Measurement of the Conditioned Eyelid Reflex

Abstract. *The magnitude of the conditioned eyelid reflex is defined as the integral of the amplitude over the time course of the blink. This measure is significantly related to the conventional measures of frequency, latency, and amplitude, but exhibits variance of its own which appears to reflect its greater sensitivity to the physiological processes underlying the blink.*

The blink reflex has been widely investigated by students of behavior, particularly those concerned with its susceptibility to modification through classical conditioning. Changes in the strength of the reflex have traditionally been inferred from measures of latency, amplitude, or simple frequency of occurrence, the latter being used most frequently. The eyeblink differs from most skeletal responses, for which frequency measures are generally appropriate, in that its occurrence is occasioned by the contraction of a sphincter muscle, the orbicularis oculi. Thus, as one may readily observe by electromyographic monitoring techniques, the period of lid closure in an awake subject corresponds to a period of continuous action of the sphincter. Since the amount of lid closure (momentary amplitude) at any instant may be regarded as reflecting the amount of sphincter contraction at that instant, it follows that the time integral of momentary amplitude, evaluated between the temporal limits set by the time course of the blink, would measure the continuous action of the sphincter muscle and would thus provide a continuous index of the strength of the blink. This measure, which I shall call magnitude (*1*), is illustrated for the case of the conditioned anticipatory blink in Fig. 1.

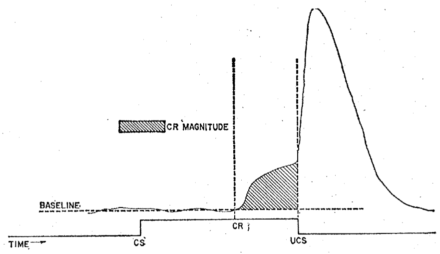

Fig. 1. An idealized tracing of a conditioned blink response (CR) followed by the unconditioned response (UCR) to the air puff. The magnitude is defined as the area under the tracing bounded by the extrapolated baseline and the occurrence of the UCR.

Table 1. Intercorrelations among measures of conditioned response strength, frequency, amplitude, latency, and magnitude. The italicized coefficients were calculated after the "non-response" trials were omitted from the data.

	Freq.	Amp.	Lat.	Mag.
Amp.	.688			
	.000			
Lat.	−.792	−.646		
	.000	*−.248*		
Mag.	.587	.856	−.713	
	.000	*.767*	*−.493*	

To estimate the relationships of this measure to the conventional indices of conditioned eyelid reflex strength, eighteen college students were each given 60 conditioning trials in which the conditioned stimulus (CS) was a circular red light (*2*), the unconditioned stimulus (UCS) was an air puff of 0.10 second duration at an intensity sufficient to support a 180-mm column of mercury, and the CS-USC interval was 1.0 second. A full description of the apparatus and procedure is available elsewhere (*3*); briefly, lid responses were recorded by mechanically connecting the shaft of a microtorque potentiometer to the subject's eyelid by means of a false eyelash. The output of the potentiometer was amplified and recorded on a moving paper record; a separate channel monitored the occurrences of the conditioning stimuli.

For each of the 1080 trials thus administered, four measures of conditioned reflex strength were obtained: (i) frequency (1 or 0, depending upon whether or not a pen deflection in the direction of closure occurred), (ii) amplitude (the maximum distance the pen deviated from the baseline prior to the onset of the UCS), (iii) latency (the time between the onset of the conditioned stimulus and the occurrence of the deflection, provided that such time exceeded 600 msec, the defined minimum latency of a conditioned response), and (iv) magnitude. The magnitude data were obtained with the aid of a specially constructed rubber stamp which had a tiny raised dot in the center of each square of a grid ruled in millimeters. By stamping the record with this stamp, then counting the dots inside the prescribed area, we obtained a measure of the desired area in square millimeters (*4*).

Estimates of the reliability of each of these measures were calculated by correlating the subjects' odd and even trial totals. Application of the Brown-Spearman formula (*5*) produced the following reliability coefficients: frequency, .966; latency, .950; amplitude, .983; and magnitude, .991. It is apparent that the magnitude measure is, by a slight margin, the most reliable of the four measures made of each response.

