EEG and vigilance behavior¹

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An attempt was made to relate a physiological index of arousal and a behavioral index to test the arousal theory of vigilance. A visual monitoring task was used and the arousing activity was motor movements between signals. The motor manipulation was found to influence physiological arousal, but not the behavioral measure of monitoring efficiency.

Frankmann & Adams (1962) suggested that the molar concept of behavioral arousal needed to be related to the S at the physiological level. Zuercher (1965) used as a point of departure in studying arousal an experiment conducted by McFarland, Holway, & Hurwich (1942) in which behavioral sources of stimulation were found to facilitate performance. Zuercher introduced exercise and mild stretching between signals and found both to facilitate vigilance performance. Zuercher concluded that complex internal and external stimulation are capable of removing vigilance decrement, as predicted by the arousal theory.

The present study can be considered an historical progression from Zuercher's experiment. Motor movement was the method of stimulation used, and electroencephalogram (EEG) measures were taken to determine the level of physiological arousal. According to arousal theory, EEG desynchronization is correlated with energizing properties of the ascending reticular activating system of the brain, and the behavioral effect should be an increase in performance level. A reduction in the usual vigilance decrement is the expectation.

Method

The vigilance task was punching a button as rapidly as possible to a signal displayed from a small display box, 46 in. in front of the seated S. The signal was defined as a change from the number 30 to the number 70, which lasted for 6 sec. The Multiple Source Vigilance Apparatus (Adams & Boulter, 1962) was utilized with a single stimulus source. Signal presentation and intersignal intervals (ISIs) were programmed by a punched tape and reader. The S's room was illuminated by a 15-W light positioned on the ceiling 6 ft above S, in order that S might have enough light to see the response button in front of him. White noise calibrated to be 73 dB (re .0002 dynes/cm²) was used to mask noises from relays and other sources. The experimental room was also sound treated.

The Reciprocal Detection Latency, or RDL (Webber & Adams, 1964), and integrated EEG alpha rhythm were the measures used. A measure called EEG A was a 6-sec sample obtained immediately prior to

the onset of each signal. EEG B was the measure taken in the 6 sec immediately following cessation of a signal.

EEG recording electrodes were placed at the O₁ and O₂ positions with a ground electrode at the A₂ position (Jasper, 1958). Raw EEG was monitored by an E & M Physiograph "4," while a portion of the signal was tapped from the physiograph's monitor leads and fed into a narrow band-pass filter (Kropfl, Chapman, & Armington, 1962). From the filter the signal was directed to an integrator (Gregg & Holsouser, 1955). All voltage excursions greater than 17 μ V within an 8-12 cps band were defined as alpha rhythm, and integrated over each of the 6-sec sampling epochs.

The Ss participated in a practice session and a criterion session on the same day. The criterion session was the presentation of 25 signals over a 50-min period. Each of the ISIs of 42, 86, 114, 142, and 186 sec was presented once during each of the five 10-min scoring periods that were defined as trials. The order of the ISIs was separately distributed for each of the trials. Two experimental conditions were involved, a motor condition for 15 Ss, and a control condition for 15 Ss. The motor condition was similar to that of Zuercher, and was a series of exercises which E defined and paced over an intercom system. The motor condition was designed to be a source of sensory stimulation to the reticular formation and cortex, which, according to arousal theory, should result in heightened vigilance performance. The exercise occurred during the 186-sec ISI for the motor group.

Results

Physiological arousal during the 6 sec prior to all signals following 186 sec ISIs in which motor movement occurred (EEG A) was averaged for all signals and compared to the average of physiological arousal during the 6 sec immediately following all such signals (EEG B). Figure 1 has these measures, with lower score representing greater arousal. The solid lines have a significant interaction effect ($F = 10.11$, $df = 1/28$, $p < .01$). The main effect between EEG A and EEG B was also significant ($F = 5.63$, $df = 1/28$, $p < .05$). The dashed lines show that the interaction effect did not sustain for other than the 186-sec ISI ($p > .05$), even though the main effect of EEG A vs EEG B showed significantly greater arousal after signals than before ($F = 9.73$, $df = 1/28$, $p < .01$). No significant differences were obtained for the RDL measure which could be related to the physiological

Fig. 1. Course of arousal before and after signal occurrence.

effects observed, although both groups had a significant vigilance decrement over trials for the RDL measure.

Discussion

Mild exercise had effects in the expected direction as shown by Fig. 1, resulting in greater physiological arousal prior to signals following the 186-sec ISIs. The increase in arousal confirms Zuercher's assumption that mild exercise results in cortical activation. The main effects of EEG A and EEG B show that, on the average, arousal was higher after signal occurrence than before. However, the significant interaction effect makes interpretation more complicated.

Relative to the nonmotor condition, the motor group had heightened physiological arousal just prior to the signal following the 186-sec ISI, and which decreased somewhat after the signal had occurred.

The nonmotor control group, however, had a low arousal level before the signal occurred, but the signal itself, being stimulation after a relatively long period of no signal, produced an increase in arousal that is seen as a lower EEG B measure.

That the physiological effect was not paralleled by the behavioral measure is difficult to understand. According to the arousal theory, it is reasonable to expect that activation of the reticular activating system should be evident in all response classes. However, central arousal as measured by EEG may influence visual sensitivity, on which Zuercher's performance measure was based, but not motor systems and their speed, on which the present response latency was based.

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Note

1. This study is based on research submitted in partial fulfillment of the Master of Arts degree at the University of Illinois. The study was supervised by Jack A. Adams.