Chapter VII

Neurofeedback: Using Computer Technology to Alter Brain Functioning

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ABSTRACT

This chapter introduces neurofeedback as a mechanism for altering human brain functioning and in turn influencing behavior. It argues that neurofeedback provides a plausible mechanism by which the individual can learn to alter and control aspects of his electrocortical activity. The chapter highlights some of the findings from both clinical and optimal performance research, showing the benefits of neurofeedback training, and outlines some of the important issues that remain to be addressed. It is hoped that outlining some of the issues that have yet to be resolved will serve a dual purpose. Initially it will assist in the understanding of some of the theoretical and methodological limitations that may be holding the field back. In addition, it is hoped that such information will stimulate researchers to work toward designing more efficient and effective research protocols and paradigms.

INTRODUCTION

This chapter provides an introduction to some of the uses of neurofeedback and highlights some of the issues from the field that are as yet unresolved. The first section describes how the electrocortical activity of your brain can be recorded and separated into a range of preset frequency components. This is followed by an overview of neurofeedback as an operant-conditioning paradigm that can enable you to learn how to use computer technology to alter specific aspects of your brain wave activity. The next section provides some evidence for the use of neurofeedback in practice, both in clinical and optimal performance settings. The chapter then focuses on some of the key issues relating to the use of neurofeedback in the field. These are the modality of the feedback given, the specific number and configuration of sensors used to record electrocortical activity, the use of standard preset training frequency ranges, the specific effect of neurofeedback training on cor-
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tical activity, issues relating to the duration and frequency of the training, and the transferable effects of neurofeedback training and whether the effects of such training are long lived or not. By highlighting some of the issues that currently limit our understanding of the effectiveness of neurofeedback training, I hope to stimulate future researchers to empirically address them. The final section of the chapter identifies the possible future trend of using full scalp recording and the feedback of multiple frequency components to provide a more comprehensive training package.

THE ELECTROENCEPHALOGRAM

Whether you are awake or asleep your brain remains active, with millions of tiny brain cells called pyramidal cells firing in synchrony representing your thoughts and dreams. However, it was not until Hans Berger discovered that by placing a number of sensors on the human scalp that such electrical activity could be recorded. What Berger originally recorded is now commonly referred to as the electroencephalogram or EEG. The EEG signal itself represents the difference in electrical potential between two sensors, where one is placed over an active region, such as your brain, and the other is placed over what is assumed to be in inactive reference site, such as your earlobe.

The main aspects of the EEG are its frequency, amplitude, and coherence. Frequency refers to the number of oscillations of EEG activity per second while amplitude is measured as half the distance between the high and low points of an oscillation. Coherence refers to how much the EEG signals recorded from two separate active sites are synchronized such that the crests and troughs of the waves occur simultaneously (see Figure 1).

The EEG recorded from a single active sensor produces a raw trace, which if then converted and replayed on a computer screen looks like a long squiggly line. However, this single trace can then be broken down into a range of predefined frequency components. Much in the same way as white light can be split by a prism into its spectral components of red, orange, yellow, and so forth, the raw trace of the EEG can be divided into a range of frequency components using a fast Fourier transform (FFT; see Figure 2).

Traditionally, the raw EEG trace has been divided into five main frequency bands. These are delta (1-4 Hz), theta (4-7 Hz), alpha (8-12 Hz), beta (13-30 Hz), and gamma (35+ Hz; see, e.g., Andreassi, 2000). As such, the EEG represents a noninvasive technique to record specific

Figure 1. Showing amplitude, frequency, and coherence of the EEG

![Waveform Diagram](image-url)