Occipital alpha activity of high and low visual imagers during problem solving[1]

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This investigation of the relationship between occipital EEG and type of imagery differed from most previous studies in that objective performance and rating measures were used to assess individual differences in visual imagery ability independently of performance on tasks during EEG recording, and in its use of a double-blind procedure. Significant results were obtained which appear contrary to those reported in previous EEG-imagery investigations. The conflicting reports may reflect the influence of methodological variables.

This study, concerned with the relation between EEG activity and mental imagery, is part of a program of research on the role of imagery in verbal learning and behavior (e.g., Paivio, 1965), and possible physiological correlates of imagery (Paivio & Simpson, 1966; Simpson & Paivio, 1966). Many investigations have attempted to relate mental processes to EEG activity and, of these, a number have been concerned specifically with the relation between the occipital EEG and visual imagery. Some investigators (see Golla, Hutton, & Walter, 1943) have reported that an individual's usual mode of thinking is related to his occipital EEG in such a manner that nonverbal visual imagery is associated with a relative absence of alpha waves, whereas habitual verbal thinking correlates with persistent alpha. However, negative findings have been reported by others (see Oswald, 1957). The present investigation of the relation between occipital alpha rhythm and mode of thinking differed from most of the previous studies with respect to two basic methodological variables. First, most investigators have used unspecified and/or ad hoc methods of assessing imagery types. The present study involved instead independent performance and rating measures to assess S's visual imagery "ability." Second, in previous studies the scoring of a S's EEG and assessment of imagery type usually have not been done independently, thus introducing potential experimenter bias. The present investigation corrected for this shortcoming by the use of a double-blind procedure.

Method

The imagery test battery (ITB) consists of a portion of the Minnesota Paper Form Board (Revised Series AA), a multiple choice questionnaire about the method of solution used by S on the Form Board (Barratt, 1953), and a modified version of the Galton Questionnaire (Hyman, 1966). A total visual imagery score resulted from the combined scores on the three subtests of the ITB. Sixty-three male students completed the ITB. Arbitrary cut-off scores of 33 and 20 resulted in two groups of nine Ss each, denoted "high" and "low" imagers, respectively. Ss were coded so that the Es were unaware of the imagery category of any particular S.

The EEGs, recorded on a Grass polygraph, were obtained using bipolar surface electrodes placed on the occipital area. The distance between electrodes was maintained at 4 in. for all Ss. Ss were tested individually in a shielded, sound-deadened room. The S was seated in a reclining chair, and after the EEG electrodes were attached, both Es moved to an adjacent laboratory. During an initial 10 min. period S was instructed to relax and keep his eyes closed. EEGs were taken for a 10 sec. period at the beginning of each min. The initial 10 min. was followed by a 10 sec. period during which S was instructed to keep his eyes open. He was then asked to close his eyes and an EEG was taken for 30 sec. Following this, S was presented a "verbal," then a "visual" problem (see Barratt, 1956), each task being divided into an information and a question phase. The information necessary for solution of the problem was projected on a screen and S was told to memorize the information and say "ready" when he had done so. When S said "ready," he was told to close his eyes and relax. The question based on the information was then given and S was directed to give the answer when he had solved the problem. The verbal problem involved determining the birthday of a fictitious character given certain information about his age in relation to another individual. The visual problem was a figure-construction task, which involved determining the number of triangles that would be formed if specific points in a sequence learned by S were joined in a visualized 5 by 5 matrix. EEGs commenced upon presentation of each question and continued during solution of the problem, including a 30 sec. period after S gave an answer.

