Research Proposal: Perceptual Disturbances in Relation to Perceptual and Electrical Noise

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Abstract

This proposal incorporates three experiments concerning perceptual disturbances: one analyzing eye movement and associated electrical activity in hallucinating patients, another assessing dream recall in patients exposed to weak pulsed electromagnetic fields (EMF), and finally the examination of phosphene induction via transcranial magnetic stimulation (TMS) and associated electrical activity. The direct link between perceptual noise, noise in the brain's electrical activity, and perceptual disturbancescan be established via the analysis of eye movement and EEG readings and the examination of their differences between the treatment and control groups. Another direct link can be uncovered between the generation of electrical noise via pulsed EMF and perceptual disturbances in the form of improved dream recall. Finally, the effects of TMS on reducing perceptual disturbancesand inducing phosphenes can be compared within the treatment group and related to the control group.

Objectives

Experiments performed by Dr. Wilder Penfield showed that dreams, hallucinations, and memories could be activated by probing the patient's temporal lobe with an electrode [1]. These experiments revealed several interesting phenomena such as the interrelatedness of certain types of perceptual disturbances with memory as well as their stimulation via electrical impulse. Today perceptual disturbances in particular remain somewhat poorly understood, with different causes being proposed and disparate evidence for establishing their credibility. A connection can perhaps be drawn between perceptual disturbances and the general causes of electrical activity and perceptual noise. Considering the well-known effects of memory on perception [2][3][4][5], perceptual disturbances caused by electrical and perceptual noise may be relatable to memory.

This proposal incorporates three experiments concerning perceptual disturbances: one analyzing eye movement and associated electrical activity in hallucinating patients, another assessing dream recall in patients exposed to weak pulsed electromagnetic fields (EMF), and finally the examination of phosphene induction via transcranial magnetic stimulation (TMS) and associated electrical activity. The short-term objectives differ from experiment to experiment and comprise directly linking perceptual noise (eye movement) to electrical activity, directly linking noise in the brain's electrical activity (from pulsed electromagnetic interference) to perceptual disturbances, and understanding the role of phosphenes while building a clearer picture of why TMS has a curative effect. Overarching short-term objectives encompass the general linking of electrical and perceptual noise to types of perceptual disturbances and examining the relationship between phosphenes, TMS, and noise generally.

In the long-term this research could lead to a clearer theoretical framework for the interrelatedness of memory and perception. Perceptual disturbances incorporate memory automatically and this may be related to electrical and perceptual noise. This can be further probed by brain region. New treatments – including variations on existing non-invasive and non-chemical techniques – can be discovered for antipsychotic-resistant hallucinating patients due to an improved theoretical framework for the curative effects of EMF induction via TMS.

Literature Review

A significant body of research has related eye movement dysfunctions with psychosis. Morita et al. reviewed the neurophysiological basis of eye movement control and characteristics in schizophrenia [6]. Holzman noted that eye movement dysfunctions are prevalent in tracking movements of psychotic patients, with rapid eye movements interrupting smooth pursuit or the complete replacement of smooth pursuit with large saccade [7]. Qiu et al. found that hallucination severity is negatively correlated with the return-sweep saccades (RSS) of exploratory eye movement (EEM) [8]. This literature links the perceptual noise of eye movement and associated electrical activity to hallucinatory perceptual disturbances.

Sekuler and Sekuler noted how stimulus noise can be useful for studying memory formation[9]. Agus et al. and Gold et al. varied stimulus discriminability by exposing subjects to different categories of repeated percepts for probing memory formation [10][11]. Jiang et al. found that similarity in visual percepts improved performance by reducing noise in memory representation [12]. If eye movement is related to both perceptual noise and noise in the brain's electrical activity, it is possible that information encoded within this noise would be of importance for understanding memory formation and its appearance in perceptual disturbances.

It is well known that another form of perceptual disturbance – dreams – is most pronounced during the rapid eye movement (REM) portion of sleep. Arnulf related extensive lesion within REM sleep executive systems to waking hallucinations [13]. There is some evidence in the literature that noise in the brain's electrical activity can produce perceptual disturbances in the form of improved dream recall. Sandyk documented a Parkinsonian patient experiencing cessation of REM sleep and dream recall who had the latter restored after receiving three treatment sessions with AC pulsed picotesla range EMFs applied extracranially. It was believed that this reactivated the reticular-limbic-pineal systems [14]. Lendner et al. noted that reduced arousal states are not necessarily only defined by synchronous oscillatory activity such as alpha wave patterns [15]. Could this electrical noise be related to or affected by eye movement or pulsed EMFs?

