

## MEASUREMENT AND MODIFICATION OF THE EEG AND RELATED BEHAVIOR

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Early studies in our laboratory showed that cats could be trained to alter spontaneous EEG patterns through contingent food reinforcement of operant configurations. In particular, rhythmic EEG patterns in sensorimotor cortex, which were related behaviorally to motionlessness, were facilitated in this manner, and showed sustained alteration across states and time. Electrophysiological changes in the sensorimotor pathways were found to accompany this effect. Additionally, several striking behavioral changes were seen as well, including in particular an enhancement of sleep and an elevation of seizure threshold to epileptogenic agents.

This latter observation raised the possibility that human seizure disorders might be influenced therapeutically by similar training. However, in man the use of food reinforcement was not practical. Further, unlike our cats, human epileptics present with characteristic EEG abnormalities. An evaluation of these abnormalities from the perspective of our cat data showed that while normal humans had analogous patterns, untreated epileptics were often deficient in normal rhythmic sensorimotor activity and had EEG patterns dominated, instead, by slower and more poorly organized patterns. It thus became necessary to develop a very different strategy in applying this methodology to epileptics.

Our objective in human EEG feedback training became not only the facilitation of normal rhythmic patterns, but also the suppression of abnormal activity, thus requiring complex contingencies directed to the normalization of the sensorimotor EEG. To achieve this, a multicomponent frequency analysis was developed to extract and separate normal and abnormal elements of the EEG signal. Each of these elements was transduced to a specific component of a visual display system, and these were combined through logic circuits to present the subject with a symbolic display. This display allowed the subject to score "points" in a variety of game formats through the normalization of EEG characteristics. Variable criteria provided for the gradual shaping of EEG elements towards the desired normal pattern. Some 50-70% of patients with poorly controlled seizure disorders experienced therapeutic benefits from this approach in our laboratory, and subsequently in many other laboratories as well.

A more recent application of this approach to the modification of human brain function in our laboratory has been directed to the dichotomous problems of task overload and underload in the contemporary aviation environment. At least 70% of all aviation accidents have been attributed to

the impact of these kinds of problems on crew performance. The use of the EEG in this context has required many technical innovations and the application of the latest advances in EEG signal analysis. Our first goal has been the identification of relevant EEG characteristics. Additionally, we have developed a portable recording and analysis system for application in this context. Findings from laboratory and in-flight studies suggest that we will, indeed, be able to detect appropriate changes in brain function, and feed this information to on-board computers for modification of mission requirements and/or crew status.

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