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# MEASURING FLICKER THRESHOLDS IN THE BUDGERIGAR[1]

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A method of measuring thresholds in animals is described and illustrated in the case of flicker fusion in the budgerigar. After training with reinforcement for pecking at a high-frequency light (115 Hz) and nonreinforcement for pecking at a low-frequency light (20 Hz), subjects were given threshold trials and reinforcement trials mixed randomly in equal number. In threshold trials (no reinforcement), the target began flashing at 115 Hz and decreased in flash rate with each peck until the subject stopped responding. During reinforcement trials, the target continued to flash at 115 Hz, and responses were reinforced on a variable-ratio schedule. Flicker thresholds obtained from two birds showed a linear relation to the logarithm of intensity in accordance with the Ferry-Porter law.

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This paper describes a method of determining sensory thresholds in animals. While we believe its potential applications are more general, both in regard to sensory functions and to experimental subjects, the present discussion is limited primarily to critical flicker frequency (CFF) in budgerigars.

Since the earlier studies of Crozier and Wolf (Landis, 1953), there has been little behavioral measurement of CFF in birds (Ginsburg, 1970). Only the pigeon has been used, with a single technique: conditioned suppression (Hendricks, 1966).

While the Blough (1958) technique of threshold measurement has been used for a number of sensory functions it has not, as far as the authors know, been applied to flicker in birds. In the Blough procedure, the animal learns a discrimination differentiation involving two keys. The subject is trained by reinforcing pecks on one key in the presence of the stimulus, and reinforcing pecks on the other key when the stimulus is absent. The present method involves a single key and the learning of a discrimination between the presence and absence of the critical stimulus, a simpler task for both subject and experimenter.

The technique is essentially the method of limits. When the method of limits is applied to CFF in humans, the subject is presented with a high-frequency light that cannot be distinguished from a steady light (60 Hz is usually sufficient). The rate of flashing is gradually decreased, and the subject is instructed to press a button when the light appears to flicker. The frequency of the light when the button is pressed is called the CFF.

In the present technique, the birds are "instructed" by reinforcing pecks at a high-frequency light (115 Hz), and by refraining from reinforcing pecks at low-frequency light. Trials are of two kinds, in a one-to-one ratio: threshold trials and reinforcement trials. In threshold trials, the rate of flashing decreases automatically with each response. The flash frequency at which the subject fails to respond for 10 sec is called the CFF. In reinforcement trials, the stimulus continues to flash at 115 Hz, and responses are reinforced on a variable-ratio schedule.

The assumption underlying the technique is that the subject is unable to discriminate between 115-Hz light and steady light. In preliminary training, it learns that pecking at a light that appears to be steady will be reinforced, but that pecks in the presence of a flickering light will not. It is assumed that the tendency to withhold pecking in the presence of the flickering light generalizes to all detectable flicker rates. During threshold trials, as soon as the bird detects flicker (which informs it that the trial will not end in reinforcement), it stops pecking.

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## METHOD

### *Subjects*

Two male budgerigars, *Melopsittacus undulatus,* purchased from a local pet store, were kept in individual cages of 10 by 12 by 14 in. (25 by 30 by 35 cm). Commercial budgie seed mixture was used as feed and as reinforcers, and the birds were kept at approximately 80% of free-feeding weights.

### *Apparatus*

A glow modulator tube (Silvania R1166) was activated by a Lafayette Flickometer, Model 1202D. The upper scale of the flickometer was used, which runs from 115 to 33 Hz. Distance on the scale was a linear function of msec/cycle rather than Hz. The shaft controlling rate of flashing was turned by an electric motor. The clutch of the motor was connected to the output of a decade interval timer. The timer was activated by the key that the bird pecked. The key was a piece of $\frac{1}{16}$ in. (1.6 mm) white Plexiglas 30 mm in front of the tube. The size of the step by which rate of flashing changed with each peck was determined by the setting on the timer. In the case of the data below, a timer setting of 180 msec provided an increase in cycle time of 0.8 msec with each response.

Each subject was tested in its home cage, which was placed in front of the stimulus panel containing the key and feeder. Reinforcement was presented by the automatic feeder which permitted the subject to eat for 2.5 sec. A 25-w frosted houselight was on continuously. The luminance of the panel was approximately 0.1 cd/m$^2$. The luminance of the stimulus was varied by inserting Wratten filters between the tube and the response key. During training the filters were not used, and the luminance of the key was 17.1 cd/m$^2$.

### *Procedure*

*Preliminary training.* The subjects learned to eat from the automatic feeder, and then to peck at the key that operated the feeder. This took from 3 to 5 days.

*Light discrimination.* Pecking on the key was reinforced when the key was lit, but not when it was unlit. Steady light was used at first; then, 115 Hz was substituted. No change in behavior was noted when the substitution was made. Discrimination was judged informally to be adequate on the basis of high frequency and low latency of response to light onset. This step took 3 to 4 days.

*Flicker discrimination.* Pecking at a light flashing at 115 Hz was reinforced, but not at a 20-Hz light ($S^{\Delta}$). When this discrimination was mastered (see comment on Step 2) $S^{\Delta}$ was varied informally between 20 and 50 Hz. This step took 3 to 5 days.

*Variable-ratio (VR) schedule.* The average number of pecks at the 115-Hz target required for reinforcement was gradually increased. This was continued for 3 to 4 days, when the subjects reached the desired level of VR 10 with a maximum of 19 responses per reinforcement.

