Studies on the visual evoked response.

II. The effect of special cortical activity

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Studies have been made on the influence of stimulus through another modality on the visual evoked response. The solution of simple (single digit, three operation) arithmetic problems caused a decrease in VER. The use of equal area, transilluminated letter stimuli with an associated button pushing task, maximized the VER and made it most constant.

In a previous report we described how the state of attention of the subject was an important factor in determining the amplitude of the visual evoked response (VER). Stabilization of the response is an obvious desideratum in any attempt at studying the visual system with the aid of the VER. The present report deals with attempts to stabilize the VER by achieving a constant level of attention. The approach to this objective was by giving the subject a set of mental tasks requiring a response. In one set of experiments this task was presented audibly from a tape recorder. In the other set of experiments the task was incorporated in the visual stimulus.

Experimental

Methods. The VER was recorded in normal human subjects via scalp electrodes, Offner-Beckman chopper-type amplifiers, and a computer of average transients (Mnemotron CAT) as described previously. In the first set of experiments where the task was presented aurally, a series of simple arithmetic problems was presented to the subject via an inexpensive tape recorder and single earphone. Each problem involved two arithmetical operations—either addition, subtraction, multiplication, or division, or combinations of these. A series of four possible answers was presented slowly after each problem presentation and the subject was instructed to press a signal button when the correct answer was presented. At this stage of apparatus development the signal button caused a light to flash in the view of the operator. No attempt was made to record numbers or correctness of responses, although this could have been done easily by using audio markers in the second channel of the tape recorder coupled in coincidence with the push button to an electronic counter. Light stimuli for these experiments were identical with those used previously. Needless to say, the audible material was purposely out of synchronization with the visual presentation.

The second set of experiments involved no auditory input. Instead the electronic flash was allowed to shine through a filter, if required, and then through a series of single transparent letters, a different letter presented at each flash. The letters were constructed to have identical transparent areas and were constructed on a unit rectangle.
Fig. 1. Apparatus for presentation of transilluminated characters. A, stepping relay; B, disc bearing characters; and C, electronic flash lamp.

of 2.5 by 3.5 mm. The letters were drawn with India ink and photographed on high contrast process film. Forty letters in negative were cut out and cemented to apertures in an opaque wheel attached to the shaft of a forty position rotary stepping relay. This 115 v. device was actuated by an ordinary double pole, double throw relay which was in turn actuated by a pulse from a Tektronix pulse generator.* For these experiments two pulse generators were fired by a single Tektronix waveform generator set at a repetition rate of one cycle per second. The first pulse generator was set to fire early in the cycle and the second to fire late in the cycle, so that the spacing between them was greater than 500 msec. The first pulse was used to fire the electronic flash stimulus. The second actuated the two relays and positioned

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*In later experiments a seventy-two position disc was used and was driven by a precision stepping motor. (Superior Electric Slo-Syn motor and translator, Allied Electronics, Chicago, Ill.)

Fig. 2. Variation of VER with repetition, actual traces. Stimulus: 0.06 degree and 685 mμ; lead: P-O (international convention); subject A.
a new letter in the aperture before the flash source. This apparatus is illustrated in Fig. 1. Since analysis time of the CAT was set at 500 msec., the letter change occurred during computer dead time, and the electrical noise from the relays was not recorded. Audible noise was minimized by enclosing the relays in a box. Since the tiny residual audible noise in this set of experiments was in fixed time relationship to the light stimulus, controls were run with the light aperture obstructed by an opaque slide to ascertain whether any auditory evoked response was being recorded. This was found not to be the case.

All of the letters of the alphabet were not used, and with 40 positions a number of letters could be repeated. The subject was instructed to press the signal button as soon as a particular letter was seen. As before, the button illuminated a signal light. It should be understood that here both the stimulus and the task were visual and both were incorporated in the retroilluminated letter. In all experiments reported here, 200 responses were summed by the computer.

**Results.** As in the previous paper, results are presented as direct tracings of original records. Here, too, in the interest of space economy, records are placed one above the other, so that each establishes its own base line. The abscissa time scale is the same for all tracings.

