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Dear Editor: Dr. Areed Barabasz

I submit this research paper titled 'Reducing Anxiety Through Virtual Reality Hypnosis' with the short title 'VRH and Anxiety' for publication in The International Journal of Clinical and Experimental Hypnosis.

This research paper looks at the neurophysiological basis of the hypnotic state using Electrocephalography (EEG) and Virtual Reality Hypnosis (VRH). Heart Rate Variability was also investigated as intraprocedural measure of hypnotic susceptibility and anxiety levels.

It is hoped that this paper will provide more research to support the idea of alternative and complementary treatments for anxiety, depression and chronic pain. This article has not been submitted for publication to any other journal.

Yours Sincerely

Candice Johnson

Reducing Anxiety Through Virtual Reality Hypnosis

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Submitted as Honours Project 2 HET802 Manuscript

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Neurophysiological research has shown that the hypnotic state is characterised by a dissociative hemispheric shift in frontal lobe of the brain. Virtual Reality Hypnosis (*Virtual Medicine©(2005) Audio-Visual Presentation Media)* is a new technology which could be applied as alternate or complementary therapy for anxiety, depression and chronic pain. Heart Rate Variability was tested as an intraprocedural measure of anxiety and susceptibility. Thirty participants with varying hypnotic susceptibility scores; low (n=9), medium (n=13), high (n=8) underwent Virtual Reality Hypnosis and Electrocephalography while having their heart rate measured. Significant increases in theta activity in the frontal areas of the brain were found for the entire group, despite hypnotisability the entire group showed dissociative effects over the time period of the hypnosis program. Further research is needed into the physiological indicators of hypnotic susceptibility to gain stronger and efficient ways to detect hypnotisability.

Hypnosis has been compared to altered states of consciousness such as sleep. Some authors have suggested that non-specific areas of the thalamocortical system dissociate during hypnosis as it does in dreaming. Although research has shown that hypnosis and dreaming are different, the comparison with sleeping is often made because it creates a good analogy of the hypnosis experience. Under hypnosis dissociation of external sensory and context cues are experienced and changes in time perception, space, reality and critical judgement are reported by some people (Gruzelier, 2005). Unlike dreaming, hypnotised people can still move and can often experience their 'dream' with movement and emotion. The sleep analogy is one of many hypotheses used to describe hypnosis.

The use of hypnosis as an adjunct to psychotherapy was devised and made famous by Dr Sigmund Freud, who used the trance phenomena (i.e. hypnosis) to tap into the unconscious - revealing underlying drives, repressed memories and attitudes that wouldn't otherwise be revealed. 'Hypnodiagnositc' therapy was used in the realms of vocational analysis, personality investigation and psychotherapy. This clinician oriented procedure was administered through the use of visual imagery, which increased recall, spontaneous associations of unconscious origin, motor phenomena linked to resistances, fears and impulse characteristics (Kline, 1951).

Hypnosis 'trance' was reported as early as 200BC. Hypnosis has been labelled as 'black magic' and feared because of "brain washing" accusations. It was also thought that those who allow themselves to be hypnotised are weak of will. As a consequence of these beliefs, hypnosis developed a bad reputation, so early studies were difficult to perform (Blankfort, 1932). In the wrong hands hypnosis can be dangerous, so it's important that potential risks are evaluated and thoroughly researched to lessen safety concerns (Erickson, 1932). A famous case of supposed death by hypnosis occurred in a castle in Hungary in 1894. A woman aged 22 suddenly collapsed and died during a hypnotic s_ance, which involved her sick brother which she could only diagnose in great detail while under hypnosis. This case was glorified and warped into a terrifying story by the European media, and some people believe this incident may have been the progenitor for anxiety surrounding the use of hypnosis as a therapeutic modality (Lafferton, 2006). Hypnosis has also been associated with personality enslavement and automatization, which has stemmed from the use of hypnosis in stage performances where volunteers perform humiliating acts for entertainment purposes (Gruzelier, 2000).

Although hypnosis is inherently safe, case reports and clinical and experimental studies indicate that the incorrect use of hypnosis can be harmful. Reported, short term adverse effects created by hypnosis (which can last for up to 60 minutes) include: headaches, drowsiness, cognitive distortion, anxiety and bad dreams. Medium to long term adverse effects (reported to last for up to three hours) include: headaches, dizziness, nausea, and a stiff arm or neck. Severe adverse events reported in association with clinical and stage hypnosis are extremely rare, and include: chronic psychopathology, seizure, stupor, spontaneous dissociative episodes, onset of a first psychotic episode and onset of schizophrenia (Gruzelier, 2000).

The clinical benefits conferred by hypnosis are significant and the adverse events can be eliminated by introducing appropriate safeguards. Pre-treatment counselling and exclusion criteria, which include: a personal or family history of psychological illness, epilepsy, agitated depression, psychotic disease, paranoid disease, unstable dissociative disorder, borderline personality disorder, acute brain syndrome, chronic brain syndrome, schizophrenia, dementia, delirium, attempted suicide, and some phobias. The Harvard and Stanford Hypnotisability Scales were developed as a method to evaluate hypnotic susceptibility, but they can also be used to screen subjects against some of the possible side-effects of hypnosis treatment (Gruzelier, 2000).