Although its causal mechanism remains unknown, TMS is a common treatment for antipsychotic-resistant hallucinations and other symptoms of schizophrenia. It functions by varying a magnetic field near the scalp to induce a current within a region of the brain. One effect of this technique has been the induction of phosphenes within the visual cortex. Schaeffner and Welchman mapped out locations in the visual cortex where TMS triggered phosphenes [16]. Importantly, phosphenes involve the creation of a *conscious and controllable* percept – the opposite of a perceptual disturbance. Considering the success of TMS in treating symptoms of schizophrenia and its associated generation of phosphenes, and further considering the notion that perceptual disturbances are related to electrical and perceptual noise, it is possible that phosphene generation is related to noise *reduction.*

Methodology

The first experiment assesses various forms of eye movement and dysfunctions thereof in both a group of patients experiencing waking auditory and visual hallucinations as well as a control group. The four types of eye movements assessed are saccades, smooth pursuit movements, vergence movements, and vestibulo-ocular movements. Saccades, which are rapid voluntary or involuntary movements of the eyes that quickly change point of fixation and occur during REM sleep, are assessed by instructing the patient to fixate alternately on two distinct targets. Smooth pursuit movements are slower voluntary tracking movements that will be examined by instructing patients to follow a small dot of light moving sinusoidally. Vergence movements align the fovea of each eye with targets located at different distances from the observer and will be tested by sitting a patient facing a near-point target and varying its distance. Vestibulo-ocular movements compensate for head movements by stabilizing the eyes relative to the external world and are tested by turning the patient's head on its long axis and observing for the doll's eyes reflex. Eye trackers will be employed and patients will be connected to electroencephalograms (EEG). It is hypothesized that there will be a difference in eye movement and thus electrical activity between the treatment group and control group.

The second experiment seeks to link weak pulsed EMFs to perceptual disturbances in the form of enhanced dream recall. Using a high-power low-frequency pulsed EMF on a group of patients experiencing limited or ceased dream recall, the dream recall of the patients will be assessed shortly after successive days of exposure to EMF with follow-up via sequential assessments one and two weeks later. The predicted effect of the high-power low-frequency pulsed EMF is that it will increase dream recall in many patients.

The final experiment requires two groups of patients once more: those experiencing auditory and visual hallucinations and a control group. TMS will be applied to the visual cortex of patients with closed eyes in each group and the induction or not of phosphenes will be reported. Auditory noise will be produced to examine whether it has any effect. The amelioration or not of hallucinations in each patient of the treatment group will also be noted. The patients will be connected to EEG. The induction of phosphenes is expected to occur in some capacity in both groups and to be accompanied by electrical activity.

All patients will be chosen fairly, with appropriate representation given for groups differing in ethnicity, religion, culture, gender and sexual orientation.

Impact

The direct link between perceptual noise, noise in the brain's electrical activity, and perceptual disturbances can be established via the analysis of eye movement and EEG readings and the examination of their differences between the treatment and control groups. Another link can be uncovered between the generation of electrical noise via pulsed EMF and perceptual disturbances in the form of dream recall. Finally, the effects of TMS on reducing perceptual disturbances and inducing phosphenes can be compared between treatment and control groups.

This research would help build a relationship between perceptual noise, electrical noise and types of perceptual disturbances. It would also link phosphene induction and noise generally while improving understanding of TMS. Since phosphenes are ultimately created and controlled by the brain, it is possible that they are the opposite of perceptual disturbances and thus reduce noise in the brain's electrical activity.

This noise, understood as information instead of synchronous oscillatory activity, may form the nexus for the interrelatedness of memory and perception as well as perceptual disturbances (memory based) and phosphene induction (not memory based). Eye movements and pulsed EMF are vitally important tools for mapping such interrelations and any underlying noise in the brain's electrical activity understood as information. Above all, the experiments provide a new, supplementary understanding of types of perceptual disturbances and their underlying theoretical frameworks, and can lead to improved treatment options in the long-run.

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