Desynchronization of the alpha rhythm of the EEG as a function of intensity of visual stimulation

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Magnitude and duration of EEG alpha desynchronization were taken as indicators of the orienting response, and the relationship of these measures to intensity of visual stimulation was investigated. The two measures selected were found to vary with stimulus intensity, although each measure exhibited a different trend over stimulus intensity.

The orienting response (OR) may be conceptualized as a rapid fleeting change in arousal level produced by stimuli relevant to the organism's survival value. For the past decade, much research has been devoted to the study of conditions which elicit ORs and the relationship between such conditions and psychological variables such as learning and perception. For example, it has been demonstrated that under conditions which have been shown to produce ORs, both learning (Maltzman & Raskin, 1965; Maltzman & Mandell, 1968) and perception (Sokolov, 1963) are facilitated.

Typically, ORs are signified by a change in some electrophysiological variable [e.g., heart rate (HR), galvanic skin response (GSR), electroencephalographic (EEG) responses] from a "base level" following stimulation. These changes, however, may be described by a number of parameters (e.g., duration, latency, etc.), and it seems reasonable to assume that variation in the OR is indicated by variation in some or all of these parameters. Despite the relatively large amount of research on ORs, data relevant to the relationships between such parameters and the properties of the eliciting stimulus are particularly lacking in the field of electroencephalography.

Desynchronization of alpha rhythm is commonly taken as the EEG OR, providing a number of parameters which may be related to the eliciting stimulus.

Three direct parameters are latency, magnitude, and duration of desynchronization. Other parameters are in use: "alpha index," defined as the percentage of time alpha activity is present (e.g., Eberlin & Yager, 1968; Hermelin & O'Connor, 1968); likelihood measures in terms of number of alpha blocks occurring (e.g., Sayer & Torres, 1966; Esecover et al, 1964); and many measures based on frequency analysis. These are not simple indices, and their use is neither fundamental nor appropriate to the

elucidation of stimulus-response relationships based on discrete stimulation.

Considering these direct parameters in turn, it is necessary to realize that pertinent literature predates the conceptualization of ORs. For example, Jasper & Cruikshank (1936) and Cruikshank (1937) reported on variation in "blocking time" with variation in intensity and duration of light stimulation. Since "blocking time" was defined as the time between the incidence of light on the eye and the dropping out of the alpha potentials, they were, in effect, concerned with the problem of the latency of the OR. However, this data is of limited value, since S numbers were small and no statistical analysis was carried out. It should also be noted that "blocking time," although related to latency of the OR, cannot be considered as its equivalent, since the former measures time from stimulus onset to maximum response (i.e., to completion of desynchronization) instead of to the onset of the response (i.e., to the beginning of amplitude reduction) as required by the latter. Thus the latency of the EEG OR has not been determined; further, the difficulty of specifying response onset precludes the use of this parameter as a measure of the OR.

Various measures of EEG amplitude are available, being originally discussed by Jasper & Cruikshank (1937). While some Es use mean amplitude or voltage (e.g., Surwillo, 1969; Legewie et al, 1969) which is independent of frequency, a measure such as integrated amplitude of the alpha waves (e.g., Burdick, 1968), which includes the effect of any variation in frequency, is perhaps the simplest and best measure of activity in a response possibly varying in both frequency and amplitude. Changes in such amplitude measures would correspond to a measure of the *magnitude* of the EEG OR. No systematic investigation of this measure and its relation to

stimulus intensity has been carried out.

A further parameter of interest, the duration of the EEG response to stimulation, may be regarded as a measure of the *duration* of the OR. This parameter also lacks precise definition in that various criteria have been employed in specifying response offset. For example, Jasper & Cruikshank (1937) took response duration ("recovery time") to be the time between stimulus onset and the reappearance of the alpha rhythm of the EEG. Other criteria such as the time to the return of five alpha waves after stimulation have been employed (e.g., Baumeister et al, 1963), although the present authors consider a return to prestimulus alpha amplitude to be a more acceptable criterion.

The aim of the present study was to investigate the relationship between the intensity of visual stimulation and two of these EEG measures of ORs (magnitude and duration of alpha desynchronization).

SUBJECTS

The Ss were 20 male students from an introductory course in psychology at the University of Sydney. All Ss were between 18 and 25 years of age, and all exhibited an alpha rhythm of at least 20-microV amplitude while resting in the dark with eyes closed. Ss were fitted with silver pad electrodes at O₁, O₂, C₃, C₄, and C_z (Jasper, 1958). Bipolar recordings were obtained between O₁-C₃ and O₂-C₄, the most clearly articulated record being selected for analysis. Recording was carried out on a Grass IID EEG with T.C. = 0.3, paper speed = 3 cm/sec, and pen deflection = 1 cm/100 microV.

APPARATUS

Visual stimulation was produced by a light stimulator, made at the University of Sydney, which emitted diffuse white light through a 10-in.-sq diffuser. The stimulator was attached to a Both interval timer allowing control of stimulus duration. Stimulus presentations were indicated on a separate channel of the EEG record by the operation of a photoelectric cell attached to the input of the EEG.

