/parietal, as well as the frontal lobes may point toward positive clinical outcomes related to training these areas.

Table 4 highlights the functional aspects associated with the lobes and hemispheres considered in this study. Of particular interest is the direction of change with respect to the interactions. In both the frontal and the temporal/parietal lobes, there is an increase in the left hemisphere compared to the right. Overall activation of the left hemisphere, particularly in the frontal lobe has been associated with positive mood, and this shift in activation has been repeatedly demonstrated in experienced meditators (Cahn & Polich, 2006; Lutz et al., 2004). Hemispheric lateralization of the right hemisphere is common in patients suffering with depression (Collura, 2014; Demos, 2005; Silberman, Weingartner, 1986). It is possible that participants within this study experienced a decrease in depressive symptoms, as well as an increase in attention, working memory and problem solving, as was seen in the results section on qualitative feedback. Additional positive feedback included, “I felt like my head was clearer and I wasn't worrying about anything. Like even when I tried to think about something random or irrelevant I couldn't. I felt very present and relaxed,” “After completing the study I found I was very relaxed and very happy for the rest of the day. It was quite a wonderful experience,”

Table 4, Hemisphere and Lobe Profiles (Demos, 2005; Collura, 2014)

Location	**Function**	**Problems/Considerations**
Left Hemisphere	Logical sequencing, detail oriented, language abilities, word retrieval, fluency, reading, math, science, problem solving, verbal memory	Depression (under activation)
Right Hemisphere	Episodic memory encoding, social awareness, eye contact, music, humour, empathy, spatial awareness, art, insight, intuition, non-verbal memory, seeing the whole picture	Anxiety (overactivation)
Frontal Lobes (General)	Planning and expressing Overall role, Planner	
Left Frontal Lobe	Working memory, concentration, executive planning, positive emotions	Depression
Right Frontal Lobe	Episodic memory, social awareness	Anxiety, fear, poor executive functioning
Parietal/Temporal Lobes (General)	Perceiving and understanding Interpreting the world	
Left Parietal Lobe	Problem Solving, math, complex grammar, attention, association	Dyscalculia, sense of direction, learning disorders
Right Parietal Lobe	Spatial awareness, geometry	
Left Temporal Lobe	Word recognition, reading, language, memory	Anger, rage, dyslexia, long-term memory, close head injury
Right Temporal Lobe	Object recognition, music, social cues, facial recognition	

The profile of mood state measure demonstrated a decrease in vigour and an increase in fatigue following 1-20Hz. This reduction in tension is seen in the reduction in high beta (22-36Hz) activity in both the Pz electrode, as well as the Epoch electrodes, with a stronger decrease in the temporal/parietal lobes (see figure 9). A reduction in high Beta is often associated with a decrease in activity in the sympathetic nervous system associated with a reduction in a variety of mental issues, including anxiety, overthinking, rumination and OCD (Demos, 2005). There is the possibility that the reduction seen in the temporal lobes allowed for an increase in problem solving, memory, positive emotions and concentration. Traditionally, when beginning training with any client it is imperative that the high Beta value not be too high as it indicates both mental and physical tension. It is always the first goal to reduce high Beta as it is difficult to train neural pathways until this brainwave has been regulated (Hamlin, Personal Communication, 2017). Therefore, 1-20Hz is a potential candidate as an early protocol for individuals struggling with mental health concerns associated with high Beta to help them regulate their arousal level prior to moving on to talk therapies, or more in-depth neurofeedback protocols.

Mindfulness and Therapeutic Trance States

With respect to trait measures and their correlation with the altered states scale (OAV), those who self-rated as having high trait emotionality (HEXACO) demonstrated a positive correlation with higher ratings of disembodiment on the OAV and trait absorption. In short, participants who experienced a high degree of disembodiment were also more emotional and more suggestible. Individuals scoring high on emotionality are “defined by such characteristics as anxiety, fearfulness, sentimentality, dependence, and emotional reactivity versus self-assurance, toughness, and bravery” (Lee & Ashton, 2004, p. 332). Individuals who rate high on absorption indicate an "openness to absorbing and self-altering experiences (Tellegen & Atkinson, 1974).