In our previous report we showed how somnolence drastically reduced the VER (Fig. 6). Here we are able to demonstrate how amplitude of VER in a normal cooperative subject is reduced with successive repetitions over a 50 minute test period (Fig. 1); Fig. 2 shows the actual records; Fig. 3 shows the variation of total negative to positive amplitude in the nine trials. The effect of the aurally presented task is shown in Figs. 4 and 5 for each of 2 subjects. In most of the instances presented the response during the audible task was smaller in amplitude than without the task. In Fig. 6, A and B the comparison of three auditory task trials and three control trials for each of 8 subjects is shown.

**Fig. 3.** Variation of VER with repetition—maximum amplitude versus time (number of trials).

**Fig. 4.** Effect of aurally presented task on VER. Subject A, multiple trials. Stimulus: 0.06 degree and 685 μ. Solid lines = control (no task); broken lines = task presented. Lead P-O.
Here, too, the response during the auditory task seems diminished.

In Figs. 7A and 7B the response to a spot during arithmetic problem solving is compared to the response to a letter stimulus of same area as the spot. In the latter case the task consists of pushing a signal button at the appearance of a specific letter. Multiple trials are presented of each of 7 subjects. In every case but one the response to the visually presented task is clearly greater. Only in the case of Subject H the two presentations caused an equal response.

In Fig. 8 the retroilluminated letter response is compared to the response from a circular spot of equal area. The relative response size appears to vary with the subject, and for two of our subjects the response to the letters is greater than that to the spot.

In another series of trials (Fig. 9) Subject J, who showed a poorer response to the letters than to the spot, now showed a better response to the letters than to even a 0.6 degree spot with some four times the equivalent light energy. The response of a second subject to the letter stimulus was at least as good as to the 0.6 degree spot.

Discussion
In this series of experiments it was our prime objective to maximize and make constant the VER to a given stimulus. Our object at present is not to study the psychology of attention but to study the effect of varying physical and physiological...
Fig. 6. A: Effect of auditory presented task on VER. Subjects A, B, C, and D; three trials of task versus three control trials. Stimulus: 0.60 degree red target. (1) A, three trials without task, and B, three trials with task. Leads P-O for subjects C, B, and A, lead A-O for the other. B: As in Fig. 6. A. Subjects E, F, G, and H.
Fig. 7A. Comparison of aurally presented task versus visually presented task. Subjects J, K, H, and F. A, stimulus: retroilluminated letter; task: button pressing at specific letter. B, stimulus: round spot of area equal to letter of A; task: button pressing at correct answer to arithmetic problem presented aurally.

quantities on the VER. In the early part of this work we were unduly influenced by the report of Davis whose auditory discrimination task enhanced the VER.

The response of our subjects to the aurally presented arithmetic problems was much more like the distraction effects which decreased the VER produced by other authors. Hernández-Peón and co-workers showed that in cats with electrodes implanted in optic tract, lateral geniculate body, visual cortex, or dorsal cochlear nucleus stimulation via a second modality lessened response to the primary modality. Similar results were obtained via implanted electrodes in humans. More recently similar results were obtained in man with scalp electrodes and a photo-
A recent reperusal of the paper by van Balen and Henkes reminded us that these authors used an unspecified auditory stimulus for distraction and used optotypes displayed during the flash to obtain attention. It should be emphasized that the auditory stimulus used by us required continued cerebration after its presentation. The visual stimulus used by van Balen and Henkes was a 6.66 degree target with the optotypes related to the stimulus in an unstated manner. In our case, the optotype was the stimulus and subtended 0.025 degree on its longest diagonal stimulating only the fovea. Despite these significant differences in experimental technique and consequent differences in latency and configuration of response, it is of great interest...
to note the general similarity of conclusions.

Of significance is the method reported above by us which allows the desired maximizing of response. The stimulus of letter recognition is much greater than that of counting flashes and makes for longer periods of uniform response. The equipment is relatively uncomplicated in relation to the total equipment needed and requires relatively little special construction. Needless to say, any figure may be substituted for the transilluminated letter, and shape variants may be studied in this way. Work continues along these lines.

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REFERENCES


