CLINICAL AND LABORATORY NOTES

AUDITORY DRIVING OBSERVED WITH SCALP ELECTRODES IN NORMAL SUBJECTS

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INTRODUCTION

After the discovery by Adrian and Matthews in 1934 that the resting rhythms of the brain could be built up in amplitude and made to assume the frequency of a flashing light, a large body of experimental work dealt with the use of photic driving in learning research (Livanov and Poliakov 1945), diagnosis of epilepsy and tumors (Loyd-Smith and Henderson 1951), and treatment of depressive psychosis (Ulett 1953). Other studies attempted to obtain auditory driving in the belief that its use might complement, or supplement in some areas, the common use of photic driving. Mainly, these studies showed, in a small number of psychiatric patients, activation of abnormal waves which bore no one-to-one relation to the pure tone intermittent stimulus (Gastaut *et al.* 1949; Goldman 1952; O'Flanagan and Gibson 1951). Still other studies, using implanted electrodes, showed single subcortical spikes in response to individual clicks (Chatrain *et al.* 1960; Sem-Jacobsen *et al.* 1956). To the knowledge of the author, however, the existence of auditory driving of the cortical rhythms themselves remained undetermined.

METHOD

The ten subjects were volunteers, from 17 to 31 years of age, who were normal clinically and had normal EEG records. Bipolar EEG channels were recorded from right fronto-parietal and bilateral parieto-occipital and parieto-temporal leads. The sixth channel recorded twitching of the left eyelid (the subjects' eyes were already closed). A low frequency (75–150 c/sec), high amplitude (120 dB) stimulus of rapid rise time and decline was obtained from a snare drum with the snares removed.

The design of the experiment called for two stimulus periods. One period contained a 40 sec interval of stimulation, followed by 40 sec of rest, at each of four frequencies (the relatively slow frequencies of 3, 4, 6, and 8 beats/sec were used because it was difficult to beat the drum faster). The other period consisted of 4 min of stimulation at 4 beats/sec. The sequence of four frequencies of the one period, and the order of the stimulus periods themselves, were counterbalanced to control for, and to allow a test of, sequence and order effects.

RESULTS AND DISCUSSION

A driving response was seen in all subjects. Analyses of variance and Scheffe t tests of frequency analyser heights showed significant responses at the fundamental of each stimulus frequency and also at second harmonics and second subharmonics of some stimulus frequencies. Other characteristics of auditory driving were: 1. Location of the main response in the auditory cortex of the Sylvian fissure (about $1\frac{1}{2}''$ above, and somewhat anterior to, the top of the ear). 2. Recruitment of response in other areas of the brain (mainly in the occipital lobes). 3. Initial wave of positive potential followed by a more variable negative wave of greater duration. 4. Long latency (0.05–0.10 sec) between a stimulus pulse and response. 5. Smooth wave form and not single spikes. 6. Possible after-discharge. Aside from the location of the main and recruited responses, the above characteristics are similar to those of photic driving (Walter and Walter 1949). Control records were run which made the possibility highly unlikely that the observed response was caused by one of the following artifacts: 1. Tympanic membrane, ear ossicle, or temporal bone vibration. 2. Muscle twitching. 3. EEG amplifier leakage. A rather surprising finding was a predominantly unilateral response in the right hemisphere in three subjects. It was subsequently found that electrode placement was more critical for auditory than for photic driving, so that unequal electrode placement is one possible explanation of the above finding. Another possible explanation is cerebral dominance (all subjects were right handed).

Other results included the following: 1. Analyses of variance and Scheffe t tests showed that length of stimulation, sequence of stimulus frequencies, and order of stimulus periods had no effect on driving. 2. Spearman rho correlations showed no relation between the driving response and resting amplitude at a given frequency. These results are similar to those from photic driving studies (Loyd-Smith and Henderson 1951; Remond 1952; Ulett and Johnson 1958). Although frequency of stimulation was an experimental variable, comparison of responses from one frequency to another was considered tenuous because of reduced loudness in the frequencies that were not easily obtained (6 and 8 beats/sec).