The three questions on the OAV associated with disembodiment included “I felt as if I no longer had a body, I had the impression I was out of my body, I felt as if I was floating”. In addition, disembodiment was then highly correlated with an increase in 1-20Hz amplitude recorded on Epoch EEG between time one and time five. There was also a noticeable increase in Theta and Alpha bandwidths for both Epoch and EEGer, with an increase in Gamma for EEGer recordings at Pz as well.

Tarrant's (2016) overview of how to train a variety of mindfulness states via neurofeedback, while speculative, offers a potential insight toward the possiblity that the increase in Alpha recorded at the Pz electrode site, as well as the rebound observed across Epoch electrodes indicates that 1-20Hz is inducing related aspects of mindfulness. Self-reports appear to validate this assumption of participants achieving a quiet mind following the treatment, "I think I feel calmer. Less distressed than I was before" and "I felt like my head was clearer and I wasn't worrying about anything. Like even when I tried to think about something random or irrelevant I couldn't. I felt very present and relaxed."

With respect to the increase in Theta, there is the potential that this is tied to the self-reported experience of disembodiment and the correlation with absorption and emotionality. Menzies, Taylor and Bourguignon (2008) reviewed the associated literature on high trait absorption, and the relationship it shares with positive outcomes with respect to mind-body interventions. Overall, it appears that a high score on absorption has both positive and negative qualities. On a positive side these individuals have a unique ability to focus their attention on 'representational resources' (i.e., imagery). They tend to respond more positively toward guided imagery and mind-body therapies in general. Yet this imaginative and creative focus can also create trouble with somatization and hypervigilance. Winkleman (2010) discussed the relationship of absorption to hypnotic tendencies. He reviewed the literature that associated an activation in Theta activity with the capacity to essentially dissociate from outer distractors and engage in a highly focused internal state, a state that is often useful for healing and therefore potentially useful for therapy.

It is possible that the intervention used in this study increased a state of absorption and induced a state wherein the client is more receptive to a variety of treatments. In a review of mindfulness and neurofeedback literature, Brandmeyer and Delorme (2013) found that both alpha and theta bands are the bands that show "the most significant change during the early stages of meditation practice" (p. 1). These bands are also tied to mind wandering and dual thinking patterns, wherein individuals become distracted by self-centred concerns. Therefore, the therapeutic aspects of the changes observed following 1-20Hz neurofeedback might be tied to the observed changes in these bandwidths following training. Although unpublished, Hargraves (2016) conducted case studies were conducted using the 1-20Hz protocol, on three occasions participants went directly into a talk therapy session. Both client and therapist reported that the client demonstrated more focus and openness toward the session, with a greater ability to control affect and remain focused on the chosen goal for that session. For example, one participant commented,

> *Neurofeedback has been very instrumental in helping me with my therapy sessions. It has helped me to be more focused and made it easier to recognize and be more cognizant of what is at the root of my issues. I have also found it helpful with meditation. It was the tool I needed in order to fully reap the benefits of meditation and ease the stress in my life. I thoroughly enjoyed the sessions I participated in and it really did change my perspective on life. I'm truly thankful to have had the chance to participate and would recommend this to anyone with depression.*

Collectively, these results potentially point in the direction of 1-20Hz as a therapeutic adjunct that could help facilitate a client's ability to approach therapy from a grounded and present state, one in which they are essentially in a nondual state that fosters the resiliency required to establish and begin working with their personal narrative in a way that helps facilitate post-traumatic growth.

Clinical Implications

Beck (2005) said that a common challenge that CBT, and all therapies face, is motivating clients to engage fully in sessions, where they are fully engaged in the process of observing and transforming their thoughts and identifying how those affect their body. As already mentioned, this is a common struggle for therapists seeking to prescribe mindfulness as well. This difficulty is especially true for individuals struggling with PTSD who are likely to discontinue therapy if they feel overwhelmed by the sessions, especially for those who struggle with body awareness due to body related traumas and abuse.

