CONTINUOUS ELECTROPHYSIOLOGICAL RECORDING

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ABSTRACT

This paper reviews the applicability of electrophysiological registration to problems of human functioning and breakdown in adaptation. It is suggested that physiological measures will be most useful when they allow evaluation of data in absolute (acceptable/non-acceptable) rather than relative terms. It is suggested that sleep and extreme cardiac activation are states which allow such judgements. The variables pertaining to these states are reviewed and it is concluded that both states may be successively monitored even under rather severe field conditions. A combination of the EEG and EOG may be used to indicate sleep intrusions, recognizable as eye closure with increased power (spectral analysis) in the alpha and/or theta bands. Cardiac activation may be indicated by conventional heart rate measures and different kinds of cardiac arrhythmias. It is suggested that recordings are extended outside work hours and that sleep latency tests are used as complements.

INTRODUCTION

The rationale for using physiological parameters in research into health and functioning is, of course, that the physiological state of the individual reveals something about his performance capacity, his health, his environmental load, or about the mechanisms behind changes in performance and health. There is a number of physiological systems which are of interest in this context. One is e.g. endocrine and other measures obtained from body fluids. In this chapter we have, however, elected to treat parameters that allow continuous recording. The reason for this is that the environmental demands fluctuate rapidly, that the functional state of the individual may fluctuate equally rapidly, and that a transient mismatch between them may have very serious consequences in transport operations. Falling asleep when driving does, for example, make up a substantial part of single vehicle road accidents (Harris, 1977).

Using the arousal continuum (Duffy, 1962) for descriptive purposes, we are not as interested in arousal per se, but rather in the extremes where it becomes too low to sustain efficient performance or too high to be compatible with health requirements. Changes in the intermediate section are seldom possible to interpret in absolute terms and may be of less interest in applied studies.

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At the lower end of the arousal continuum our major interest is sleep since this state, by definition, involves non-responsiveness to environmental stimuli as well as cessation of purposeful behavior (Kleitman, 1963), both of which are clearly undesirable during attention-demanding tasks. It should also be borne in mind that transport operations frequently involve irregular work hours and monotonous stimulation, which both lead to reduced alertness (O'Hanlon, 1981; Åkerstedt et al., 1982). Sleep-like states, fatigue and similar concepts have been measured in many different ways (Grandjean, 1979; Wierwille, 1979) but sleep proper is physiologically defined by electroencephalographic (EEG) and electrooculographic (EOG) measurements (Rechtschaffen and Kales, 1968).

At the upper end of the arousal continuum there is not as obvious a choice as the sleep concept and there is a large amount of measures which are of interest (cf. Ursin and Ursin, 1979; Sharit and Salvendy, 1982). Our own preference is electrocardiographic (ECG) parameters since there exist criteria of acceptability both with respect to heart rate (Åstrand and Rodahl, 1970) and heart irregularity (Hinkle et al., 1974) and since cardiac-behavioral relationships have received intensive research attention (Obrist, 1982).

In the following sections we will discuss transport operations and arousal in relation to continuous measurement of the EEG, the EOG, and the ECG.

EEG AND EOG MEASURES

The EEG registers the changes of electrical potentials on the scalp which are considered to represent brain electrical activity (cf. Creutzfeldt, 1976). For clinical EEG:s the international 10-20 system for placing (19) electrodes is frequently used (Jasper, 1958). Early studies and those concerned with sleep (Rechtschaffen and Kales, 1968) may use fewer electrodes. The EEG pattern is often described in terms of its frequency content; 0-3 Hz = delta activity, 3-8 Hz = theta, 8-12 Hz = alpha, 12-30 Hz = beta. This may be evaluated visually but is nowadays also automatically analyzed via e.g. bandpass filtering and subsequent integration of power, zero crossing analysis, autocorrelation, spectral analysis, etc. (cf. Rémon, 1977).