Table 1. Optomotor responses of echolocating bats.

Bat	Visual angle subtended by stripe (degrees)	Number of trials on which bat moved		Total No. of trials	Trials on which bat moved (% total)
		Same direction as stripes	Opposite direction to stripes		
		Emballonuridae			
Saccopteryx bilineata	5.0	46	0	47	(98)
	white	0	4	20	(20)
Saccopteryx leptura	0.7	34	1	38	(92)
	gray	1	1	15	(13)
		Phyllostomidae			
Phyllostomus hastatus	3.0	17	0	18	(94)
	0.7	0	0	> 8	(0)
Anoura geoffroyi	0.7	24	0	26	(92)
	gray	0	0	15	(0)
Carollia perspicillata	0.7	1	35	39	(92)
	gray	1	2	17	(18)
Artibeus jamaicensis	3.0	18	0	19	(95)
	0.7	0	0	> 8	(0)
		Desmodontidae			
Desmodus rotundus	0.7	24	3	29	(93)
	gray	3	2	15	(33)
Diaemus youngi	3.0	41	9	53	(94)
	gray	21	28	51	(96)
		Vespertilionidae			
Myotis lucifugus *	6.0	0	16	18	(89)
	3.0	14	12	47	(55)
Myotis lucifugus †	6.0	0	15	23	(65)
	3.0	3	4	29	(24)

* 7.5 Watts. † 100 Watts.

similar. This bat was characteristically more active in the chamber than were any of the other species studied.

During experiments with neotropical species (first three families in Table 1) the stripes were illuminated by a 100-watt, 120-volt bulb operated at 60 volts and positioned 20 cm above the top of the cylinder. The illumination provided at this voltage was near the minimum at which the experimenter could still clearly distinguish the outline of the bat's body against the white floor of the cylinder. Experiments with *Myotis lucifugus* were conducted at two levels of stripe illumination both of which gave similar results. One series of experiments employed a 7.5-watt bulb; the other, a 100-watt bulb. In both cases the bulbs were operated at their rated voltage of 120 volts and were positioned 40 cm above the top of the aluminum cylinder.

The data indicate that, under the above experimental conditions, the minimum separable visual angle of *Phyllostomus hastatus* and *Artibeus jamaicensis* probably lies between 3.0 and 0.7 degree, and that of *M. lucifugus*, between 6.0 and 3.0 degrees, as judged by optomotor responses. Four other species responded to 0.7 degree—the narrowest stripes available. At the time *Saccopteryx bilineata* was tested, stripes narrower than 5.0 degrees were not available. Consistent data for 0.7-degree stripes have not yet been obtained with *Diaemus youngi* because of its restless behavior in the chamber (*3*).

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3. The data reported here suggest that the visual capabilities of echolocating bats may vary significantly between species or higher taxa and be correlated with particular feeding habits, ecological niches, or behavior patterns. Bats of the genus *Saccopteryx* are insectivorous species which often feed in the daytime and roost on exposed surfaces of forest trees. *Phyllostomus hastatus* is a large omnivorous bat whose diet includes fruit, insects, and small vertebrates. *Anoura* is a nectar feeder; *Carollia* and *Artibeus* are frugivorous. The Desmodontidae, or true vampires, live solely on blood of birds and mammals. *Myotis lucifugus* is a common temperate-latitude insectivorous species. Investigations are now in progress in an attempt to elucidate the possible importance of vision as a sensory modality, along with echolocation, in the lives of Microchiroptera.
4. I thank Prof. D. R. Griffin, Drs. H. Markl and N. Suga, Mrs. D. Dunning, and Mr. R. Loregnard of the Trinidad Regional Virus Laboratory, and the New York Zoological Society for the use of facilities of the William Beebe Memorial Tropical Research Station in Trinidad, W.I. Supported by 1-F2-MH-13, 945-01 from NIH, grants from the Society of the Sigma Xi Research Fund, and the Milton Fund of Harvard University.
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Electroencephalographic Activation: Nonspecific Habituation by Verbal Stimuli

Abstract. *A decrease in the duration of the electroencephalographic activation response to a series of different words: emotional, "neutral," and scrambled occurred. The response to "neutral" words was consistently briefer than that to the other words. This result is evidence of a nonspecific habituation of activation, which implies that habituation to classes of stimuli can occur.*

In his discussion of the extinction of the orienting reflex, Sokolov utilizes the concept of a "nervous model" of the stimulus (*1*). The magnitude of the orienting response is assumed to be proportional to the difference between the brain representation of the present stimulus and the nervous model of prior stimuli.