Motivation

Peper, Nemoto, Lin and Harvey (2015) argue that utilizing neurofeedback as an adjunctive therapy in which the client is given the power to learn to, and to witness, their own physiological arousal within the context of negative cognitions, is one way to motivate clients toward deeper therapeutic work. 1-20Hz neurofeedback appears to both help a client reconnect with a more stable sense of self (via Alpha upregulation), while also reducing tension in the high Beta bandwidths. As stated, the preliminary case studies demonstrated a positive outcome for clients struggling with a variety of clinical difficulties, including PTSD, depression and anxiety. It is possible that allowing a client to enter into a low arousal state, coupled with a more integrated and grounded sense of self helps to facilitate the client’s ability to engage more thoroughly in the content of talk therapy in a way that may not otherwise be available to them during the early therapy sessions. As the client continues to progress in therapy, this neurofeedback protocol, along with others, can potentially help to further validate and support the insights gained in therapy by continually rewarding the client, and thus enhancing motivation by making the possibilities for change more salient. Neurofeedback also rewards the client for achieving a more grounded and relaxed arousal pattern, both mentally and physiologically.

Arousal

In addition, this neurofeedback protocol could be used as a precursor to therapy. Traditional neurofeedback requires 10-20 sessions occurring once to twice a week, with sessions lasting between three and fifteen minutes. When used in this way, it could be particularly helpful for clients struggling with affect regulation to obtain some insight into self and develop the ability to regulate their arousal level before beginning to work on the cognitive aspects of their distress. As mentioned earlier, the ability to develop a healing narrative and move toward post traumatic growth requires a small degree of resiliency. Resiliency (i.e., the ability to regulate arousal to some degree) is an essential foundation that allows a client to take the first steps toward engaging with their trauma in a cognitive way through talk therapy. Without an intrinsic sense of, and ability to regulate arousal a client may become over aroused and either dissociate or move into a hypervigilant state, both of which "hijack" the ability to remain present and engage in therapy.

Sudden Gains

Another interesting perspective to consider is the concept of sudden gains. A client who experiences a sudden gain is believed to be tied to the ability to "negotiate and complete important therapeutic tasks that are a prerequisite to therapy induced change" (Haas, Hill, Lambert, & Morrell, 2002, p. 1158). Fennell and Teasdale first identified sudden gains in 1987, and reported "that clients who experienced at least a 50% reduction in Beck Depression Inventory (BDI; Beck, Ward, Mendelsohn, Mock, & Erbaugh, 1961) scores in the first 2 weeks of treatment had a 100% recovery rate, while those who did not had an 11% recovery rate" (as cited in Busch, Kanter, Landes & Kohlenberg, 2006). Thus far, 70% of patients in this study experienced a positive change in their affect, with another 17% experiencing a negative change and 14% having no response. 70% of participants exposed to 1-20Hz reported a positive change that could be potentially conceptualized as a sudden gain, coupled with the client's ability to identify and report a change in the way they feel is likely to motivate them to continue with treatment, as it has been objectively and subjectively been demonstrated as effective. Overall, it is possible that a combination of 1-20Hz neurofeedback, combined with CBT could elicit outcomes that have yet to be documented through research, with an emphasis on eliciting sudden gains.

Future Directions

Future studies should work toward properly validating 1-20Hz with proper controls and a comparison to a well validated neurofeedback protocol, a sham and a control condition to help identify what is unique about 1-20Hz. The inclusion of eyes open and eyes closed baselines would allow for a more accurate comparison with the active condition that was conducted with eyes open. Furthering this validation would be the inclusion of cognitive tasks that measure creativity, attention and mindfulness. Further studies should be conducted to isolate the set and setting elements (i.e., music and images used) to assess how each individual component contributed to these findings. In addition, traditionally neurofeedback requires 10-20 sessions before the brain fully adapts and maintains the changes. Thus, it would be advantageous to conduct case studies to further assess changes over time. Once the underlying mechanisms are understood, further tests on a clinical population to see what population 1-20Hz neurofeedback might serve, while offering further insight and direction for future research. Finally, if 1-20Hz is deemed to have clinical relevance, combining it with CBT therapy to assess how 1-20Hz impacts motivation and sudden gains would be warranted.