Intercorrelations among the various measures are presented in Table 1. The italicized coefficients were calculated after the trials in which no responses were obtained were omitted from the data. We thus obtained a more accurate index of the utility of the magnitude measure for the description of individual responses, an application to which it may be best suited. All intercorrelations in Table 1 are corrected for attenuation due to unreliability of both the predictor and criterion variables.

It is evident that the magnitude measure provides a description of the physical properties (latency and amplitude) of the responses which is statistically superior to that provided by the commonly used frequency measure. The average of the absolute correlations of frequency with latency and amplitude is .743; the average absolute correlation of magnitude with these two variables is .797, a difference which is significant beyond the .01 level. This difference, coupled with the fact that the correlation between frequency and magnitude is relatively low, indicates that the frequency measure does not account for variance among conditioned responses which would seem to be related to the physiological processes by which such responses are produced. In addition, the magnitude measure appears to possess variance which cannot be accounted for by a linear combination of latency and amplitude ($R_{m.al} = .870$, where R is the multiple correlation coefficient). This finding is in line with anecdotal observations; the majority of response tracings exhibit irregularities which cannot be quantitatively described without reference to the changes in continuous amplitude over time.

Application of the magnitude measure as a dependent variable in future conditioning studies would seem fruitful for a number of reasons. The variance which it seems to display uniquely may be lawfully related to unexplored independent variables. Second, the introduction of a continuous dependent variable would render the results of eyelid conditioning experiments mathematically comparable to those of experiments concerning other response mechanisms (such as the galvanic skin response) for which continuous measures have been devised. Finally, and most important, the magnitude measure apparently provides the most veridical quantitative representation of the physiological process by which an eyeblink occurs. As such, its use can only assist in integrating the psychological and physiological phenomena which define classical conditioning.

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References and Notes

1. The term *magnitude* has been used by Humphreys [*J. Gen. Psychol.* **29**, 101 (1939)] to denote the average amplitude (including zeroes) of a finite set of conditioned responses. Since my use of the term is with reference to properties of a single response, the likelihood of confusion would seem to be minimal.
2. Grason-Stadler Model E4580 Multiple Stimulus projector.
3. H. S. Pennypacker, *J. Exptl. Psychol.* **67**, 33 (1964).
4. I thank Ronald Mourant and Stuart Fabric for their assistance in tabulating and analyzing the data.
5. Q. McNemar, *Psychological Statistics* (Wiley, New York, 1955), pp. 156–160.
6. Supported in part by USPHS grant M 5063. An earlier version of this report was presented at the Psychonomic Society, Philadelphia, 1963. I thank H. D. Kimmel, R. B. Masterson, and W. F. Prokasy, Jr., for their helpful comments.

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Attack Elicited by Stimulation of the Thalamus of Cats

Abstract. *Electrical stimulation of sites in the medial thalamus leads to attack upon rats. This attack summates with attack elicited by hypothalamic stimulation. Stimulation of other thalamic sites suppresses hypothalamic attack, while excitation of still others facilitates it.*

The role of the medial thalamus in emotional functioning is not clearly established. In man, aside from other effects, destruction of the dorsal medial nucleus appears to reduce aggression and anxiety at least temporarily (*1*). In laboratory animals, the same procedure has yielded increased (*2*), reduced (*3*), or unchanged (*4*) emotional reactivity. Electrical stimulation of the dorsomedial nucleus induces fear-like responses (*5*), and excitation of midline thalamic nuclei has induced a high level of excitement in at least one instance (*6*). In our study, stimulation of different portions of the midline thalamic structures has been found (i) to elicit attack, (ii) to summate with attacks elicited from the hypothalamus, and (iii) to suppress this same response. The different loci for these effects may explain the discrepancies in previous results.

Table 1. Mean latent period between stimulation of the medial thalamus and attack.