Results

To score the EEGs, pen deflection (amplitude) was measured in mm by an assistant who had no knowledge of the purpose of the experiment. Three intervals of 10 pen deflections each were measured on the EEG corresponding to the time during solution of each problem, namely, (a) the first sec. after the question was presented, (b) the sec. before the answer was given, and (c) a 1 sec. interval randomly selected between presentation and answer. The average of the three samples represented the mean EEG amplitude

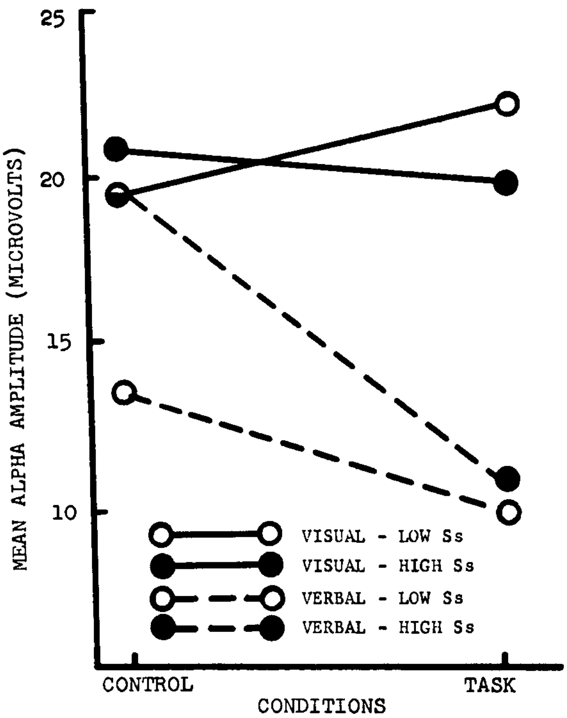

Fig. 1. Mean alpha amplitude of high- and low-imagery Ss during control and experimental periods on visual and verbal problems.

during solution of a problem. Similarly, mean EEG amplitudes were obtained for the 30 sec. "control" periods following the time at which S gave an answer. These data were anlyzed by a 2 by 2 by 2 analysis of variance with imagery type (high versus low), problem type (verbal versus visual), and conditions (task versus control) as variables. The relevant means in μV appear in Fig. 1. The main effect of conditions was significant ($F = 5.56$, $df = 1/16$, $p < .05$) indicating EEG attenuation during solution of the problems. The interaction of problem type with conditions was significant ($F = 6.94$, $df = 1/16$, $p < .05$), the EEG attenuation being greater during the verbal than visual task relative to their respective control conditions. The main effect of imagery type was not significant ($F = 0.09$), but the interaction of imagery type and conditions approached significance ($F = 3.31$, $df = 1/16$, $p < .10$). The high imagers tended to have greater EEG amplitude during the control condition than did the low imagers. The interaction of imagery type with task type and conditions was not significant ($F = 0.17$).

Discussion

The verbal and visual problems of the present study were the same as those used by Barratt (1956), but the results are opposite to his in that Barratt found greater occipital EEG attenuation to the visual task. A cortical specific interpretation (e.g., Golla et al, 1943) of Barratt's results would hold that greater occipital activity, hence greater desynchronization, is involved in the visual than the verbal problem. The results, however, can be interpreted in terms of general activation or arousal (cf., Oswald, 1957). An arousal interpretation of Barratt's finding implies that the visual task was the more difficult one, whereas the EEG data in the present study suggest that the verbal problem was more difficult. This problem was further investigated here by having an independent sample of 104 male Ss do both the verbal and visual problems. The verbal and visual tasks were correctly answered by 49 and 84 Ss, respectively, indicating that the verbal task was more difficult. This finding is consistent with the EEG data and an arousal interpretation of the effects of the cognitive problems involved in the study (cf., Paivio & Simpson, 1966).

The finding that the high imagers had greater EEG amplitude than the low imagers during the control condition (i.e., resting alpha) is contrary to the results reported by Golla et al (1943) who have indicated that visual imagers have little or no resting alpha. The discrepancy presumably is a consequence of procedural differences, particularly in regard to the assessment of imagery type. Considered along with the conflicting reports in the literature, the present findings suggest that no firm statements can yet be made relating modes of thinking to EEG patterns.

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