Limitations

The current study was conducted on a relatively small sample of non-clinical participants who were students from the University of Western Ontario. The current study was further limited by low sampling rates related to the EEG device used for recordings that reduced the amount of analyses that could be conducted on the data. In addition, the current study did not isolate potential third variables related to music and sound used in the study.

Summary

Despite the limitations to the current study, this research has moved the field of neurofeedback forward by focusing on the importance of 1-20Hz and its relevance toward furthering the required validation of neurofeedback protocols. This study has contributed toward the formal validation of protocols that will enable future clinicians to diagnose and treat a variety of mental health disorders. Such protocols can help clients gain insight, motivation and affect regulation by bringing unconscious brain oscillations into view. Furthermore, research investigating the underlying neural mechanisms that are at the root of the positive outcomes associated to both mindfulness and psychedelic therapies are the same networks neurofeedback addresses. Indeed, neurofeedback offers both an enhanced and reflective type of mindfulness training, as well as a substance free option for those who are unable to access psychedelic therapies due to their current illegal status and current restriction within psychological research. In addition, neurofeedback holds the potential to augment and support psychedelic therapies, with respect to preparation and integration once these therapies become legalized for therapeutic use. Continued research in this area has the potential to foster a new wave of neuro-informed therapeutic modalities; therapies that emphasize and support the non-dual states underlying resiliency. Fostering a natural and intrinsically driven capacity for self regulation.

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Heather Hargraves

Education

MA Counselling Psychology April 2017
University of Western Ontario, London, ON

- *Thesis*: Therapeutic Induction of Altered States of Consciousness: Investigation of 1-20Hz NFB
- *Supervisor*: Dr. Alan Leschied

Bachelor of Arts, Honours Specialization Psychology April 2015
University of Western Ontario, London, ON

- *Thesis:* Meditation Breath Attention Score (MBAS): Development and Investigation of an Internet-Based Assessment of Focused Attention During a Meditation Practice
- *Supervisor:* Dr. Paul Frewen

Bachelor of Arts, Honours Philosophy
University of Windsor, Windsor Ontario April 2004

Honours and Awards

Psychiatry Seed Funding 2015
Western University, London, ON

Honours Society 2015
Brescia University College, London, ON

Nomination for "Outstanding Contribution to Student Life" Award 2014
Brescia University College, London, ON

Deans Honours List 2014, 2015

Manuscripts

Frewen, P., Hargraves, H., Depierro, J., D'Andrea, W &Flodrowski, L. (April, 2016). Meditation breath attention scores (MBAS): development and investigation of an internet-based assessment of focused attention during meditation practice. *Journal of Psychological Assessment.*

Frewen, P., Hargraves, H., Ros, T. (In Preparation). Induction of Altered States of Consciousness by Pz 1-20Hz Inhibition EEG Neurofeedback: Proof-of-concept of a Translational Neuroscience Approach informed by Psychedelic Medicine.

Poster and Oral Presentations

Hargraves, H., & Frewen, P. (2016 May). Meditation Breath Attention Score (MBAS): Sensitivity to Meditation Type. Canadian Psychology Association Annual Meeting. Vancouver BC.

Hargraves, H., & Frewen, P. (2016 June). Neuro-Mindfulness: 1-20 Hz Desynchronization Neurofeedback. Poster presentation at the *Schulich Department of Psychiatry Research Day*, London, Canada.

Hargraves, H., & Frewen, P. (2015 June). Meditation Breath Attention Scores (MBAS) and other Meditative Experiences across Different Meditation Practices. Poster presentation at the *Schulich Department of Psychiatry Research Day*,London, Canada.

Hargraves, H., & Frewen, P. (2015 May). Meditation Breath Attention Score (MBAS): Sensitivity to Meditation Type. In Ellis, W., Mitchell, J., Swartzman, L., & Tsang C. *The Ontario Psychology Undergraduate Thesis Proceedings*. Oral presentation at the 45th Annual Ontario Psychology Undergraduate Thesis Conference: London: Western University.