The efficacy of hypnosis therapy was evaluated by Flammer & Bongartz (2003) in a meta-analytic study using 444 publications (based mostly on clinical studies where 70% used classical hypnosis and 19% used modern hypnosis techniques). The evaluation indicates that hypnosis is reasonably effective (d=0.63) in the treatment of affective disorders, psychotic disorders, obsessive compulsive disorders, anxiety disorders and schizophrenia. However, hypnosis procedures had a low efficacy (d=0.44) when they were used as a substitute for anaesthesia.

The ability to be hypnotised varies significantly from person to person. The most popular theory to account for the inter-individual variation in hypnotisability is personality. It's been suggested that the personality traits of the individual (in particular – people rated high on the personality factor of "Openness to Experience") are more likely to be hypnotisable (Kirsch, Silva, Comey, & Reed, 1995). The personality factor of Openness to Experience is described as someone who is more open minded to new experiences, and their attention can be absorbed in something for a long time. They are more likely to fantasise, be creative, and have high intellectual curiosity. People high in Openness to Experience often have expanded awareness of things such as dreams and altered states of consciousness; they are also likely to be high in aesthetic responsiveness (Glisky, Tataryn, Tobias, Kihlstrom, & McConkey, 1991).

In a study by Lynn & Rhue (1986), it was found that fantasy prone people with an "Openness to Experience" were 80% more likely to be rated as highly hypnotisable. Although, according to this study, the person's attitude towards hypnosis (i.e. motivation, atypical interpretation of hypnotic suggestions and rapport with the hypnotist) was a more important factor contributing to hypnotisability than personality type. It was also suggested that only those who are interested in hypnosis are likely to volunteer for a hypnosis study and therefore gaining a bias in the type of people studied for hypnosis susceptibility.

Absorption is a term used to describe a person's disposition to enter states characterised by cognitive restructuring. This restructuring process may operate by expanding or restricting the individual's attention, by altering their cognition, or by changing their perception of self. According to Tellegen & Atkinson (1974), individuals rated high in "absorption" are normally rated high in hypnotisability. In a more recent study, Glisky and colleagues (1991) examined the relationship between absorption and hypnotisability, and found no significant relationship between the two factors. Instead, they concluded that absorption was related to fantasy–prone, personality types. In similar studies, Manmiller, Kumar & Pekala (2005), purported that absorption was, in fact, a poor predictor of hypnotisability, and absorption was more likely related to creativity than hypnotisability.

New techniques in psychophysiological research have recently been devised, which clearly delineate hypnosis from other - altered states consciousness (i.e. relaxation, meditation and sleep). Brain mapping studies indicate that the anterior cingulate gyrus plays the key role in hypnosis. An epidemiological study of people with a damaged anterior cingulate gyrus support the findings of brain mapping studies: i.e. a damaged anterior cingulate gyrus is normally associated with difficulty in distinguishing the imaginary from the real (Naish, 2005). Currently, the most popular debate in hypnosis research is whether or not hypnosis is a function of attention or dissociation. Recent publications in hypnosis research indicate that attention theories are flawed, and it seems that dissociation models for hypnosis are now preferred (Gruzelier, 2005).

The following studies look at these two areas of research. Carli, Cavallaro & Santarcangelo (2007) explored the possibility that high and low hypnotisables preferred different stimuli and tested a theory that hypnotisability is a function of attention. This hypothesis was tested by measuring the degree of body sway, which is thought to indicate attention. The study indicated that high hypnotisables do not show body sway following suggestions for reduced global sensitivity and perception, but low hypnotisables show significant body sway following the same suggestion. The highly hypnotisable people, it seems, find it easier to create visual and perceptual imagery compared to people with low hypnotisability. Other important factors, which seem to be associated with an increase in hypnosis susceptibility included: fantasy proneness, expectancy, attention, absorption, acquiescence and consistency of motivation.

An electrocephalograpy (EEG) study by Fingelkurts and colleagues (2007) indicates that an altered state of consciousness occurs in highly hypnotisable individuals during hypnosis. Significant changes in all bandwidths of the EEG showed there was an alteration in brain connectivity. This finding was unchanged for the same participant a year later. The authors concluded that separate cognitive modules and subsystems are incapable of communicating with each other in hypnosis suggestion, showing an altered state of consciousness (Andrew A Fingelkurts, Alexander A Fingelkurts, Sakari Kallio, & Antti Revonsuo, 2007). This study also supported previous research claiming that frontal areas were significantly affected during hypnosis. It was shown that the left frontal areas lost functional connections and communication with the rest of the cortex. It was also found that during hypnosis communication between the cortex and thalamus was reduced compared to baseline measures. Increased synchronicity within the left and posterior sections of the cortex may indicate enhanced fast habituation and selective attention as indicated by theta activity. Beta activity, which has been shown to indicate imagery processes, was also found in the frontal areas of the brain (Fingelkurts *et al.*).

Another study by Fingelkurts and colleagues (2007) used an EEG to identify an altered state of consciousness, and determine cerebral differences between a resting state and a baseline state of hypnosis. The frontal areas of the brain showed a distinctive change in oscillation during pure hypnosis compared to baseline - especially in the prefrontal and right occipital EEG channels. It was also found that after hypnosis, brain signals were still different from baseline; suggesting that coming out of hypnosis takes time, and may even have a lasting effect on the brain (Alexander A Fingelkurts, Andrew A Fingelkurts, Sakari Kallio, & Antti Revonsuo, 2007).