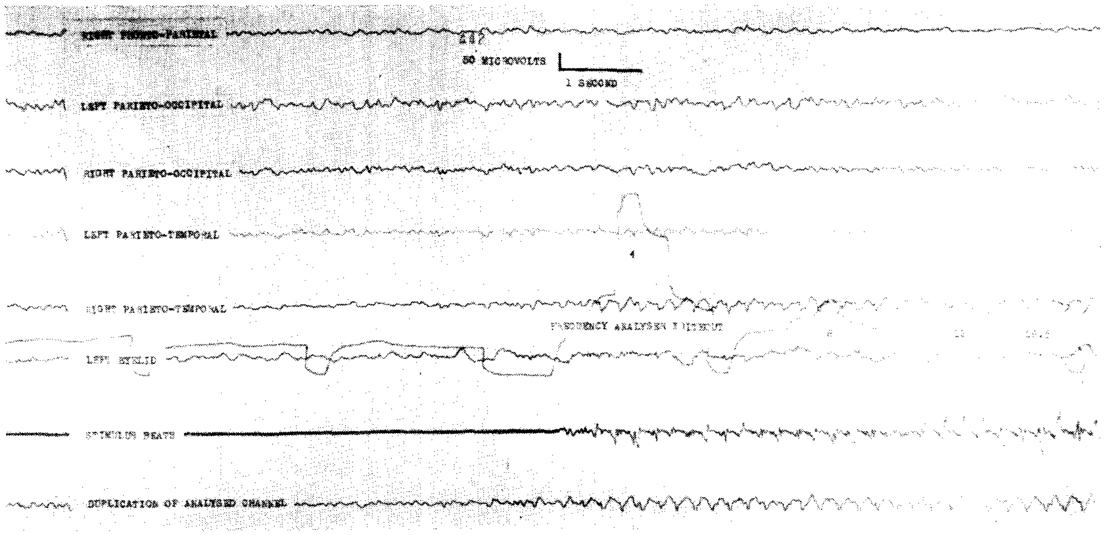

Fig. 1
Subject EW. Response to first stimulation.

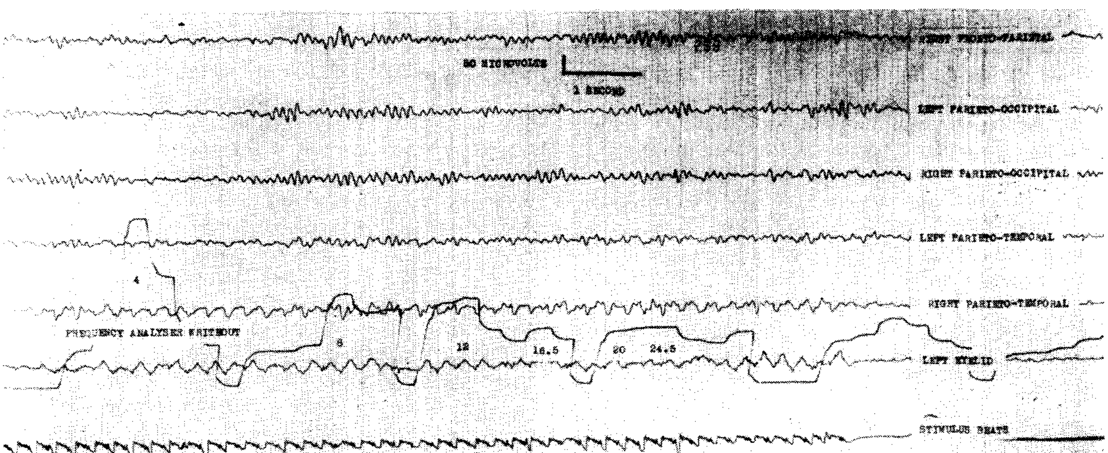

Fig. 2
Subject TR. Driving and eyeblink responses at end of stimulation.

Involuntary eyeblinks, which are usually the first sign of a myoclonic reaction that may spread and lead to a convulsion, occurred in the records of, and were reported as bilateral by, half of the subjects. This is a high proportion compared to results from photic driving (Ulett *et al.* 1955). By Fisher's Exact Probability Test, eyeblink response was shown to occur in those subjects who showed greatest driving. It is interesting that a subject who showed high driving had previously experienced rhythmic eyeblinks from drums beating in a band. Abnormal wave forms, which are seen in about 5 percent of normal subjects under photic driving (Mundy-Castle 1953), were not observed in any of the subjects.

Many of the above characteristics of auditory driving can be seen in the records reproduced here of the two subjects who showed most driving (Fig. 1 and 2). The driving response, eyeblinks, and stimulus beats are all recorded as downward deflections.

The following subjective responses were reported by one or more subjects: fear, astonishment, amusement, back pulsing, muscle tightening, stiffness in chest, tone in background, humming, rattling, visual and auditory imagery. By Fisher's Exact Probability Test, however, none of the subjective responses were related to degree of driving. Except for the absence of sensations of changes in loudness, frequency, and character of the sound, which were precluded by the somewhat irregular stimulus, the above responses are similar to those obtained by Walter and Walter (1949) with photic driving.

CONCLUSIONS AND SUMMARY

The method of obtaining, and some of the characteristics of, auditory driving were given. Points that need further study can be deduced from the results of this experiment. The best uses of auditory driving in psychological research and medicine should be ascertained. Finally the correspondence (which was examined in an unpublished paper by the author) between auditory driving and response to drum beats in primitive dance ceremonies should be investigated in the field.

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