*Threshold trials.* On these trials, the target began flashing at 115 Hz. Each peck lowered the flash frequency. After the subject failed to peck for 10 sec, the target light was extinguished and the frequency was noted. At first, only a few threshold trials were introduced in each daily session, mixed in with about 20 reinforcement trials. The number of threshold trials was gradually increased over about a week until the level of 50% threshold trials was reached.

For final threshold determination, 10 threshold trials mixed with 10 reinforcement trials in a pre-arranged random order were given in each daily session lasting from 10 to 30 min. Intertrial time was approximately 30 sec following reinforcement trials and 20 sec following threshold trials. Five different luminances were presented in each daily session in random order.

## RESULTS

Table 1 shows threshold trials during a typical session from the results of Subject A. This particular session lasted 11 min.

Means and standard deviations for each of the two subjects are presented in Table 2. In the case of Subject A, each mean is based on 10 thresholds, which were obtained in five daily sessions. In the case of Subject B, each mean is based on 25 thresholds, which were obtained in 13 daily sessions.

Figure 1 shows CFFs for each of the two subjects as an increasing function of log luminance. The best-fitting straight lines, determined by the method of least squares, are: Bird A, $CFF = 22.6 \log I + 57.6$; Bird B, $CFF = 19.2 \log I + 49.7$.

Table 1

Sample Session from Subject A

| *Number Trial* | *Filter Density* | *CFF* |
|---|---|---|
| 2 | 1.2 | 41 |
| 3 | 1.0 | 45 |
| 4 | 0.3 | 68 |
| 6 | 0.0 | 76 |
| 9 | 0.6 | 63 |
| 11 | 0.0 | 79 |
| 12 | 1.2 | 46 |
| 15 | 1.0 | 56 |
| 18 | 0.6 | 60 |
| 20 | 0.3 | 68 |

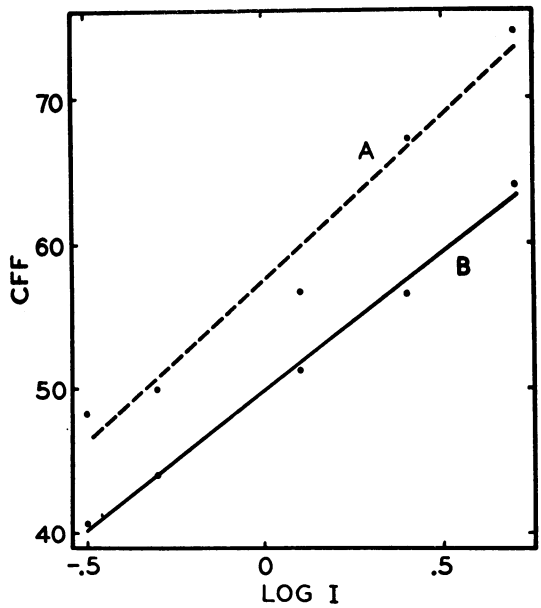


Fig. 1. Flicker thresholds in Hz as a function of log luminance. The abscissa is equal to 0 at 1 ft-L (3.42 cd/m²). In curve A, each point is the average of 10 threshold determinations; in curve B, each point is the average of 25 determinations.

## DISCUSSION

The linear relation between frequency and log intensity is interpreted as an instance of the Ferry-Porter law. According to this law, as intensity increases the frequency at which the subject can detect intermittency of the stimulus also rises; *i.e.,* the flicker threshold increases. Other interpretations of this relationship are possible. One could attribute it to performance variables, rather than to perceptual variables. For example, it might be that as target brightness rises, the latency for cessation of responding falls.

The present method permits unusually rapid data collection. Each daily session, in which 10 CFF thresholds were obtained, lasted an average of 12 min for Subject A and 20 min for Subject B. Threshold determinations themselves required about 15 sec for Subject A and about 25 sec for Subject B.

Whether or not the present method yields a true sensory threshold will depend ultimately on parametric studies. The more conditions under which the results vary in the manner expected for thresholds, the more likely it is that we are really dealing with thresholds.

This method should also be applicable to any other situation where an absolute threshold is desired. Consider, for example, how it might be used to obtain absolute thresholds for light in a dark room. The subject will have access to a translucent key. Behind this is a neutral-density wedge that can be made to rotate with each peck at the key. Pecks at the key when it is not illuminated are reinforced on a variable-ratio schedule, while pecks at the illuminated key are never reinforced.

When these conditions lead to reliable control over behavior, reinforcement trials will be interspersed with threshold trials. A threshold trial begins with the wedge positioned at its greatest density. With each peck, it is rotated to a lesser density. It is predicted that, during a threshold trial, the subject will continue pecking until it can detect the light. If a relation is found between luminance at which pecking ceases and time in dark, this could be interpreted as a dark adaptation curve.

Table 2

Means and Variability of CFFs

| *Filter Density* | *Bird A* *M* | *Bird A* *S D* | *Bird B* *M* | *Bird B* *S D* |
|---|---|---|---|---|
| 0.0 | 74.7 | 4.2 | 64.0 | 10.0 |
| 0.3 | 67.2 | 6.4 | 56.7 | 7.7 |
| 0.6 | 56.4 | 4.3 | 51.2 | 12.4 |
| 1.0 | 50.0 | 6.1 | 44.0 | 8.8 |
| 1.2 | 48.4 | 19.0* | 40.7 | 8.4 |

*This high variability appears to be due to a single deviant value on the first day of testing. If this value were discarded, the S D would be 4.4.

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