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Augmentation of the air puff-elicited eye blink by concurrent visual and acoustic input

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The human eye blink elicited by a periorbital air puff increases in amplitude as the intensity of the air puff is increased. The present research indicates that, within wide limits, the presentation of either a light flash or a tone at the moment of air puff presentation adds a constant increment to the reaction elicited by the air puff. It is concluded that each of the modalities tested has independent access to the neural systems in which elicited eye blinks are instigated.

The research reported here asked how the human eye blink to a periorbital air puff might be influenced when either a light or a tone was presented simultaneously with the reflex-eliciting event. Intuitively, it seemed reasonable to expect the blink to be enhanced by such stimuli, but whether the enhancement would be large or small and how it might vary as a function of air puff intensity were questions that could be answered only empirically. Information about the nature of these effects is important because of its bearing on the interpretation of the neural systems in which the eye blink reflex is instigated. It is a curious fact that, despite widespread use of eye blinks as indicator reactions in both classical conditioning and reflex modification paradigms (Black & Prokasy, 1972; Hoffman & Ison, in press), little is known about the input-output relationships exhibited by the neural systems that control this response. The present investigation provided a more or less direct analysis of those relationships under conditions in which inputs from two modalities were combined.

EXPERIMENT 1

Within fairly wide limits, the amplitude of the eye blink elicited by an air puff directed at the skin of the orbit is an increasing function of air puff intensity. Experiment 1 examined this function and asked how it might change when a flash of light occurred simultaneously with the air puff.

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Method

Subjects. The subjects were nine (five female, four male) undergraduate and graduate students at Bryn Mawr College.

Apparatus. The research was conducted in an Industrial Acoustics Corporation (IAC) ventilated double-wall isolation room. This facility has an ambient noise level less than 20 dB (re. 20 $n\mu N/m^2$).

The techniques used to produce and measure periorbital air puffs and for measuring the eye blink have been described in detail by Marsh, Hoffman, and Stitt (1976). Visual stimuli were produced by an Argus electronic flash unit (Model E-3). The flash unit was placed outside the IAC chamber and was focused through the multilayered sound-insulating window of the chamber onto a rear-projection screen (34 x 31 cm) mounted 65 cm in front of the subject.

Procedure. After a subject had been appraised of the nature of the research and had agreed to participate, he or she was seated in the IAC room and fitted with the air puff delivery and response measurement devices. Each subject was then tested with air puff intensities of 100%, 60%, 30%, and 0% (no stimulus) of the maximum intensity available (2,100 N/m^2). At each intensity, the air puff was presented both alone and with a simultaneous light flash (intensity = 3.43×10^{-2} cd/m^2; duration = .3 msec; rise-decay time < .1 msec).

During the experimental session, stimuli (air puff alone or air puff plus flash) were presented in random order at intervals of 20 sec. Each stimulus was presented four times for a total of 32 trials/subject. Measurements of eye blink amplitude were recorded for 200 msec after the onset of the stimulus; on those trials on which no stimuli were presented, measurements were taken for 200 msec starting 20 sec after the previous trial.

Results

Figure 1 shows the mean amplitude, averaged across subjects, of eye blinks elicited in each of the eight experimental conditions. A Treatment by Treatment by Subjects analysis of variance was used to evaluate the reliability of the observed trends. This test revealed (1) a significant effect of air puff intensity [$F(3,24) = 12.80$, $p < .001$], (2) a significant effect of the air puff

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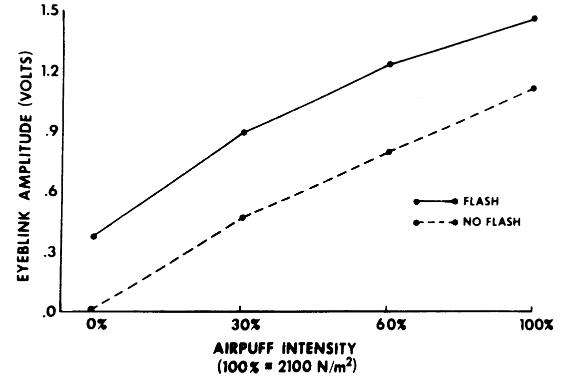

Figure 1. Mean amplitude of air puff-elicited eye blink with and without a simultaneously presented light flash.

alone vs. air puff plus flash manipulation $[F(1,8) = 14.78, p < .005]$, and (3) no significant interaction between the two conditions $(F < 1.0)$.

Discussion

These data imply that air puffs and light flashes have largely independent access to the neural systems responsible for elicited eye blinks. As expected, response amplitude was an increasing function of air puff intensity. What was uncertain was how this function might change when light flashes occurred simultaneously with the air puffs. The answer is clear. The function is simply shifted upward by an amount that approximates the reaction to the flash alone.