Cat	No. of trials	Mean latency (sec)	S.D. (sec)	Stimulus intensity (ma)
6143M	25	6.8	2.9	0.60
11193M	20	4.7	1.9	0.60
11133M	21	7.2	2.8	0.40
11183M	20	4.3	0.9	0.30

Nine cats had electrodes implanted aseptically in regions of the lateral hypothalamus where stimulation regularly elicited attack. In the same operation calibrated guide tubes through which calibrated electrodes were later lowered to the thalamus were also mounted on the skull.

Of these nine cats, only one would attack a rat placed in its cage without being stimulated electrically. On the other hand, all nine would attack a rat savagely when stimulated electrically through the hypothalamic electrodes. Deeply anesthetized rats were used in this experiment. Dummies and stuffed rats are unsuitable, since the response deteriorates when they are the attack objects.

The hypothalamic stimulation consisted of biphasic square waves, each lasting 2.0 msec and occurring 62.5 times per second. Stimulation was continued until the cat bit the rat or in the case of the attack being suppressed, for 30 seconds.

Movable electrodes were used in the exploration of the thalamus. Unintentional movement of these electrodes in the active unanesthetized cat was avoided by placing a plastic cap over them and by making an indirect connection to the leads.

With the movable electrode, testing usually began at the level of the cingulate gyrus and proceeded ventrally in small steps. At each step, three observations were made: the effect of stimulating the test point, the effect of stimulating the lateral hypothalamus, and the effect of stimulating both test point and hypothalamus in combination. During the combined stimulation, the individual pulses to the hypothalamus took place 6 msec before those to the thalamus, so as to avoid stimulating the area between the hypothalamus and thalamus.

When an effect was found that was relevant to our study, the site was stimulated at intervals for 1 hour, and the electrode was then cemented in place. The currents required to produce an effect were greater in the stage when the electrode was being moved than after it had been fixed in place for a week.

The positions of the tips of both the movable electrodes and the ones

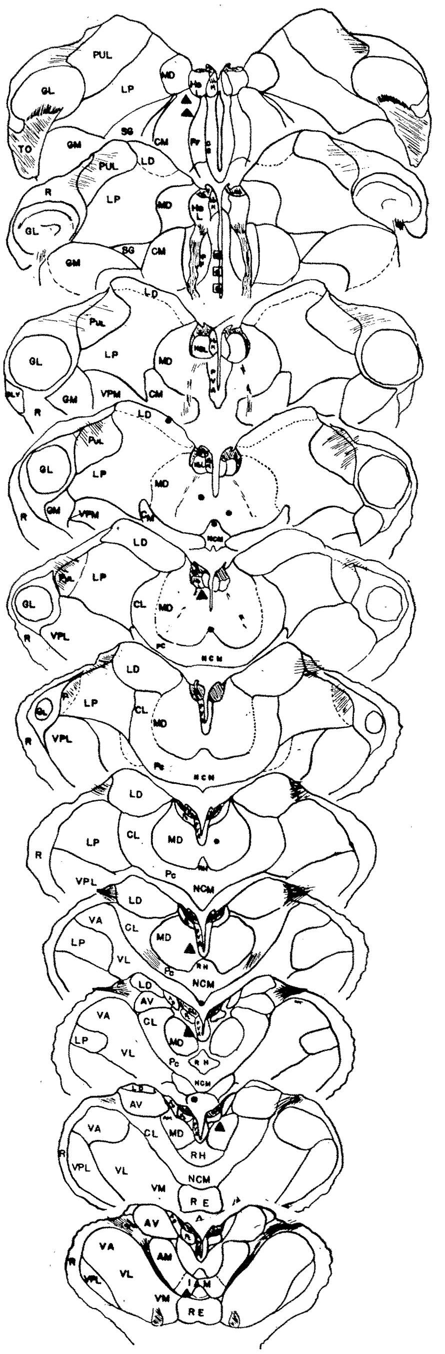

Fig. 1. Points in the thalamus giving rise to attack (dots), suppression of hypothalamic attack (triangles), and facilitation of hypothalamic attack (enclosed dots). Sections begin at F 11.5 and continue posteriorly at 0.5-mm intervals. Points were determined histologically.