# The effects of auditory stimulation on phosphene sensitivity [1]

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*Detection thresholds for phosphenes were measured in the presence and absence of moderate auditory stimulation. Thresholds were consistently lower in the presence of a 60 dB, 3000 Hz. tone for all 19 Ss tested. Large variations in threshold levels were noted among the Ss.*

The purpose of the present study was to devise a method for measuring the effects of concurrent heteromodal stimulation on visual sensitivity. Reviews of the literature reveal that direct inferences concerning the effects of auditory stimulation on the sensitivity of the visual system cannot be made because of complexities both in the stimuli chosen and in the experimental design (Gilbert, 1941; Ryan, 1940). Part of the difficulty stems from the use of the term "visual sensitivity" without qualification when it is not referring to sensitivity to intensitive variations in luminous flux. For example, three references were cited in a recent study of visual-audio interaction which "...have confirmed that the presence of sound improves visual sensitivity" (Sheridan et al, 1966). The three sensitivity measures were acuity thresholds, recognition thresholds and degree of "contralateral relationship" between seeing and hearing. None of these studies indicate that simple photosensitivity was affected by the presence of sound. The manipulations in these and earlier intersensory experiments involve so many higher order variables of perception that the isolation of stimuli which may facilitate or inhibit the visual system is not possible.

The present study was restricted to investigating the effects of pure tone stimulation on sensitivity to intensity variations in the stimulus, i.e., absolute thresholds for visual sensations were obtained. Since this was to be the first of a series of experiments designed to parcel out dimensions of vision which are sensitive to heteromodal stimulation, we chose the most basic form of stimulation available to us: low amplitude alternating current applied directly to the peripheral visual system through forehead and temporal electrodes. The resulting sensations have been termed "phosphenes" and are characterized as a flickering in the periphery of the visual field at threshold. Photic stimulation may or may not accompany the electrical stimulation. If it does, the phosphene effect is a modulation of what is seen. Thus, the sensations produced are not attributable to variations in photic stimulation and are perhaps minimally affected by visual perceptual variables. It was assumed that the least complex and most "central" forms of heteromodal stimulation would be least likely to obscure interactive effects. Tests of the limits of this assumption which would involve direct and diffuse cortical stimulation of the sensory areas was not feasible, nor was electrical stimulation of the peripheral auditory structures.

## Method

Nineteen Ss (14 male and five female) between the ages of 18 and 24 were used. They were seated 3 ft. from a dimly illuminated (0.2 log ft.-L) wall and told to fixate a cross which was directly ahead and 32-1/2 in. from the floor. Peripheral photic stimulation was provided by a $2^{o}$ square of light (1.6 log ft.-L) $27^{o}$ to the left of the fixation point. These conditions were chosen by trial and error and resulted in lower phosphene thresholds than in total darkness. Illumination was held constant throughout the experiment. Clearly supra threshold phosphenes were reported as flickering sensations in the entire visual field with accentuation in the periphery. Closer to threshold, only peripheral sensations were reported.

A Hewlett Packard model 200 AB oscillator was used to provide a 20 Hz stimulating current administered through a pair of Beckman bipolar electrodes. One electrode was taped to the left temple and the other to the center of the forehead. Large current limiting resistors (150-560k$\Omega$) between the S and the oscillator reduced the variability in current due to resistance changes in the S. For two Ss the resistance had to be lowered to 56k $\Omega$ in order to reach threshold.

Another oscillator (Hewlett Packard model 200 CD) and a pair of Grason-Stadler model 39 earphones provided a 3000 Hz tone at 60 dB re 0.0002 dynes/cm$^2$. The tone was presented during half of the 40 trials in an ABBA sequence of blocks of 10 trials (nine Ss) or a BAAB sequence (10 Ss). Five min. rests were given between the blocks of 10 trials. The onset of the tone also served as a warning signal before E gradually increased the stimulation current until the S indicated that the threshold had been reached by saying "now." Descending trials, in which the S reported the absence of the phosphene, alternated with ascending trials. In the absence of the tone, a verbal warning signal was given. E read a vacuum tube voltmeter placed across the fixed resistance in the circuit. During the last six sessions of the experiment, the voltmeter was located in another cubicle and read by an assistant who was naive regarding the procedure and purpose of the study.