Hoffman and Ison (in press) have suggested that the eye blink elicited by a periorbital air puff is an aspect of an incepient startle reaction and that its amplitude is determined by the level of activation of a neural system in which startle is organized. More specifically, it was hypothesized that the level of activity of this system is determined by the number of neurons recruited by the eliciting event. The data depicted in Figure 1 are consistent with this hypothesis. Presumably, air puffs of increasing intensity recruit increasing numbers of neurons, and the addition of a constant intensity light flash adds a constant amount these numbers.

EXPERIMENT 2

This study provided a second arena for accessing the proposition that the separate modalities have independent access to the neural systems in which startle is organized. In particular, the work asked how the simultaneous presentation of tones would influence the eye blinks elicited by air puffs of various intensities.

Method

Subjects. The subjects were nine (four female, five male) undergraduate and graduate students at Bryn Mawr College.

Apparatus. The devices for the production and delivery of the air puff and for the measurement of the eye blink were the same as used in Experiment 1. Acoustic stimuli were produced by a Coulbourn precision signal generator (Model S81-06), their rise-fall times were controlled by a Coulbourn selectable envelope rise-fall gate (Model S84-04), and their intensities were controlled by a General Radio decade attenuator (Type 1450-TB). These stimuli were presented to subjects through TDH-39 earphones fitted with MX-41/AR cushions. The earphones and acoustic stimuli were calibrated with a General Radio precision sound-level meter (Type 1561-A), fitted with a P-7 microphone and an ANSI Type 1 coupler. ANSI (1969) norms were used as a reference for all calibrations.

Procedure. After having been briefed and fitted with the apparatus, each subject was tested with air puff intensities of 100%, 60%, 30%, and 0% (no stimulus) of the maximum intensity available (2,100 N/m^2). At each intensity, the air puff was either presented alone or presented simultaneously with an acoustic stimulus (frequency = 1 kHz; duration = 200 msec; rise-fall time = 2 msec) of 90, 70, or 50 dB HL.

During the experimental session, each subject was exposed to four blocks of trials. Within each block, all four levels of air puff intensity were employed. Each intensity was presented four times in succession; each presentation was either paired with one of the three tone intensities or presented alone. Thus, each block consisted of 16 trials. Across the four blocks, the order of presentation of air puff intensity was varied according to a Latin square; within each block, under each level of air puff intensity, the tone intensity was varied according to a Latin square. Each subject was thus exposed to a total of 64 trials with an intertrial interval of 20 sec.

Results

Figure 2 shows the mean amplitude, averaged across subjects, of eye blinks elicited in each of the 16 experimental conditions. A Treatment by Treatment by Subjects analysis of variance performed on these data revealed (1) a significant effect of air puff intensity $[F(3,24) = 29.87, p < .001]$, (2) a significant effect of tone intensity $[F(3,24) = 6.12, p < .005]$, and (3) no significant interaction between the two main effects $[F(9,72) = 1.48, \text{n.s.}]$.

Discussion

As in previous studies, the amplitude of the air puff-elicited eye blink was an increasing function of air puff intensity, but the shape of the function in Experiment 2 was somewhat different from that obtained in Experiment 1. Most likely, this difference reflects little more than individual variations in sensitivity, since the subjects in the two experiments were not the same.

A second difference between the results of Experiments 1 and 2 was that in Experiment 2 most of the inputs that were added to air puffs were too weak to themselves produce detectable responses. As seen in Figure 2, tones of 50 and 70 dB produced no reactions when presented alone. Even so, these

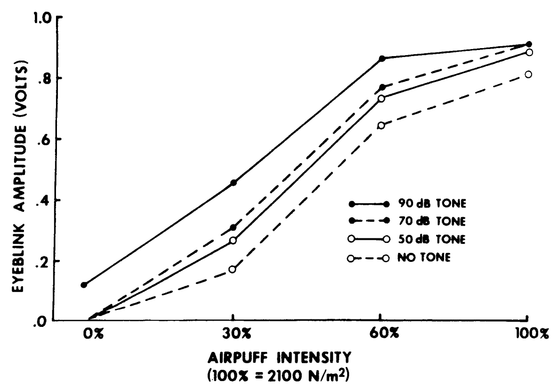

Figure 2. Mean amplitude of air puff-elicited eye blink with and without a simultaneously presented tone of a given intensity.

tones (like the 90-dB tone and the light flash of Experiment 1) added an essentially constant increment to the reactions elicited by the various air puffs. The only departure from this observation was when the 90-dB tone was added to the strongest air puff. This, however, may merely mean that there was an upper limit on response amplitude for these particular subjects.

In any event, the data and the statistical analysis in Experiment 2 reveal that throughout most of their range, the functions relating eye blink amplitude to air puff intensity are almost exactly parallel when tones of various intensities are added to the air puffs. This finding is in obvious accord with the results of Experiment 1. Considered together, the two experiments provide a clear indication that the separate modalities have largely independent access to the neural systems responsible for the occurrence of elicited eye blinks.

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