PROCEDURE

After attachment of recording electrodes, Ss were seated in a sound-reduced cubicle where the diffuser was centrally aligned at Ss' eye level. Ss were instructed to remain relaxed and facing the stimulator with their eyes open during the experiment. Following the instructions, the cubicle was then darkened and 10 min of EEG recording was obtained under conditions of no stimulation.

This period was followed by the presentation of three light stimuli at intensities of 1.30 (I₁), 1.98 (I₂), and

Fig. 1. Percent reduction in alpha magnitude as a function of light intensity.

2.67 (I₃) log fL, each presentation being of 1 sec duration. The three stimuli were presented in a random order and at random intervals between 60 and 120 sec for each S. After presentation of the final stimulus, 3 min of EEG recording was obtained under conditions of no stimulation.

RESULTS

A measure of the amplitude of the alpha rhythm was obtained for each S for each 1-sec period: (1) in the 10 sec immediately preceding the first stimulation period, (2) during stimulation, and (3) in the 20 sec following each stimulus presentation.

The measure consisted of the sum of successive vertical displacements about the mean zero level for the 1-sec period. For each S, the following measures were obtained: (1) percent reduction in alpha amplitude during each stimulus period compared with prestimulus level, and (2) the time taken for the alpha amplitude to return to prestimulus level following each stimulus presentation.

The values so obtained were analyzed for trend over intensity of light stimulation using a repeated measures design. The analysis revealed that change in alpha amplitude at light onset (i.e., the magnitude of the EEG OR) bears a quadratic relationship to

the light intensities employed ($F_{1, 38} = 5.96$, $\alpha = 0.05$), while the recovery time (i.e., duration of the EEG OR) bears a linear relationship to these light intensities ($F_{1, 38} = 31.2$). The mean data are presented graphically in Figs. 1 and 2.

DISCUSSION

The lack of covariation between the two measures considered in this study has important implications. If EEG response parameters may be taken as indicative of OR parameters, then the present results indicate that different relationships may hold between the intensity of the eliciting stimuli and the parameters of ORs associated with such stimuli. For example, it appears that (within the range of stimulus intensities studied) a linear relationship exists between stimulus intensity and OR duration, while a quadratic relationship exists between stimulus intensity and OR magnitude. It is possible, however, that the duration of EEG desynchronization does not constitute a pure measure of the visual OR, since this could be affected by poststimulus events or processes (e.g., afterimages). This possibility is currently under investigation.

REFERENCES

- BAUMEISTER, A. A., SPAIN, C. J., & ELLIS, N. R. A note on alpha block duration in normals and retardates. *American Journal of Mental Deficiency*, 1963, 67, 723-725.
- BURDICK, J. A. Relation of alpha frequency to amplitude variability. *Perceptual & Motor Skills*, 1968, 26, 216.
- CRUIKSHANK, R. M. Human occipital brain potentials as affected by intensity-duration-variables of visual stimulation. *Journal of Experimental Psychology*, 1937, 21, 625-641.
- EBERLIN, P., & YAGER, D. Alpha blocking during visual after-images. *Electroencephalography & Clinical Neurophysiology*, 1968, 25, 23-28.
- ESECOVER, H. B., TORRES, A., TAYLOR, R., WILKENS, B., & MALITZ, S. Contingent alpha blocking and sensitization. *Nature*, 1964, 201, 1247-1248.
- HERMELIN, B., & O'CONNOR, N. Measures of the occipital alpha rhythm in normal, subnormal and autistic children. *British Journal of Psychiatry*, 1968, 114, 603-610.
- JASPER, H. H. Report of the committee on methods of clinical examination in electroencephalography. *Electroencephalography & Clinical Neurophysiology*, 1958, 10, 370-375.
- JASPER, H. H., & CRUIKSHANK, R. M. Variations in blocking time of occipital alpha potential in man as affected by the intensity and duration of light stimulation. *Psychological Bulletin*, 1936, 33, 770.
- JASPER, H. H., & CRUIKSHANK, R. M. Electroencephalography II: Visual stimulation and the after-image as affecting the occipital alpha rhythm. *Journal of General Psychology*, 1937, 17, 29-48.
- LEGWIE, H., SIMONOVA, O., & CREUTZFELDT, O. D. EEG changes during performance of various tasks under open- and closed-eyed conditions. *Electroencephalography & Clinical Neurophysiology*, 1969, 27, 470-479.
- MALTZMAN, I., & MANDELL, M. P. The orienting reflex as a predictor of learning and performance. *Journal of Experimental Research in Personality*, 1968, 3, 99-106.
- MALTZMAN, I., & RASKIN, D. C. Effects of individual differences in the orienting reflex on conditioning and complex processes. *Journal of Experimental Research in Personality*, 1965, 1, 1-16.
- SAYER, K. E., & TORRES, A. A. Effect of anxiety on alpha responsiveness to light stimulation. *Psychological Reports*, 1966, 19, 1143-1146.
- SOKOLOV, E. N. *Perception and the conditioned reflex*. Oxford: Pergamon Press, 1963.
- SURWILLO, W. W. Relationship between EEG activation and reaction time. *Perceptual & Motor Skills*, 1969, 29, 3-7.

Fig. 2. Duration of alpha desynchronization as a function of light intensity.