## Results and Discussion

Phosphene thresholds were lower in the presence

**Table 1. Means for the 10 Threshold Measurements for each S**

Thresholds are in microamperes.

| S | A tone off | B tone on | B tone on | A tone off | S | B tone on | A tone off | A tone off | B tone on |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 22.5 | 15.2 | 15.6 | 19.3 | 2 | 70.8 | 77.8 | 72.1 | 66.9 |
| 3 | 17.0 | 15.0 | 13.5 | 15.8 | 4 | 41.0 | 48.4 | 52.6 | 47.7 |
| 5 | 143.6 | 136.3 | 138.4 | 198.5 | 6 | 62.2 | 68.2 | 72.5 | 60.5 |
| 7 | 175.2 | 152.4 | 146.8 | 172.8 | 8 | 108.3 | 125.1 | 117.5 | 119.3 |
| 9 | 33.1 | 28.8 | 28.0 | 30.5 | 10 | 36.1 | 37.2 | 38.9 | 36.5 |
| 11 | 35.1 | 29.3 | 32.5 | 37.6 | 12 | 41.9 | 45.9 | 53.7 | 48.2 |
| 13* | 33.9 | 18.4 | 17.0 | 16.2 | 14 | 49.9 | 51.2 | 53.0 | 45.5 |
| 15* | 49.5 | 25.1 | 27.0 | 28.1 | 16* | 88.6 | 79.3 | 89.7 | 61.8 |
| 17* | 27.1 | 21.8 | 21.8 | 23.0 | 18* | 80.3 | 115.6 | 116.8 | 104.8 |
| | -- | -- | -- | -- | 19* | 28.8 | 28.2 | 29.5 | 22.3 |
| Means | 59.7 | 49.1 | 49.0 | 60.2 | | 60.8 | 67.7 | 69.6 | 61.4 |
| SD | 19.5 | 18.1 | 17.8 | 23.9 | | 8.2 | 10.3 | 9.7 | 9.7 |
| Grand Means | Tone on, 55.1; tone off, 64.3. | | | | | | | | |

* *measurements recorded by an experimentally naive assistant from another room.*

of the tone than in quiet for all 19 Ss. Table 1 shows that the mean stimulation amplitude at threshold was 9.2 μA greater in the quiet condition, and no individuals reversed this relationship. Since there was no overlap in the data, no statistical tests were performed. Various aspects of our results corroborated earlier findings. Our first attempts at determining thresholds were beset with the same difficulties described by Motokowa (1958). In total darkness untrained Ss found it very difficult to discriminate electrical phosphenes from the "gray light" of the retina and often gave reversals within a trial. Reversals were almost eliminated by providing a combination of photic and electrical stimulation. The large variability of the baseline thresholds among different individuals is typical of past studies (Clausen, 1959). This may be attributable to variations in the resistivity of the tissue and bony pathways to the excitable structures rather than to large differences in the excitability of the structures themselves. No sex differences in the magnitude of the heteromodal effect nor in the absolute threshold levels were apparent.

Even though the exact mechanism of phosphene production is unknown, the present results suggest that their threshold levels can serve as useful indicators of sensitivity shifts in the visual system which may be a function of other stimulation. It will be of interest to determine which among the modalities other than audition produce similar intersensory effects, or if indeed these effects can be appropriately termed intersensory rather than attentional. Thus far the onset rate of the secondary stimulus has not been systematically varied, and it is difficult to compare the arousal effect of the stimulus versus the verbal ready signal in the control condition. The effects of auditory stimulation on diffuse photically produced thresholds for vision will be the object of a future study in this series of experiments.

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## Notes


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