Egner and colleagues (2005) performed a study using fMRI and EEG coherence to look specifically at the anterior cingulate cortex (ACC) and the lateral frontal cortex (LFC). Using EEG and fMRI, the ACC was targeted using a control related activity and the LFC was targeted using the stroop task. The fMRI data showed that conflict related activity was present in the ACC during hypnosis. This observation was most evident in the highly hypnotisable. This change occurred compared to baseline and those who had low hypnotic susceptibility. There was no change in the LFC using the tasks. The EEG coherence results showed a decrease in functional connectivity (gamma) between the frontal midline and the left lateral sites. This occurred in those who were highly hypnotisable. It was suggested that individual differences in the frontal attention systems could be linked to susceptibility. It was also suggested that dissociation of conflict monitoring and cognitive control processes occur during hypnosis (Egner, Jamieson, & Gruzelier, 2005).

Katayama and colleagues (2007) used EEG technology to unravel, suspected microstates of hypnosis, much like the four stages of sleep. The four states were classified as A, B, C and D. With limited findings, the authors proposed that A might be associated with abstract thoughts, B with visualising thoughts, C with increased attention and D with decreased attention. The first stages (A and B) were light states of hypnosis - similar to meditation. Stages C and D were associated with deep hypnosis - similar to the altered states observed in schizophrenia. Altered states of consciousness observed in schizophrenia are shown in EEG traces by impaired control/executive functions in the frontal areas, functional dissociation of frontal and other brain areas, reduced supervisory attention and orbito-frontal suppression.

An EEG hypnosis study Gruzelier (1998) showed that task interference (Stroop task) indicates a dissociated state during hypnosis. There was more task interference in hypnosis compared to non-hypnosis, suggesting that hypnosis impairs attention through dissociation. Hypnosis dissociated the cognitive and affective systems of the anterior cingulated (Gruzelier). Dissociation was also evident during a verbal category and design fluency task with reduced connectivity on the left anterior processes (i.e. the left lateral and medial areas). In other studies that used a mismatch task with electrodermal orienting, negativity waves were reduced in the frontal areas, which showed that the limbic areas were also affected during hypnosis. It was also shown that electrodermal and electrocortical responses to auditory were shifted in favour of the right hemisphere and visual areas. Using the haptic sorting task, it was found that people with medium hypnosis susceptibility had more visual sensitivity than people with low hypnosis susceptibility. It was also shown that people with low hypnosis susceptibility had poor attention skills at baseline: although, interestingly, their attention improved during the hypnosis induction (Gruzelier).

The difference between distraction and hypnosis were delineated during a study comparing the Evoked Response Potentials (ERPs) of hypnotised and distracted volunteers exposed to a painful stimulus. Compared to a control group, self rated pain scores and amplitude of N200 and P350 were significantly lower in the distraction and hypnosis groups. The authors suggested that ERP differences observed between hypnotised and distracted individuals indicates that these processes occur separately in the brain. This study indicates that distraction techniques filter pain to the thalamic and thalamocortical areas to prevent pain registration in the somatosensory cortices. Hypnosis, on the other hand, apparently dissociates sensory and evaluative processing at the cortical level (Friederich *et al.,* 2001).

Positron Emission Topography (PET) studies indicate that the occipital lobe also plays a role in hypnosis and the lasting effects of hypnosis therapy. In theory, using visual imagery to tap in to the sensory system for vision imparts an effect in the brain and, perhaps, some hypnotic memory. It allows the association with real situations and connects it to other sensory areas such as taste and smell. During hypnosis, this process may be responsible for learning, re-activation of learned memory in the normal waking state, and cessation of inappropriate behaviours (Halsband, 2006). Other PET studies show that increasing the use of visual imagination during hypnosis activates the occipital lobe, which then plays a role alongside the frontal areas. The combined role of these two centres is to transfer and combine suggestions with visual imagery (Rainville *et al*., 1999).

Another study by Rainville and colleagues (2002) showed that relaxation and hypnosis are different phenomena, with different parts of the brain being activated during these states. Using PET, it was shown that during relaxation bilateral, frontal and right occipital areas were positively activated and right posterior parietal lobe, mid and inferior temporal, right somatosensory cortex and insula showed negative correlations. In the hypnosis/absorption condition, positive correlations were found for the inferior parietal cortex, thalamus, anterior cingulate cortex, bilateral prefrontal and left nucleus lentiformis. There were negative correlations in the left inferior parietal cortex, precuneus and both sides of the occipital cortex. This finding suggests that relaxation and hypnosis use different neural mechanisms (Rainville, Hofbauer, Bushnell, Duncan, & Price, 2002).

Hypnosis has been used successfully to treat problems with psychological, somatic and psychosomatic origins. In children, hypnosis has been used with cognitive behavioural therapy to increase school attendance and ameliorate psychological problems associated with separation anxiety. After 12 weeks of therapy using metaphors, positive reframing of negative associations, relaxation training, and suggestions to aid confidence building and anxiety reduction, school attendance rose from 67% to 90% (Roberts, 1998).

A combination of hypnosis, cognitive behavioural therapy (CBT) and psychodynamic theory has also been used successfully in the treatment of hyperhidrosis (excessive sweating), which was caused by that was caused by social anxiety. In this case, rather than using pharmacotherapy or surgical options, the client used hypnosis therapy to focus their thoughts and attention on resolving their social anxiety instead of focusing their thoughts and attention on the outcome of their anxiety (i.e. sweating) (Kraft & Kraft, 2007).