Conferences & Seminars

Mend the Gap: Bridging the Gap Between Spirituality and Psychiatry, Department of Psychiatry, Western University (Seminar: November 2016)

Beyond Psychedelics Conference, Czech Republic, Prague (October 2016)

Academic Research Day Annual Conference, Department of Psychiatry, Schulich School of Medicine and Dentistry (UWO) (June 2016)

Canadian Psychological Association Conference, Canadian Psychological Association, Victoria, B.C. (May 2016)

TMS: Its Origins, Current Practice and Future Directions Conference, London, Ontario (May 2016)

What is a Level of Consciousness, Department of Clinical Neurological Sciences, Western University (Seminar: March 2016)

Academic Research Day Annual Conference, Department of Psychiatry, Schulich School of Medicine and Dentistry (UWO) (June 2015)

45th Annual Ontario Psychology Undergraduate Thesis Conference (UWO) (May 2015)

Relevant Lecture and Group Facilitation Experience

Laura Evans Seminar: Mindfulness Meditation 2017

- Seminar on mindfulness meditation
- Discussed resiliency and techniques to manage stress
- Overview of neurological changes related to mindfulness practices

Emerging Proud Interview (Online) 2017

- Discuss therapeutic potential of neurofeedback as an alternative to medication
- Discussed novel ways of reconceptualising current trauma treatment models
- Discuss trauma and how it changes the brain

Laura Evans Seminar: Mindfulness Meditation 2016

- Seminar on mindfulness meditation
- Discussed resiliency and techniques to manage stress
- Overview of neurological changes related to mindfulness practices

London Abused Women's Shelter 2016

- Seminar on how trauma changes the brain
- Discussed resiliency and techniques to manage stress
- Co-facilitation of a group session

Western University 2016

- Mindfulness lecture on Finding Balance
- Discuss intrinsic connectivity networks
- Lead group meditation

MAPS: Global Psychedelic Dinner 2016

- Psychedelics: A Therapeutic Perspective
- Emphasis on trauma, post traumatic growth and integration
- Overview of neurofeedback and intrinsic connectivity networks

Western University 2015

- Seminar on post traumatic growth
- Instruct a forty minute lecture
- Discuss theory and current research

London District Distress Centre 2015

- Seminar on how trauma changes the brain
- Discussed resiliency and techniques to help callers and volunteers manage stress
- Lead a 1 hour yoga class and meditation session for volunteers

London Abused Women's Shelter 2015

- Seminar on how trauma changes the brain
- Discussed resiliency and techniques to manage stress
- Co-facilitation of a group session

London Abused Women's Shelter 2015

- Seminar on Mindfulness
- Discussed various meditation techniques
- Co-facilitation of a group session

Brescia University College 2012

- Instruct a forty-minute seminar on mindfulness meditation
- Topics included history, theory and practice
- Mindfulness meditation instruction

Certifications

Neuromeditation Training (14 Hours)	2017
EEG Biofeedback: Neurofeedback in a Clinical Practice (32 hours)	2016
Boundless Heart Compassion Training with Sharon Salzberg (8 weeks)	2016
SafeTalk Suicide Intervention Training	2016
Applied Suicide Intervention Skills Training	2014
Tri-council Policy Statement (TCPS) certified	2013
Hand Reflexologist	2014
Thai Massage Yoga Therapist	2013
Foot Reflexology Certification	2011
Yoga Teacher Certification	2007

Clinical & Research Experience

Western University- *Research Assistant* October 2016 - Present

- Facilitation of 4th R Program (Uniting our Nations)
- Facilitate classroom activities
- Mentor Children in Healthy Relationships

Dr. Bill Newby- *Draft Assessment Writer* Oct 2014 - Present

- Observe and take clinical notes during psychological assessments for the London and Windsor Police force
- Observe PTSD maintenance screenings for the London police
- Draft/edit clinical assessments

