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Retinal influences upon the trace phenomenon

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These experiments were designed to determine whether the threshold of the trace phenomenon (the streak of light that is observed when a light is moved rapidly within the field of vision) could be influenced by the adaptation conditions of the retina and/or the nature or locus of the imposed stimulus. The experiments employed a rotating light stimulus, the speed of which could be systematically varied and accurately determined. In Experiment 1 it was predicted that the trace threshold would vary as a function of dark adaptation and stimulus intensity, in Experiment 2 it was predicted that the threshold would vary as a function of dark adaptation and stimulus locus, and in Experiment 3 it was predicted that the threshold would vary as a function of color adaptation and stimulus color. None of the predictions were supported. It was concluded that the trace phenomenon is probably due to central cortical activity rather than to peripheral processes within the retina.

These experiments were designed to determine whether the adaptation conditions of the retina and/or the nature of the visual stimulus can affect the trace threshold. The trace phenomenon has been observed by almost everyone, although most people may have paid little attention to it. At night, if a sparkler or a firebrand is whirled or moved back and forth rapidly, a streak of light may be observed. What causes this streak or trace? The authors hypothesized that this trace is due to perseverating processes in the photochemistry of receptors in the retina. If this hypothesis is correct, varying the adaptation conditions of the retina and the nature of the imposed stimulus should affect the trace threshold. On the other hand, if the trace is solely due to some central process within the cortex, as hypothesized by Vitenzon (1956), the peripheral conditions of the retina should have no influence on the trace threshold.

Vitenzon (1956) established that several depressant drugs, insufficient sleep, and brain damage all can function as cortical inhibitors in depressing the trace reaction. He concluded that "successive induction in the cortex is the main physiological mechanism involved in the course of the visual trace phenomenon" (Vitenzon, 1956, p. 225).

Hypotheses

The overall prediction was that the threshold of the trace phenomenon could be significantly influenced by varying the adaptation conditions of the retina and/or the nature of the stimulus. In Experiment 1 it was predicted that the trace threshold would vary as a function of dark adaptation and stimulus intensity, in Experiment 2 it was predicted that the threshold would vary as a function of dark adaptation and stimulus locus, and in Experiment 3 it was predicted that the threshold would vary as a function of color adaptation and stimulus color.

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METHOD

Subjects

In both Experiments 1 and 2, 24 subjects were used. In each experiment, subjects were divided into three groups of eight, half males and half females. In Experiment 3, 16 subjects were divided into two groups of 8, half males and half females. All subjects were undergraduate students at DePauw University. All were screened for corrected or normal 20/20 vision.

Apparatus

The trace apparatus consisted of a motor, to which a 2-ft metal rod with a bulb at the end was attached. The speed of stimulus rotation was controlled with a Variac, and in Experiments 1 and 2 the speed of rotation was determined by a voltmeter connected in series between the Variac and the motor. In Experiment 3 the speed of rotation was determined by a tachometer attached to the shaft of the motor.

The trace apparatus was concealed behind a screen that was painted dull black to minimize glare. A rectangular area (19 in. high by 29 in. wide) was cut in the screen, so that subjects were able to see only the top half of each rotation cycle. All subjects sat 10 ft from the screen. All experiments were performed in a photography darkroom that was 15 ft square with walls and ceiling painted dull black.

Procedure

Adaptation treatment. The subjects in all experiments were brought into the test room individually, seated in a chair, and given the following instructions: "We want you to participate in a psychology experiment. We will not attempt to trick you in any manner, and no pain will be involved. We will now give you 15 min to rest, during which time your eyes will become adjusted to the light in the room. You are to remain seated and should relax as much as possible."

Each of the three groups in Experiment 1 was adapted for 15 min in different intensities of ambient light—dim (25 W), medium (100 W), and bright (200 W)—located 4 ft above the subject's head. The three groups in Experiment 2 were also adapted in three levels of ambient-light intensity—dark (no light at all), medium (100 W), and bright (200 W)—located 4 ft above the subject's head. The two groups in Experiment 3 were adapted to two different-colored ambient lights, provided by

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red and blue 150-W bulbs located 4 ft above the subject's head.

After the 15-min adaptation period, each subject was told the following: "We are now ready to begin the experiment. Your job is to look through the rectangular opening there in front of you and to focus on a moving light stimulus that will appear in that opening. Sometimes you will see a moving dot of light turn into a streak, and sometimes you will see a streak of light turn into a moving dot. We want you to tell us exactly when the dot becomes a streak and when the streak becomes a dot. We will now demonstrate this to you. See the dot of light moving faster? Just about now it will turn into a streak. See? Now watch the streak. Just about now it will turn into a moving dot. It is your job to say NOW when you see the dot turn into a streak or the streak turn into a dot. Are there any questions?" These familiarization trials were run under the test conditions (see below) experienced by each group.

Test trials. All trials for all groups were separated by 30-sec intervals. All stimulus bulbs regardless of wattage and color (see below) were masked by black tape, except for the central .25-in.-diam portion.

The three groups in Experiment 1 were tested in the same ambient-light intensities in which they had been adapted: dim, medium, and bright. Each group was also tested with different levels of stimulus intensity (provided by three different-wattage—5-, 7.5-, and 10-W—opaque bulbs). Thus, each subject received 18 trials, 6 at each stimulus intensity, 3 ascending and 3 descending. Both stimulus intensity and direction of presentation were presented randomly.

The three groups in Experiment 2 were also tested in the same ambient-light intensities in which they had been adapted: dark, medium, and bright. The stimulus was held constant at medium (7.5-W opaque bulb). A total of 12 randomly presented trials, half foveal and half peripheral, half ascending and half descending, were given to each subject. (Peripheral exposure was obtained by having the subject view the rotating stimulus out of the corner of his eye while fixating on a white dot 45 deg to the left of the motor shaft.)

The two groups in Experiment 3 were tested in the same-color ambient light to which they had been adapted: red or blue. Each subject was given a total of 16 randomly presented trials, half ascending and half descending, half with a 7.5-W blue stimulus light and half with a 7.5-W red stimulus light.

RESULTS

The most notable finding of the three experiments was the consistency of the negative results. Neither the adaptation conditions nor the nature of the stimulation had any significant influence on the trace threshold; indeed, hardly any discernible trends were present in the data.

In Experiment 1 the F ratio for light adaptation was .40; for stimulus intensity, it was .52; and for the interaction between light adaptation and stimulus intensity, it was .10. In Experiment 2 the F ratio for peripheral vs. foveal stimulation was .03; for levels of adaptation, it was 1.7; and for the interaction between locus of stimulation and level of adaptation, it was .18. In Experiment 3 the F ratio for red vs. green adaptation was .01; for stimulus color, it was .44; and for the interaction between stimulus color and ambient color, it was .85.

Although all the results were negative, their consistency suggests that the processes that account for the trace phenomenon are central rather than peripheral. As such, they are in agreement with the findings of Vitenzon (1956).

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