In the treatment of trauma victims, a combination of cognitive and emotional hypnosis therapy has been helpful to train victims with affect management, strengthening of the ego, re-processing of the trauma, body sculpting and mindfulness skills (Poon, 2007).

The science literature indicates that hypnosis is a useful and effective tool for the management of anxiety symptoms. In a pre-surgical environment described by Elkins et al., (2006), hypnosis reduced preoperative anxiety by 56%.. Reports made by parents, hospital staff and children that used hypnosis to manage anxiety symptoms prior to an invasive medical procedures showed that anxiety levels decreased significantly when compared to previous medical procedures without hypnosis (Butler, Symons, Henderson, Shortliffe, & Spiegel, 2005). Students have also reported the efficacy of hypnosis for managing stress and anxiety (i.e. associated with exams and submitting assignments) (Hart & Hart, 1996).

Virtual reality has been used successfully as a form of distraction therapy to reduce the pain associated with invasive medical procedures. Many of these studies have focused on burn patients with significant analgesic requirements. An early study by Hoffman et al., (2000) used a game to absorb the patient into the virtual reality environment. From this study, the authors reported reduced pain and anxiety during painful procedures and concluded that immersion in a virtual reality environment can be used as a powerful non-pharmacological analgesic. A study by Hoffman et al., (2004) indicates that analgesic requirements can be reduced by increasing the depth of immersion in a virtual world.

Virtual reality environments have also been used for hypnosis inductions, and tested for efficacy in hospital environments. The development of a virtual reality hypnosis (VRH) system means that a hypnotist or clinician is not required for hypnotherapy.

In practitioner-guided hypnotherapy, the patient invariably conducts a character analysis of the hypnotherapist, and the efficacy of therapy is limited by the patient's appraisal of the practitioner and the amount of trust and rapport established between them. The practitioner may need several hours with a patient to build enough rapport for successful hypnosis, and, by that time, the patient may have lost confidence in hypnotherapy for the treatment of their condition. In a virtual environment, therapy is interfaced with technology, so the user is not confronted by inherent desires for character analysis and establishing high-level trust and rapport with the person operating the equipment (Carbis & Mastropaolo, 2003). Without rapport, the patient will most likely feel uncomfortable and be unwilling to attend to the hypnotic procedure or be unwilling to dissociate.

VRH has many advantages, which are not available to a clinician using voice commands to guide the patient into a trance state. These include: providing visual stimuli to assist with guided imagery; binaural beat signals, environmental sounds and visual and narrative metaphors. According to White et al. (In Press, 2009) VRH can increase hypnotic susceptibility, which increases a patient's likelihood of being hypnotised compared to traditional hypnosis methods. Compared to practitioner guided hypnosis, VRH has fewer side effects (e.g. nausea), and during stressful or painful situations the patient's ability to concentrate and relax are improved. In a study of analgesic requirements and anxiety levels in burn patients, Patterson *et al.,* (2004), showed that VRH helped to reduce anxiety levels by 26% and analgesic requirements by 50%.

Another study performed with burn patients by Patterson and colleagues (2006) used virtual reality hypnosis to deliver hypnotic analgesia. By using VRH, opioid medication use was cut by 50% and subjective reports of pain and anxiety were significantly reduced during the wound care procedure (Patterson, Wiechman, Jensen, & Sharar, 2006).

Other advantages of the virtual reality hypnosis technology, pointed out by Patterson and colleagues (2006), is the use of visual imagery, which allows the patient to keep their eyes open during the procedure; thereby helping those people who find it difficult to focus - especially patients with pain management problems. The technology may also be useful for the deaf, since written hypnotic suggestions could be presented as subtext beneath visual stimuli. In a virtual environment, hypnosis is achieved by the use of recorded images, verbal communication and non-verbal sounds, and the depth of relaxation and/or the trance state is not dependant on the hypnotherapy skills of the person operating the device. In practitioner-guided hypnotherapy, the depth of relaxation and/or the trance state is dependant on the skills of the hypnotherapy practitioner (Carbis and Mastropaolo 2003).

Reports by Patterson et al., (2006) indicates that virtual reality hypnosis is a useful tool for managing anxiety in burn patients, so it's very likely that this procedure will also be useful in the management of other anxiety disorders. In hospital/trauma environments it could potentially help patients feel less anxious.

Virtual reality hypnosis is a drug free alternative to the management of anxiety disorders, and, since any reduction in drug use has significant health benefits for patients presenting with situational and psychological anxiety issues; therefore it is an important area for further research.

At Virtual Medicine Pty Ltd, (Melbourne Australia) Dr Colin Carbis and Joe Mastropaolo developed and patented the concept of Virtual Reality Hypnosis (Carbis & Mastropaolo 2003). This device contains a variety of different hypnosis programs; which include smoking cessation, weight loss, anxiety/panic/depression management, sleep disorders, children's programs and hypnotic susceptibility tests.

The main focus of this project is to determine the efficacy of the Virtual Medicine Pty Ltd virtual reality hypnosis device for inducing hypnosis. The efficacy of this unique form of virtual reality hypnosis was tested using the hypnotic susceptibility program on the machine. The aim of this project was to evaluate the hypnotic susceptibility program, and extrapolate the efficacy of virtual reality hypnosis as a method for reducing physiological signs of anxiety in a normative adult sample. The hypnotic susceptibility program was delivered via visual and auditory stimuli using headphones and LED screen lightweight goggles.

