

## Role of Entrainment in Rehabilitation

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### Introduction

Entrainment is an interesting phenomenon in biological systems. This is a process through which two signals that are close to each other in frequency get entangled into a single frequency. Two pendulums connected to a common support bar move quickly toward entrainment. The entraining signal could be from outside the body. In the field of chronobiology, a familiar example is sleep-awake cycle in humans that is driven by external light cues.

One of the most common entraining signal sources is the so-called Schumann Resonance (SR). This resonance occurs as electromagnetic waves bounce back and forth between the surface of the earth and the ionosphere. Ionosphere contains full of charged particles and behaves like a mirror for these electromagnetic waves. Schumann Resonance is the result of these oscillations and the resonance frequency falls within the alpha range of the brain waves. It is thought that this resonance is essential for normal human activity; it is possible that entrainment of biological signals between humans could be understood on the basis of Schumann Resonance [1].

### Brainwave Entrainment

Brainwave entrainment (BWE) is an interesting area wherein a rhythmic response is elicited in the EEG of a person as a result of driving cortical neurons by means of external light or acoustic signals. When a flashing light in the field of view of a person is close to alpha frequency of EEG, for example, the brain waves tend to lock to this external signal! The experiment is similar to Neuro feedback systems; the difference being in EEG entrainment, a light source in the visual field of the person is driven at around alpha frequency. Under these conditions, the brain wave tends to follow the external signal. Entrainment of CNS activity has been used in diverse areas of rehabilitation such as in cognitive function deficits, PMS, stress, pain, headache, migraine and some behavioral problems [2]. This may be termed free running Brain Wave Entrainment (BWE). However, it is thought that a free running system such as this (not related to one's own EEG, see below) could, if used improperly, lead to photic generated problems.

Earlier work in this area was related to driving EEG through signals derived from one's own EEG with proper phase adjustment [3]. This system may be termed EEG Biofeedback devices and have been used for rehabilitation of special cases of CNS disorders. Limitations of a free running BWE are not expected in this method since the signal is derived from one's own ongoing EEG activity. The raw EEG of a person is sent through a processing system and depending on the application, theta, alpha or beta wave is selected for feedback. Phase adjustment is required for maximizing the outcome. This filtered, phase adjusted EEG-derived signal is then fed to a light source whose intensity varies in accordance with the ongoing EEG activity. Rehabilitation of many stress related problems are reported through this procedure.

### Entrainment through Acoustic Coupling

It is also possible to accomplish entrainment of physiological parameters such as blood flow through acoustic coupling. Again, these acoustic signals could either be self-generated or impressed through external means. The latter is achieved when EEG-derived signal drives

an acoustic signal (similar to light signals in the above example) or as free standing acoustic signal from an external auditory source.

The endogenous signal could be self-generated (voiced) sounds. An interesting report is available when certain prayers and mantras are enunciated. They seem to "increase synchronicity of cardiovascular rhythms when they are recited six times a minute. There was also an increase in baroflex sensitivity" [4].

Another interesting example is changes in blood flow in the brain as observed through fMRI [5]. Twelve healthy volunteers were asked to chant 'OM' and the neurohemodynamic correlates were observed using fMRI. The study showed bilateral deactivation in orbitofrontal, anterior cingulate, thalamic, hippocampal and in right amygdala which were statistically significant. It was concluded: "The neurohemodynamic correlates of 'OM' chanting indicate limbic deactivation. As similar observations have been recorded with vagus nerve stimulation treatment used in depression and epilepsy, the study findings argue for a potential role of this 'OM' chanting in clinical practice" [5].

Since most tissues in the body are piezoelectric, it is possible to explain that voiced chanting could elicit electrical activity that could drive physiological signals into entrainment and also could provide changed blood flow conditions.

### Entrainment and Coherence

Entrainment could give rise to synchronization and coherence in the activity of diverse systems in the body. Synchronization of two signals means they have same time sequence whereas coherence is a mathematical measure of how close in phase two signals are in a system. Normally, when EEG waveforms at two locations on the scalp are compared, it is obvious they are not related in phase in any manner. During meditating, electrical activities from many areas of the brain are seen to be coherent, implying they work in synchrony apparently exchanging information over large areas of the scalp. In a review paper, the authors have summarized observations in mindfulness and Transcendental (TM) meditations wherein cardiac and respiratory synchronization is reported which is not seen during normal relaxed condition [6]. The paper proposes "a mechanism of neurophysiological changes during meditation at the cellular level based on neurovascular coupling and at the global brain activity level from the autonomic response generated by cardio-respiratory synchronization" [6].

It is further postulated that higher coherence between different sites of the brain may be associated with higher creativity, emotional

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Received March 03, 2016; Accepted April 20, 2016; Published April 27, 2016

Citation: Srinivasan TM (2016) Role of Entrainment in Rehabilitation. J Yoga Phys Ther 6: 233. doi:10.4172/2157-7595.1000233

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stability and overall improvement in moral and ethical attitudes [7]. Since higher coherence between two areas of the brain implies these areas are interlinked in activity, such coherence may produce a global effect and could lead one towards higher states of consciousness.

## Conclusion

Entrainment is an interesting phenomena happening all the time in the body-mind of individuals. We are tuned to nature through entrainment; our biological clocks are responsive to variations in weather, season and light-dark cycles. Thus, Ayurveda recommends tuning our diet to environmental conditions so that this natural entrainment could be facilitated and there is no conflict in the mind-body as variations in nature are experienced. It is possible that a rehabilitation regimen is more effective in one part of the day than at some other point of time during a 24 hour cycle.

Research in meditation has opened doors of our perception to some unusual events taking place in the brain. The consequence of brain coherence in rehabilitation is difficult to understand fully at this time. It could be involved in improving memory, regulate emotional

responses, reduce effects of stress and useful in management of some geriatric problems.

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