

Alpha Waves, Intelligence and the Orienting Reflex: A review

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The most complex biologically existing structure is the human brain. Though there are documented studies showing evidence of brain interventions as early as the stone ages in form of trepanation, its understanding persists at incipient stages and the instrument for recording its basic activity remains the electroencephalogram. In this era of developing and innovative technology, design thinking and marketing, the desire to adequately quantify thought processing remains an enigma which prompts many to design tools that would significantly define the state of the mind. Hence, the need to revert to the basics of neuronal responses in the brain, the association of these responses elicited in an electroencephalogram, correlating the component of this behavioural state of readiness, arousal or response with intelligence and finally augmenting relentless and historic research in this field to generate data for further analysis until a consensus is reached.

The electrical activity reflects both the intrinsic activity of neurons in the cerebral cortex and the information sent to it by sub cortical structures and the sense receptors. Even today the only fact about alpha rhythm that we can be sure about is that the alpha rhythm is the most common component of the brain's electrical activity, the electroencephalogram which can be recorded in a healthy awake adult human. The term alpha activities rather than rhythm are often used to encapsulate the wider concept of alpha oscillations which range from frequencies of 8-13Hz. Though rhythmic synchronisation of neurons activity is the main mechanism here, the formation of a neuronal assemble is accompanied by a rhythmical increase in the total potential, whereas a disruption of the neuronal assemble is characterized by a decrease in total potential. Thus, the well-known phasic structure of alpha activity (or alterations of synchronisation and desynchronisation periods) mainly reflects the processes of formation and disruption of cortex neuronal assembles respectively and not rest and active states. Recent evidence shows that event related upper alpha desynchronization (ERD) is related to cognitive performance and in comparatively more intelligent subjects, during semantic processing this was more significant in the left hemisphere. The ontogenetic changes of interconnected parameters (myelination, alpha frequency, processing speed, and short-term memory span) go in parallel and interpretation of the alpha frequency-intelligence relationship also seems to be consistent with the brain myelination hypothesis of intelligence (Miller 1994).

Alpha waves have been described best for learning. While experiments have also proved that alpha activity is more in gifted persons, a correlation has been made between an increase of alpha brain waves either through electrical stimulation, mindfulness or meditation and the ability to reduce depressive symptoms and increase creative thinking by facilitating relaxation of both mind and body. Studies have demonstrated that there is a direct correlation between alpha activity, intelligent quotients and the marks obtained at senior secondary school level which is self explanatory in explaining the relationship between IQ of a person and alpha activity (Shah et al, 2012). In a study by Norbert Jausovec and Ksenija Jausovec (2012) the changes in upper alpha band desynchronisation indicated that processes related to long term memory were also influenced.

Measured IQ is also positively correlated with the strength and persistence of orienting reactions which may be strengthened by conditioning and that this may lead to improved performance in intellectual tasks. The orienting reflex refers to an assortment of bodily reactions elicited by novel or unexpected stimuli. These include postural adjustments, such as pricking up the ears in response to an auditory stimulus, autonomic nervous system reactions, such as digital vasoconstriction, as well as EEG desynchronization. The intellectually gifted children differ from average ones in initial orienting reactivity to innocuous stimuli and in rapidity of habituation of orienting reflex (Kimmel and Dana 1978). While the former had larger orienting reactions and habituated more slowly than the average ones, this strength and persistence of the orienting had been shown to be positive and monotonic from IQs 30 through levels above 160 in their study. The results of such a study support the assumption that attention and cognitive performance involves orienting reactions and these primitive neurophysiological mechanisms such as ORs are involved in complex intellectual functioning.

Habituation is one of the most fundamental properties of behaviour and is the simplest form of learning. That the stimulus itself becomes unimportant because nothing happens after repeating it causes habituation towards that particular stimulus. This is such a basic mechanism that few deny it occurs in humans even though it involves complex processes of stimulus recognition. However, if one stimulus in a series of such presentations is left out then dishabituation occurs while unexpected strong stimuli can make a habituated response reappear temporarily. Apparently the omission of an event can itself be an event. The orienting response

is also believed to play an integral role in preference formation. While deciding between two options, subjects in studies by Simion and Shimojo choose the items they preferentially orient their gaze toward. This gaze can occur while the stimulus is present or after it has been removed, the latter causing the gaze to be fixated at the point in which the stimulus had been present. Interestingly, gaze bias ceases following a decision, suggesting that gaze bias is the cause of preference and not its effect. In addition to novelty of the stimuli, studies have also demonstrated the role of emotions in orienting attention. Several recent studies have found that despite a decrease in overall amplitude of late positive potential with repeated presentation of the same picture, emotional pictures continue to elicit a larger positive potential (Codispoti et al 2006). Habituation is also related to the level of arousal in a subject. EEG, a cerebral cortical activity and skin conductance level (SCL), sympathetic autonomic activity associated with arousal has been studied separately, despite their potential to reflect complementary dimensions of reticular-thalamo-hypothalamo-cortical activating networks and a substantial relationship between them has been demonstrated (Lim et al 1996).

Classic conditioning is said to involve cognitive processes in terms of formation of association between stimuli and there are theories of how classical conditioning cluster around the detection of a discrepancy between expected and observed events (Rescorla and Wagner 1972).

As the desynchronisation of EEG is a component of orienting reflex and studies have demonstrated relationship of intelligence with alpha activity it becomes relevant to state that level of intelligence that can be improved by habituation in orientation can also be quantified and documented on a scale that can be interpreted to show whether the subject has improved.

Besides application in competitive zones to assess intellectual gain this template of alpha activity, orienting and intelligence can also be used to provide information on improvement in comatose patients secondary to brain injury and cerebral hypoxia as withdrawal of life-sustaining therapy (WLST) decisions continue to lead to mortality in patients who do not readily regain consciousness after severe brain injuries. This would benefit those who either would have recovered eventually or are on stem cell therapy. The use of EEG in brain mapping using P300 as Brain Electrical Activation Profile Test also called P300waves test demonstrates the practical application of EEG as a deception detection test in practical use.

Notably, the use of EEG to aid prognostication is increasingly explored in comatose post-cardiac arrest patients, especially since various targeted temperature management (TTM) protocols introduced continuous EEG monitoring as standard of care in these patients.

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