The primary aim of this study was to identify the neurophysiolocal basis of the 'hypnotic state' by using the Synamps 2 Neuroscan EEG (32 channel system) at EEG bandwidths in the range 3.5 to 7.5Hz (theta) to obtain a spectral analysis. It was hypothesised that dissociative effects would be shown when the participant was under hypnosis. This should be identified by a hemispheric shift in theta activity - particularly in the midline-frontal areas of the brain. In previous studies, this kind of brain activity has been identified as what clinicians describe as a hypnotic state (Gruzelier, 1998). It was predicted that theta activity in the frontal areas would be significantly different during a hypnotic state compared to baseline measures of EEG measured during relaxation. Declines in subjective and physiological indicators of anxiety are expected with the use of virtual reality hypnosis. It was also predicted that heart rate variability would be significantly lower during hypnosis compared to baseline.

In this study, heart rate variability was being analysed for its efficacy as a physiological marker of relaxation, which is normally used as a prelude to a deepening process, trance states and hypnotherapy. If heart rate variability progressively declines during the induction/deepening/trance process, then it may be possible to use heart rate variability as a measure of intraprocedural anxiety and susceptibility. If heart rate variability is effective for this process, then it may be useful as an alternative method for observing the transition into hypnosis and, additionally, reduce the need to perform a hypnotic susceptibility test: a procedure that can be time consuming and may not reflect a patient's true ability to be hypnotised.

The results of this study provide further research findings on the efficacy and potential of virtual reality hypnosis, which should provide practitioners with the confidence they require for introducing this drug free technology into the broader hospital /clinic environment for managing anxiety, depression, panic and their associated somatic co-morbidities.

Method

Participants

Thirty-two participants attended the Brain Sciences Institute to undergo Virtual Reality Hypnosis. Two of the participants were excluded from the analysis; one was due to technological difficulties, which created inconsistencies with the data. The other was due to a recent head injury, resulting in loss of consciousness, which was not revealed prior to testing. The final sample consisted of 21 females and 9 males. The age range of the sample was 18 to 49. The majority of the sample (17 participants) was in the 18 to 23 age group. Only 7 of the participants had previously experienced or participated in hypnosis. The other 23 participants had no previous hypnosis experience.

Materials

Subjective ratings of anxiety were measured with the Depression Anxiety Stress Scale (DASS21) (Lovibond & Lovibond, 1995). The DASS21 is a 21-item self-report inventory used to measure the severity of anxiety and depression. Levels of trait anxiety and depression are measured using a four-point Likert scale (0= did not apply to me at all and 3= applied to me very much, or most of the time). The scores on this scale can range from 0 to 63. The DASS21 has been shown to be a reliable measure of anxiety with a strong internal consistency (_=.88). This measure has been used extensively in psychological research and has been psychometrically validated as a sound measure of anxiety and depression.

The Harvard Group Scale of Hypnotic Susceptibility – Form A (HGSHS-A) (Shor & Orne, 1962). This scale measures a person's ability to be hypnotised. The HGSHS-A has 11 items of hypnotic suggestion to assess a person's susceptibility to hypnosis during their induction. It does not require application by a trained hypnotherapist, and is well used and validated in hypnosis research. The patient suitability program on the Virtual Reality Hypnosis Unit (*Virtual Medicine©(2005) Audio-Visual Presentation Media)* contains a program, which is similar to the HGSHS-A. The VRH hypnotic susceptibility program is easy to follow, since instructions for scoring etc are displayed on the external screen for the administrator to follow. The hypnotic susceptibility scale includes hypnotic suggestions such as arm rigidity, arm immobilisation, a mosquito hallucination, an itch sensation, taste hallucinations of sweet and sour, an auditory voice hallucination and a negative visual hallucination. In the VRH susceptibility test, suggestions for anosmia were excluded from this study, since the strength of the odour needed to perform this test was too overpowering for the small room that was used for testing.

Electrocephalography was performed using a 32 channel EEG Neuroscan Synamps system to test the effects of VRH on the brain. Electrodes were also placed near the eyes to control for eye movement artefact in the EEG for analysis purposes. A pulse oximeter was used to measure heart rate and heart rate variability was recorded manually every 5 minutes during the hypnosis program.

Procedure

Volunteers were excluded from the study if they had a personal or family history of epilepsy, schizophrenia, a psychiatric disorder, a head injury resulting in concussion or loss of consciousness or they participate in regular, recreational drug use. Volunteers who chose to participate in the study were invited to attend the Brain Science Institute for a 2 hour testing session. When the participant arrived, they were provided with an ethics form and an informed consent disclosure form. Volunteers were then asked to complete the DASS21.

Each participant had a 32 electrode cap placed on their head, and conductive gel was inserted into the cap to achieve an effective contact for the electrodes. Areas on the mastoids and horizontally and vertically from the eye were prepared using Nu-Prep and alcohol wipes, and electrodes attached. The eye electrodes were used to measure horizontal and vertical eye movement, which typically creates muscle artefact in the EEG signal and would be removed during EEG analysis. The participant was then asked to relax in a beanbag with a towel behind their head for additional comfort. The duration of the hypnosis task was about 45 minutes, so consideration for the comfort of the volunteers were taken into account to increase their chances of being hypnotised.

