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FINAL TECHNICAL REPORT

*Attention, habituation, & conditioning as related to evoked
brain waves*

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TISIA A

During the period covered by this grant the following tasks were accomplished.

I. Technical Developments.

This year, a number of improvements have been developed in the techniques already used, such as:

a) Magnetic tape recording of stimulation plans. The use of positive and negative pulses described in the previous report proved to be ineffective, so a pulse-modulation technique has been developed; also, a simple endless-loop device was worked out;

b) Magnetic tape recording of EEG. A pulse frequency-modulation technique was tested, consisting of a modified stimulator (Grass or Tektronix) as a recording modulator, followed by a very simple detection scheme involving injection of recorded train of pulses on to the ink-writing galvanometer.

II. Results

A. Experiments in man.

Experiments were carried out under the same conditions and with the same methods as described in the final technical report corresponding to the 1961-1962 period.

Changes in the visual evoked response.

1. Attention. Changes in the attentional state provoked modifications in the amplitude and constitution of the visual evoked response (VER). When the subject paid greater attention to the photic stimulus -center of the stimuli, observation as to

whether any change in frequency or intensity is perceived- VER amplitude increased. In every single case this effect upon amplitude did not persist beyond the attentional fixation period.

This VER change is elicitable even when the subject is habituated or at different levels of habituation. When the subject was habituated, any change in the intensity or frequency of the photic stimulus or the presence of an extra-stimulus of an identical or different pattern, provoked a VER increase (dishabituation).

The repetitive nature of VER was modified by changes in attention. In some cases it was possible to establish the temporal coincidence of the second response with the perception of the first positive afterimage. This connection seems to be very close since a very selective attention is required for the perception of the afterimage. It was precisely when the subjects paid marked attention that the repetitive response was developed. On the other hand, during distraction and habituation the VER tended to become simple, its late components disappearing, that is, VER was multiple during attention and less complex during inattention.

2. Conditioning. Time-conditioning and sensory conditioning.

a) Time conditioning. Once VER habituation is obtained through continuous intermittent photic stimulation, the photic stimuli (unconditioned stim.) were discontinued during regular, constant periods (darkness, conditioned stim.). In this fashion dishabituation was provoked after 2 or 3 trials; this was accompanied by an increase in VER amplitude, which re-assumed the characteristics it showed prior to habituation. With the same light-darkness association, following 10-15 trials, VER amplitude decreased once

again.

During continuous intermittent photic stimulation the subjects stated that their attention diminished. Following discontinuous photic stimulation and after the first interruption of the flashes, they believed that the experiment had finished. However, following few presentations, they realized that after a constant period of darkness, the flashes always reappeared and as a result their attention toward them increased. With repetition of the light-darkness trials, attention again decreased.

b) Sensory conditioning. A tone delivered in the darkness period during discontinuous intermittent photic stimulation also provoked VER changes. When, after obtaining habituation to light-darkness, the tone-light association was presented, responses increased in amplitude (dishabituation) following 3 to 8 presentations. This increase was always conspicuous and at times exceeded the amplitude preceding habituation. This dishabituation was more recurring and inconstant than that obtained with the light-darkness association. The presence of a tone at the beginning of the darkness period (light-tone association) resulted in modifications comparable with the tone-light association, although both less important and less inconstant.

The increase in VER amplitude elicited with the light-tone and tone-light associations persisted over several trials but amplitude rapidly diminished when the tone was discontinued (extinction).

When the photic stimulus acted as an unconditioned stimulus

(tone-light association) changes in the response were greater than when it acted as a conditioned stimulus (light-tone association). In other words, the unconditioned VER changes were more important than those observed in the conditioned VER.

The subjects submitted to the tone-light association stated that following several trials they realized that the tone was always followed by a series of flashes. Hence, when they began to hear the tone they were already "prepared" to see the light and therefore paid more attention to it. Conversely, the light-tone association had the same effects upon attention to sound, while effects upon attention to light were, on the other hand, variable.

c) Topographic changes. In both types of conditioning, changes were likewise observed in the topographic distribution of VER. With the succession of trials, the amplitude of the response recorded outside the occipital region increased more significantly than it did in this region.

