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Attentional Factors in the Inhibition of a Reflex by a Visual Stimulus

Abstract. *A brief stimulus presented to various regions of the visual field inhibited the eyeblink elicited by a subsequent tap to the skin between the eyebrows. Subjects were able to switch their attention toward or away from the target area without moving their eyes. In doing so they changed the amount of inhibition.*

More than a century ago, Helmholtz noted the "curious fact" that by mere conscious effort one can focus attention on any portion of the visual field and that the process "is entirely independent of the position and accommodation of the eyes" (*1*). According to Helmholtz, an observer might be gazing at a fixation point while at the same time concentrating on some other part of the visual field. If, at this moment, a stimulus is presented briefly, the observer's impression of its features in the attended region will be markedly enhanced.

We wondered whether a reflex-modification procedure could be used to study the attentional phenomenon that Helmholtz described. Reflex-modification describes the finding that almost any sensory event presented prior to a reflex-eliciting signal can, given an appropriate lead interval, inhibit the reflex so that it either fails to occur or occurs with reduced amplitude (*2, 3*). We asked if the amount of reflex inhibition engendered by a brief visual stimulus would vary as a function of its location in the visual field and if this amount would change when subjects were told where the stimulus would appear.

In these experiments, the target response was the reflexive eyeblink elicited by a brisk tap to the glabella (the flattened region between the eyebrows), and the reflex-modifying stimulus was a brief (50-msec) spot of light presented 150 msec before the tap. The spot of light subtended a visual angle of 2° and had a brightness of 5.38 μL, a value that was near but clearly above the threshold for its detection.

The devices for eliciting and measuring the eyeblink have been described elsewhere (*3*). Briefly, they consisted of a miniature solenoid and a d'Arsonval meter, the pointer of which was connected to a length of polyethylene tubing fastened to the left eyelid with a small piece of micropore tape. Both units were attached to a lightweight headband and were positioned so that activation of the solenoid (15 V d-c for 30 msec) caused a silicone rubber ball (5 mm in diameter) to strike the glabella. The resulting eyeblink caused the meter coil to move through a magnetic field, generating a voltage that was amplified and displayed on a storage oscilloscope. Visual stimuli were produced by briefly illuminating a grain-of-wheat bulb mounted behind a neutral density filter fastened to the cursor of a standard perimeter. The track on which the cursor rode girded a black, fiberboard half cylinder (radius, 28 cm) having a series of 1-cm (diameter) holes along the horizontal meridian at 0° (the foveal location) and 20°, 40°, 60°, and 80° in both the nasal and temporal fields. Translucent plastic covered each hole so that the subject could not tell where the cursor was and hence where the flash might appear. Just above 0° were two additional holes; behind one was an infrared light source and behind the other was the telescopic lens of an infrared television camera used to monitor the subject's direction of gaze (*4*).

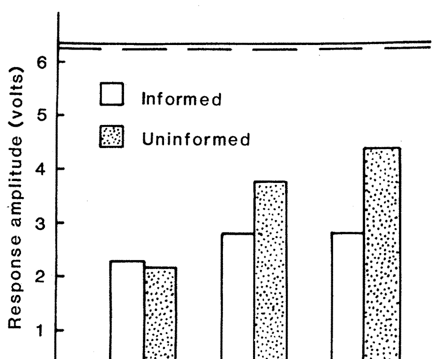

Fig. 1. Mean amplitude of tap-elicited eyeblinks when taps were preceded by a reflex-inhibiting light flash at various visual angles. Subjects were either informed or uninformed of where the flash might appear. Also indicated are the mean amplitudes of tap-elicited eyeblinks on control trials when subjects were informed (solid line) or uninformed (dashed line) of where a flash might appear, but the flash was withheld.

Testing was conducted in a dimly illuminated room. After a subject had been fitted with the headband and experienced a few taps, she was told that a series of such taps would be delivered and that on some trials the tap would be preceded by a flash of light in one or another of the holes. Subjects were told that they need pay no attention to the taps but that they should report when and where each flash appeared. At the start of a trial, the subject placed her chin in the chin rest and fixated her right eye on a small (visual angle, 4 minutes) point of dim light 2 cm above the 0° location.

Twenty subjects (*5*) each received 36 trials at intervals of approximately 15 seconds. Each trial ended with a tap. On half of the trials the subject was informed of where the light flash might appear. This instruction had the following form: "If there is to be a visual stimulus on this trial it will appear at location *X*." Of the 18 informed trials, 12 contained a tap preceded by a reflex-modifying light flash at either the foveal location (0°) or at the 20° or 40° locations on the temporal side. This stimulus was presented at each of these three locations four times. On the remaining six informed trials (two per location) the tap was presented but the visual stimulus was withheld. On the 18 uninformed trials, subjects received no instructions regarding the location of

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the light. Six trials consisted of tap only. On the remaining 12, the tap was preceded by the flash four times at one of the three retinal locations (0°, 20°, and 40°). All trials were presented in a random order that changed from subject to subject. On every trial, the experimenter monitored the position of the subject's right eye, beginning the trial (presenting a stimulus plus tap or a tap alone) only when the direction of gaze was firmly fixed on the spot just above the foveal location (*6*).