To ensure that eye movement was distinct, biological calibrations were performed using an eye blink and a saccade activity. These movements were recorded in the EEG. The participant was then asked if they were still willing to participate in the hypnosis susceptibility test. If they still wanted to participate, the pulse oximeter was placed on their finger, the goggles were placed on their head and adjusted for comfort, and then the headphones were placed on their ears. Before starting the hypnosis program, the participant was reminded about the length of the session (about 50 minutes), and asked to make themselves as comfortable as possible. During hypnosis, the heart rate was recorded manually every five minutes and the EEG files were created every 10 minutes. After 20 minutes of suggestions for relaxation and deepening, the volunteer's responses to various suggestions were recorded using the administrator's screen, which provides a description of how to score responses to each suggestion.

At the end of each hypnosis session, the earphones, goggles and oximeter were removed and the participant was tested for their response to post-hypnotic suggestions: i.e. hypnotic amnesia and a coughing reaction to three knocks on the desk. The participant was then taken out of hypnosis and told they would remember everything about their hypnosis experience. As part of the de-briefing process, the administrator also asked the volunteer a series of questions about certain parts their hypnosis experience: i.e. their age regression and dream experience. Scores for post-hypnotic suggestions were added to other susceptibility scores to complete the evaluation. After the EEG cap and electrodes were removed, the participant's hair was washed to rid the hair of any excess electrode gel.

Statistics

The hypnotisability of each participant was scored according to Egner (2005). Although the original figures used by Egner were adjusted because the the anosmia susceptibility test was excluded in this study. Low hypnotisables were those who score ≤2, medium hypnotisables were those who scored 3-7, and those who were highly hypnotisable scored ≥8. The results showed low hypnotisables (N=9), medium hypnotisables (N=13), high hypnotisables (N=8).

The EEG spectrum data was analysed using Brain Vision Analyser© v1.04.0002 (Brain Products GmbH, Munich). Each participant had 45minutes worth of EEG recording; each participant's EEG was saved in five separate files with four of them lasting ten minutes and one of them lasting five minutes. These files were epoched into 300second segments (or five minutes). Each of these epoched files represented different parts of the hypnosis process; i.e. Time 1: baseline, Time 2: hypnosis induction, Time 3: hypnotic susceptibility, Time 4: age regression and dreaming, Time 5: wake countdown. Each epoch was corrected for eye movement artefact, and a Fast Fourier Transformation was conducted to all of the epoched data to achieve spectrum analysis data. The spectrum data was taken from the theta bandwidth (3.5 to 7.5 Hz) and was exported into SPSS for analysis. Spectral power changes were then analysed using a 3(hypnotisability) x 5(time) repeated measures ANOVA. Firstly the electrodes were grouped into lobes (occipital, temporal, parietal and midline-frontal areas). Then more specific analysis of the frontal areas were performed by using a 3(hypnotisability) x 5(time) repeated measures ANOVA, this compared midline and frontal areas as well as left and right hemispheres of the frontal lobe. Each lobe and each frontal area were also tested independently to see if there was any significant change in the EEG over time and across susceptibility group.

The Heart rate data, anxiety scores and demographic information were analysed using SPSS. Heart rate data was recorded every five minutes during the hypnosis session which totalled 45 minutes. In particular the heart rate data was tested across hypnotic susceptibility groups and time using a 3(hypnotisability) x 9(time) repeated measures ANOVA.

The assumptions of ANOVA were upheld and corrected if violated during the analysis. Although the group sizes were similar they were exactly the same in size, which creates the ANOVA to be less robust against violations of homogeneity and normality. This was considered when reporting statistics and those statistics that are approaching significance were only reported to represent trends that may be relevant to future study.

Results

To test the heart rate data and EEG data; repeated measures ANOVAs were performed. This was to test if there was any significant change in heart rate and EEG over the time of the hypnosis and across hypnotic susceptibility groups. It was found that there was no significant interaction between heart rate over time and hypnotic susceptibility. It was also found that there was no significant change in heart rate over the whole of the hypnosis period. When heart rate was compared between baseline (time 1) and hypnotic susceptibility (time 3) conditions there was no significant difference in heart rate variability across the times or susceptibility group. Although noticeable changes in heart rate were observed during the hypnosis session, there were changes in heart rate variability during the susceptibility tests. Those in the high hypnotisable group showed high heart rate variability values for the mosquito hallucination (25 minutes) and itch hallucination (30 minutes) (See Figure 1).

It was found that there was a significant change in the EEG over time when comparing all lobes of the brain; high theta activity was found in the frontocentral areas and parietal areas of the brain ($F(1,27)=8.03$, $p<0.01$, partial __=.23, observed power=.78, MSE=142.13). Although this significant difference was across time and the same was not found across the different hypnotisability groups.

More specific comparisons were performed and repeated measures ANOVA revealed that there was a difference in theta activity between left and right hemispheres in the frontal areas of the brain across time. There was more theta activity in the left hemisphere of the frontal lobe of the brain, which suggests a hemispheric shift in activity that is similar to dissociation. Although this result only approached significance due to the assumption of repeated measures ANOVA, a lower-bound adjustment had to be made, if a Greenhouse- Geiser adjustment was made then this change over time would have been significant ($F(3.18,5.89)=2.75$, $p<0.05$, partial __=.09, observed power=.67).