Observations described in items 1, 2 and 3 bear out the important role paid by attention in the process determining the adequation of sensory inflow to existing requirements or to the interest of the situation prevailing. They also show how during positive attention a selectivity of the sensory field becomes established as a result of the interaction of the following factors: 1) facilitation of the corresponding sensory channel or channels; 2) inhibition of the useless channels. The increase in VER amplitude constitutes the electrophysiologic expression

of such a facilitation. On the other hand, negative attention or inattention is reflected by block of the stimuli and as a result, by an inhibition of the useless channels and by a consequent VER amplitude decrease. Changes in VER amplitude, provoked by conditioning, are similar to those observed in man during voluntary attention and opposed to those resulting from habituation and distraction. They might be regarded as the result of an increase of attention toward the conditioned stimulus.

3. Changes in EEG background activity.

Continuous intermittent auditory stimulation at a frequency of 1/sec had in almost every subject a definite hypnagogic effect. This effect was accompanied by changes in EEG background activity. With the onset of stimulation there appeared in some cases a short-enduring blocking reaction which disappeared a few seconds later. As the stimulation progressed the alpha rhythm was replaced by the rhythms characteristic of natural sleep. The levels attained were not the same in every case; their depth varying even in one identical subject. In none was level D attained, levels B and C being the most frequent. The "spontaneous" oscillations of this audiogenic sleep were a prevalent feature. During continuous intermittent auditory stimulation, in some subjects these oscillations were so pronounced that at times they involved a shift from sleep to wakefulness.

Interruption of continuous intermittent auditory stimulation provoked different effects: 1) an arousal reaction with the presence of an alpha rhythm in a group of sleeping subjects; 2) a blocking reaction in wakeful subjects; 3) in another group, EEG background activity underwent no variations. During discontinuous

auditory stimulation, i.e., the association of intermittent clicks with a period of silence, background activity changes were different. In few cases was the hypnagogic effect evident. In most, a succession of alpha rhythms and blocking reaction became established. The latter -which developed with the silence- gradually diminished in duration until it disappeared with the increase of trials.

B. Experiments in guinea pigs.

Variations of cochlear microphonics and auditory nerve action potentials during distraction and habituation were studied.

Twenty-five guinea-pigs were implanted with permanent electrodes near the round window. In ten the middle-ear ossicles were removed. In 20 animals, a short polyethylene tube of 0.40" internal diameter was implanted into the middle-ear. Habituation was provoked by auditory stimulation. Clicks and tone pips were delivered to the unrestrained, awake animal, by means of loud-speakers or a deaf-aid earphone connected to the middle-ear polyethylene tube. Distraction and dishabituation were obtained either by photic or by electrical stimulation.

Potentials were recorded by means of a tape-recorder monitored with a CRO and processed afterwards by the photo-optico-electronic averaging method.

During continuous intermittent auditory stimulation progressive changes in the amplitude of the auditory nerve action potentials and cochlear microphonics were observed. Within the first 3-4 minutes an increase of both responses was observed in most cases. If the animal was then distracted by a photic or electric

stimulus, a waning in auditory nerve action potentials and cochlear microphonics could be seen. With progression of the auditory stimulation the amplitude of the auditory nerve action potentials and cochlear microphonics decrease constantly in a waxing and waning fashion. When the animal was habituated a photic or electric stimulus produced an increase of the auditory nerve action potential and cochlear microphonics (dishabituation).

In the animals without the middle-ear ossicles the same results were observed. Increase in responses was also elicitable by associating each pip or click with an electric stimulus.

The foregoing experiments show that centrifugal regulation is also present at the receptor cell level.

The persistence of the above changes, after ablation of the middle-ear ossicles, demonstrates that the prereceptor elements do not play an important role in this regulation. These results are in accordance with those described for the visual function in man.

III. Papers

A. Published.

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B. In press.

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C. Under preparation.

García-Austt, E., Bogacz, J. and Vanzulli, A.- Evoked responses in man. IV. Influence of attention on photic responses.

Handler, P.- A "duplex" technique for magnetic tape recording.

Handler, P.- Some improving modifications of the Tektronix 502 oscilloscope.