When preceded by a light flash, taps produced much smaller blinks than when presented alone (Fig. 1)—the basic reflex modification phenomenon. The configuration of data in Fig. 1 illustrates the effects of the two manipulated factors, stimulus location and foreknowledge of that location. A repeated measures analysis of variance on the observed amounts of inhibition (calculated by subtracting the mean amplitude of a given subject's response to a given light plus tap from that subject's response to tap alone) revealed significant overall effects of stimulus location [$F(2, 75) = 22.63$, $P < .01$], foreknowledge [$F(1, 75 = 17.18$, $P < .01$], and the interaction between these factors [$F(2, 75) = 4.19$, $P < .05$]. A subsequent Newman-Keuls analysis indicated that in the uninformed condition the foveally presented stimulus produced significantly more inhibition than either of the peripherally presented flashes: 20° ($P < .05$) and 40° ($P < .05$), and that the latter were not significantly different from each other ($P > .05$). There were no significant differences among the three locations on informed trials. Similar statistical comparisons showed no significant differences in the amount of inhibition produced by foveally presented stimuli on informed versus uninformed trials ($P > .05$). There were, however, significant differences between informed and uninformed trials when the 20° ($P < .05$) and 40° ($P < .05$) locations were compared. In both cases more inhibition was produced by the flash when the subject knew where the flash would be presented.

The results of experiment 1 indicate that the inhibitory effects of a stimulus presented to the periphery were enhanced when a subject was forewarned of the presentation location. No such enhancement effects were found at the foveal location. In experiment 2 we asked whether instructions to ignore the foveal region (and attend elsewhere) would reduce the amount of inhibition induced by a stimulus presented to the fovea. It seemed possible that if foreknowledge enhances inhibitory effects by directing attention toward a given location, instructions to ignore a given region where attention was already focused might reduce those effects.

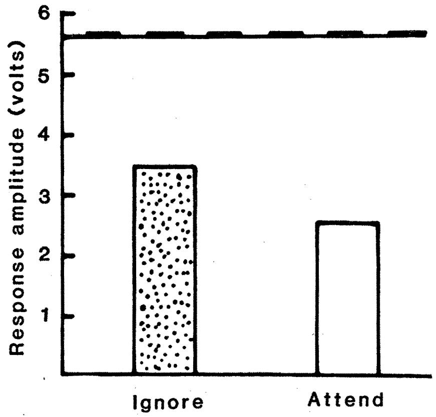

Fig. 2. Mean amplitude of tap-elicited eyeblinks when taps were preceded by a reflex-inhibiting flash presented to the fovea. Subjects were told either to attend to or to ignore this target location. On control trials, subjects were told to attend to (solid line) or to ignore (dashed line) the foveal location, but the flash was withheld.

The apparatus, stimuli, and number of trials were the same as those in experiment 1, with the following exceptions. Each of 12 new subjects was instructed that the light flash would always be presented to the fovea. On 18 of the trials, subjects were instructed to concentrate on the foveal location, where their gaze was fixed. On the other half of the trials, subjects were told to maintain their direction of gaze but to ignore the foveal location and to concentrate on the 40° peripheral location. On 12 trials (six with foveal concentration and six at 40°), the tap was presented but the visual stimulus withheld.

A test for related measures revealed a significant difference between the amounts of inhibition generated when subjects attended to (as opposed to ignored) the foveal location [$t(11) = 3.68$, $P < .05$] (Fig. 2). We thus concluded that, when instructed to do so, subjects can ignore stimulation in the direction of gaze and in doing so reduce its reflex modifying effect.

When viewed together, the data from experiments 1 and 2 indicate that the amount of reflex inhibition produced by a visual stimulus presented prior to a tap to the glabella depends on where in the visual field the stimulus is presented and on whether or not the subject is concentrating on that area. When directed to do so, subjects were able to attend to various regions in the visual field without shifting the direction of gaze; they thereby enhanced or reduced the amount a visual flash inhibited an elicited eyeblink.

In many respects these findings and the conclusion they generate are consistent with those of Posner *et al.* (*7*), who used a reaction-time task to assess the effects of attention on the detection of signals presented to various parts of the visual field. They likened attention to a spotlight that enhances detection of an event within its beam. Their work, like ours, reveals that attention can be directed either toward or away from the foveal location. However, whereas they studied a voluntary response, we studied an involuntary reflex and therefore made no demand that the subjects control the indicator response (their eyeblinks). This factor may be important in future studies of attention with subjects (such as children) who might have difficulty in meeting the demands of voluntary tasks.

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* Reprints may be obtained from H.S.H.

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