Specific to changes in EEG over time baseline (time 1) and hypnotic susceptibility stages (time 3) of the hypnosis were compared using a repeated measures ANOVA. There was a significant difference in the EEG across all of the lobes for baseline (time 1) and hypnotic susceptibility (time 3) stages of the hypnosis ($F(1,27)=10.11$, $p<0.01$, partial __=.27, observed power=.87, MSE=45.31). This theta activity was mainly in the frontocentral areas of the brain and in the parietal areas for the hypnotic susceptibility stage of the hypnosis. Baseline (time 1) and hypnotic susceptibility (time 3) were also compared for the frontal areas of the brain which showed a difference across time that was approaching significance (F(1,27)=3.37, p=.07, partial __=.11, observed power=.43), the theta activity was high for most of the frontal areas of the brain during the hypnotic susceptibility test but it was the highest in the left hemisphere of the frontal lobe.

Post hoc analyses were performed on subjective measures of anxiety which were measured by the DASS21 and it was shown that there were no significant relationship between anxiety levels and hypnotic susceptibility.

Discussion

The EEG spectral analysis revealed some interesting findings in the theta bandwidth, although from a neurophysiological perspective, there were no observable differences between hypnosis and relaxation. The differences between hypnosis and relaxation were clearly apparent during observations of their behaviour and physiological responses to virtual reality hypnosis (e.g. complete relaxation of skeletal muscles etc). Traditional, practitioner guided hypnosis methods indicate that about 5% of people are unhypnotisable and 10% of people are highly hypnotisable to extreme depths (Stark 2005). In this study, using virtual reality hypnosis, nearly a third of the group scored high on hypnotisability. This result is consistent with reports from other research in virtual reality hypnosis (Hoffman, Doctor, Patterson, Carrougher, & Furness, 2000; Hoffman *et al*., 2004; Patterson, Tininenko, Schmidt, & Sharar, 2004; Patterson *et al*., 2006), which indicates that virtual reality could make hypnosis more accessible to a greater number of people.

In this study, the EEG data indicates that the difference between low and high hypnotisables was not significant. However, the EEG data did show that during the virtual reality hypnosis program, theta activity in the frontal areas of the brain changed progressively over time, suggesting that all participants, regardless of their susceptibility rating, experienced a meditative state or deep sense of relaxation.

Dissociative affects were present in EEG data from the entire group (i.e. high and low hypnotic susceptibility), and although these results were based on trend, it's worth noting that the left side of the midline-frontal areas of the brain of all the people tested were close to a hemispheric shift in activity. According to relevant literature, this kind of brain activity is only found in deeply hypnotised individuals (Gruzelier, 1998). The data collected from this study indicates that the virtual reality hypnosis program has an extraordinary capacity for generating a deep sense of relaxation/meditative state, and people who cannot be hypnotised may still have the ability to become dissociated.

The findings in this study are consistent with previous hypnosis research using EEG. A study published by Fingelkurts and colleagues (2007), used a comparison of EEG data for baseline measurements and deep hypnosis to show that frontal areas of the brain were dissociated during hypnosis. Furthermore, frontal areas of the brain were associated with a significant shift in theta activity during hypnosis: especially the left hemisphere, which lost active functional connections with the rest of the cortex (Fingelkurts, *et al*. 2007). Croft and colleagues (2002) showed that pre-frontal areas of the brain were dissociated from other neural functions, and this hypnosis induced dissociation created interference between the gamma/pain relationship. The authors inferred that hypnosis interferes with normal anterior brain function, which involves high order attention systems (Croft, *et al.*)

Similar conclusions were also drawn from a study that focused on individual differences in hypnotic susceptibility, which indicated that the ability to become hypnotised depends on the capacity of the individual's frontal attentional system to be dissociated. According to Egner et al., (2005), hypnosis can dissociate the processes of conflict monitoring and cognitive control, which are found in the frontal areas of the brain. In particular, a decrease in functional connectivity between frontal midline and left lateral EEG sites was found in those who were highly hypnotisable. The ability to dissociate from conflict monitoring and control processes allows hypnotic suggestion (Egner, *et al.*). The interference in frontal lobe functions has also been found in hypnotised individuals asked to perform cognitive tasks, and this dissociation of the frontal areas was responsible for an increase in task errors compared to baseline measures of cognitive performance (Green & Lynn, 1995). The increase in task errors was evaluated by using a Stroop Task on hypnotised individuals. It showed that EEG activity was significantly reduced in the left anterior areas of the frontal cortex (i.e. anterior cingulate cortex), where a hypnosis induced dissociation was most evident (Gruzelier, 1998).

In this study, it was clear that many of the participants were highly hypnotised (based on results of the hypnotic susceptibility test), but this finding was unusual because the difference in EEG results between the hypnotic susceptibility groups was not significant as expected. Each of the susceptibility group's response to the hypnosis was noticeably different in behaviour and in physiological response, but these differences were not apparent in the EEG.

Heart rate was a novel thing to measure in a hypnosis study. It was thought that heart rate could be a physiological indicator of hypnotic state, although this finding was not significant. It is thought that the heart rate variability did not change significantly over time in the statistics because heart rate is a physiological mechanism which is designed to stay relatively consistent. Those who were highly hypnotisable had an increased heart rate when they were performing the susceptibility tests. Heart rate changes were especially noticeable when some of the tests created a fight or flight response; for example the mosquito illusion and the itch hallucination both showed large increases in heart rate when the participant was hypnotised.