Western University – *Research Assistant* Sept 2015 - Oct 2016

- Conduct Neurofeedback and EEG Studies
- Data analysis in MATLAB and SPSS
- Literature Review

Relevant Work and Management Experience

7D Health – *Head of Neurofeedback* Oct 2016 – Present

- Validation of Neurofeedback Protocols
- Research and Design: Virtual Reality and Neurofeedback Interfaces
- Adjunctive Neurofeedback Therapist to local Psychologists

Sole Haven Healing Center – *Owner/ Therapist* 2011 - 2015

- Offering support with stress reduction and general well being
- Services include yoga, meditation, reflexology and Thai yoga massage

Practice Loft Yoga Studio- *Owner/Teacher* 2010 - 2011

- Manage finances and operations
- Scheduling of classes and workshops
- Yoga and meditation instructor

Relevant Practicum Experience

Student Development Centre – *Dr. Gail Hutchinson* Sept 2016 - Present

- Counselling Internship
- Neurofeedback therapy
- Develop mindfulness groups utilizing the Muse headset
- Offer Lectures on Mindfulness

Gilpin and Associates - *Dr. Michelle Gilpin* 2014 - 2015

- Teach mindfulness techniques to clients
- Created mindfulness handouts and toolbox
- Observe learning assessments
- Draft behavioural notes

Private Clinical Practice – *Anne Newby* 2014 - 2015

- Work one on one with a private client
- Teach mindfulness/relaxation strategies
- Observe therapy sessions

Western Ontario - *University Lab School* 2013 - 2014

- Learn and practice the lab school philosophy
- Help children develop intrinsic problem solving skills
- Development of observational and assessment skills for children
    - motor, cognitive, social, language, literacy, strength and needs

Relevant Volunteer Experience

London Abused Women's Shelter – *Volunteer* 2015 - Present

- Seminar on mindfulness & how trauma changes the brain
- Discussed resiliency and techniques to manage stress
- Co-facilitation of a group session

Westover Treatment Centre - *Volunteer* Summer 2016

- Observe weekly group meetings
- Conduct semi-structured interviews to assess participant's trauma history
- Assess addiction-related mental health concerns

Distress Center – *Volunteer Facilitator* 2014 - 2015

- Train new volunteers
- Answer crisis, distress and seniors help line
- Provide emotional and crisis intervention support
- Offer seminars of mindfulness and how trauma affects the brain

Brescia University College – *Girl's LEAD Yoga Instructor* Summer 2014

- Yoga and meditation instructor
- Intermediate camp local girls aged 9-11
- International camp: high school students from Hong Kong

Western Ontario - *University Lab SchoolVolunteer* Summer 2014

- Observe and interact with children within the lab school
- Help children develop intrinsic problem solving skills
- Support lab school teachers

Western University – *Undergraduate Research Assistant* 2013 - 2014

- Assist with MA in neuroscience meditation research
- Set up EEG and neurofeedback electrodes
- Operate EEG, neurofeedback software

Brescia Psychology Association – *Volunteer* 2012 - 2013

- Yoga instructor for annual mental health week events
- Mindfulness meditation instructor for annual mental health week events
- Yoga and meditation instructor for annual shine the light on woman's abuse event

Sivananda Yoga Center, Mumbai India – *Volunteer* 2007 - 2008

- Prepare ashram for yoga teacher training
- Secretarial duties
- Instruct Yoga classes

Hospice Foundation – *Volunteer* 2006 - 2007

- Weekly visits with a client
- Ongoing support for patients and their families
- Caring patient advocate

CNIB – *Volunteer* 2005 - 2007

- Weekly visits to a client
- Reading books/Walks around the city
- Support and transportation for doctor's appointments

University of Windsor Peer Support – *Volunteer* 2003 - 2004

- Offer support and information for first year students

Extracurricular Participation

Brescia Psychology Association – *VP External Affairs* 2014 - 2015
Brescia University College, London ON

Software Experience

- Microsoft Word
- Microsoft PowerPoint
- Microsoft Excel
- PsychINFO
- IBM SPSS
- Nexus-32 Biotrace
- EEGer
- Matlab
- EEGlab