It became easier to predict if a participant was becoming hypnotised by looking at their heart rate during the hypnosis program, this was alongside other physiological indicators. Those who were hypnotised seemed to lose rigidity, especially in the neck when they were getting into the deeper stages of hypnosis, whereas those who weren't hypnotised seemed relaxed but not to the extent of those who were hypnotised. During the testing sessions participants who were not hypnotised had a steady heart rate throughout the hypnosis program. The heart rate of participants who became highly hypnotised dropped as they were in the induction stage of the hypnosis, and rose when susceptibility tasks were being conducted, and then became steady again during the dreaming and age regression stage (time 4) of the hypnosis. These trends were interesting when considering the anxiety levels of the participants throughout the study, Many participants in this study commented that they felt like they were approaching a hypnotic state, but as soon as the hypnotic susceptibility test was administered and they had to move their arms they felt like they had woken up. It could be argued that the hypnotic susceptibility test can be disruptive to hypnotic induction, as it creates more physiological awareness and an alert state. So it is possible that the hypnotic susceptibility test may not truly reflect a person's ability to become hypnotised. The efficacy of the Harvard Group Scale of Hypnotic Susceptibility Form A (HGSHS: A) was tested by Piesbergen and Peter (2006). It was found that hypnotisability could not be precisely measured or predicted with the use of the HGSHS: A, alone. Other factors such as personality and absorption need to be included in the hypnotisability measure. It is also suggested by Piesbergen et.al. That the HGSHS: A is only a test of hypnotic suggestibility and not necessarily hypnotic ability, which is important to consider while conducting the test. Based on these findings it would be reasonable to conduct further research in the area of physiological signs of hypnosis that can be measured such as heart rate variability, galvanic skin response and respiratory changes.

Most of the participants that were highly hypnotisable through the VRH program reported that they felt relaxed and in high spirits for a few days following the hypnosis program. Some participants were required to stay at the Brain Sciences Institute for longer than scheduled because they still felt sleepy after the hypnosis. Most participants found the hypnosis program enjoyable and relaxing. This was enhanced by the quiet and comfortable environment in which the hypnosis took place. Participants noted that they felt safe and at ease in the cozy dark room sitting in a bean bag. This level of relaxation and hypnosis may not have been achieved in a brightly lit room, or uncomfortable seating where they could not relax totally; this was especially important for the EEG as the caps can cause strain to the neck. These qualitative findings are important for those who wish to administer hypnosis therapy or virtual reality hypnosis with more success.

Hypnosis therapy in itself can induce anxiety, so a safe feeling about the place where hypnosis takes place helps to build confidence in the technology, and rapport with the technician or therapist. It is thought that younger people would be more open to VRH as the technology is not threatening as it can be likened to watching television or listening to music in headphones. It's also important to note that the hypnosis programs are the same for everyone so VRH reduces the likelihood of manipulation of the participant, and therefore reduces anxiety in the patient before the program is administered. Participants in VRH know that they will not be asked to participate in humiliating situations and will not feel vulnerable at any time; this helps to build rapport with the therapist and trust in the therapy.

Occasionally, establishing rapport or even communicating with a patient is extremely difficult, so traditional counseling / hypnosis methods are nigh impossible. This type of patient was admitted to the Burns Unit of a large metropolitan hospital after the Bali bombing on the 12th of October 2002. The patient was a 28-year-old male with burns to 45% of his total body surface area. His physical progress and medical management were compromised within 10 days post admission when he manifested symptoms consistent with acute stress disorder (ASD), characterized by anxiety, tearfulness, insomnia, panic attacks, low mood, depression and irritable outbursts. He refused radio and television connections, was agitated by nursing staff opening curtains in his room, and refused all visitors - except his immediate family. He was uncooperative with medical and nursing interventions, he had limited interaction with hospital staff, and he was particularly aggressive and verbally abusive towards the attending psychiatrist. Virtual Reality Hypnosis was provided as an adjunct to existing therapy after ASD symptoms began to impact significantly on his recovery and pain management requirements. In the virtual reality environment, auditory and visual stimulation from the "real world" was limited, and it created a stress free environment conducive to relaxation and altered states of consciousness. After a few sessions, the symptoms of ASD subsided and he began psychotherapy with the hospital psychiatrist (Personnal Communication Colin Carbis)

Hypnosis has been shown to help well-being in those with high stress situations for example; exam time. Self-hypnosis techniques have reduced anxiety and depression levels, enabling them to reach their goals (Laidlaw et al., 2003). Another study showed that hypnosis helped immune function, reduced the levels of clinical depression and anxiety in a student group during exam periods (Gruzelier, 2002). Complementary and alternative medicines are treatments that are available to people who suffer from anxiety, depression, chronic pain and other illnesses. It has been shown that hypnosis can be successful in reducing anxiety, cancer pain, nausea, chronic pain, insomnia and panic disorders. Other therapies such as massage, meditation, relaxation and biofeedback are also beneficial for those who suffer from anxiety. Practitioners who are aware of the benefits of alternate and complementary therapies can help their patients to the best of their abilities (Mamtani & Cimino, 2002).

Further research should be conducted to test the efficacy of the Virtual Reality Hypnosis Unit, such as the anxiety reduction program. Research has been proposed to use VRH in reducing anxiety in children in stressful or painful hospital situations. The application of the technology in a clinical setting is ideal to test the machine's efficacy.

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APPENDIX

Figure 1: Heart Rate Over Time