The nervous model is described as a multidimensional memory trace representing simultaneously the intensity, quality, and temporal characteristics of the previous stimuli. If a new stimulus differs from prior ones by more than a just-noticeable difference, the orienting reflex is reinstated. The components of the orienting reflex follow the same rule. The duration of electroencephalographic (EEG) activation decreases while the latency of activation increases with repeated stimulation. After a change of stimulation, the duration of activation increases and latency decreases (*2*).

Sokolov also proposed that after repeated presentation of stimuli varying within a restricted range, the nervous model is generalized to match the range of stimuli. There is surprisingly little EEG experimental data relevant to this hypothesis. In an extensive review of the problem of arousal in the nervous system, Gray (*3*) notes that he did not know of any studies of the extent of stimulus generalization during the stages of generalized and localized EEG activation. The following experiment confirms Sokolov's hypothesis.

Various words (in capital letters) were flashed onto a screen in a controlled temporal relation with the EEG occipital alpha-activation cycle (*4*). Occurrence of alpha (8 to 13 cy/sec, $> 5\mu$v) caused a relay to close ("on"). Nonoccurrence of alpha caused it to open ("off"). This relay controlled the stimlus function. When alpha occurred for 0.4 second, a syllable was

presented. The duration of presentation was determined by the duration of the alpha burst up to a limit of 0.6 second. Otherwise, the stimulus was not presented.

The subjects, 20 men and women who were volunteers from the hospital staff, were comfortably seated in a very quiet audiometric test room. The stimuli were "white on black" projections of words presented by an ordinary 500-watt projector, through a glass window behind the subject, to a screen in front of the subject. The subject saw only the projected word which was about 60 cm long and 5 cm high from a distance of 2 meters. The illumination at the location of a projected letter was 4.4 to 5.5 lumens per square meter. When the stimulus appeared, the subject pressed a hand switch marking the EEG record. This simple task gave evidence that he was awake during the experiment. The EEG was recorded bilaterally with bipolar parietal-occipital electrodes. The ground electrode was placed over the mastoid. All recordings were obtained with eyes open.

Three groups of projected words were used: *kotex, raped, bitch,* and *penis* were emotional; *dance, child, broom,* and *glass* were "neutral"; *lhdic, pdaer, caend,* and *hbtic* were scrambled versions of child, raped, dance, and bitch, respectively. All subjects received the same sequence of scrambled words; the emotional and neutral words were arranged differently for each of two groups of ten subjects. The particular sequence of emotional and neutral words was systematically varied from subject to subject. First, *lhdic* was presented 28 to 30 times. For group A the next word was an emotional word, presented ten times; then *pdaer* was presented ten times; then neutral word; then *caend*; then emotional; then *hbtic*; neutral; then *lhdic*; emotional; *pdaer*; neutral; *caend*; emotional; *hbtic*; neutral. The words presented to group B were the same except that the emotional words and neutral words were in reversed positions. Between every ten presentations, there was a brief pause while the slide was changed. The data presented here are the "on" and "off" durations of the stimulus relay associated with alpha burst and no-alpha activation durations.

Prominent alpha rhythms were recorded from these subjects even though their eyes were open throughout (*5*). The average "on" durations were constant at 0.4 ± 0.5 second throughout the experiment, and will not be discussed further. This duration included the latency of activation which was about 0.2 second.

Table 1. Average "off" durations (in seconds) for successive blocks of trials and each type of word.

Word type	Block				
	1	2	3	4	$\bar{X}$ words
Emotional	5.4	3.9	4.2	3.2	4.2
Scrambled	5.0	4.1	4.1	3.0	4.0
Neutral	4.7	3.1	3.1	2.3	3.3
$\bar{X}$ blocks	5.0	3.7	3.8	2.8	

The "off" durations varied depending on the number of previous presentations, the group of words being presented, and more complex interactions to be discussed. For purposes of statistical analysis the first 20 presentations of the initial scrambled word were ignored. The remaining trials were divided into four successive blocks of four trials, each containing ten presentations. Each block contained two trials with scrambled words, and one each of emotional and neutral. In each trial ten presentations were pooled. These data were analyzed by variance analysis, the differences between the two sequence groups (A and B), the three groups of words (emotional, scrambled, and neutral), the four successive blocks of trials, and the interactions of these being evaluated. We discuss only significant comparisons. First, for all three groups of words, there was a decline of "off" durations over successive blocks ($P < .001$). This decline began at a lower level for "neutral" words and continued lower, while scrambled and emotional words produced similarly longer durations (Table 1). The F for words was significant ($P < .05$). There

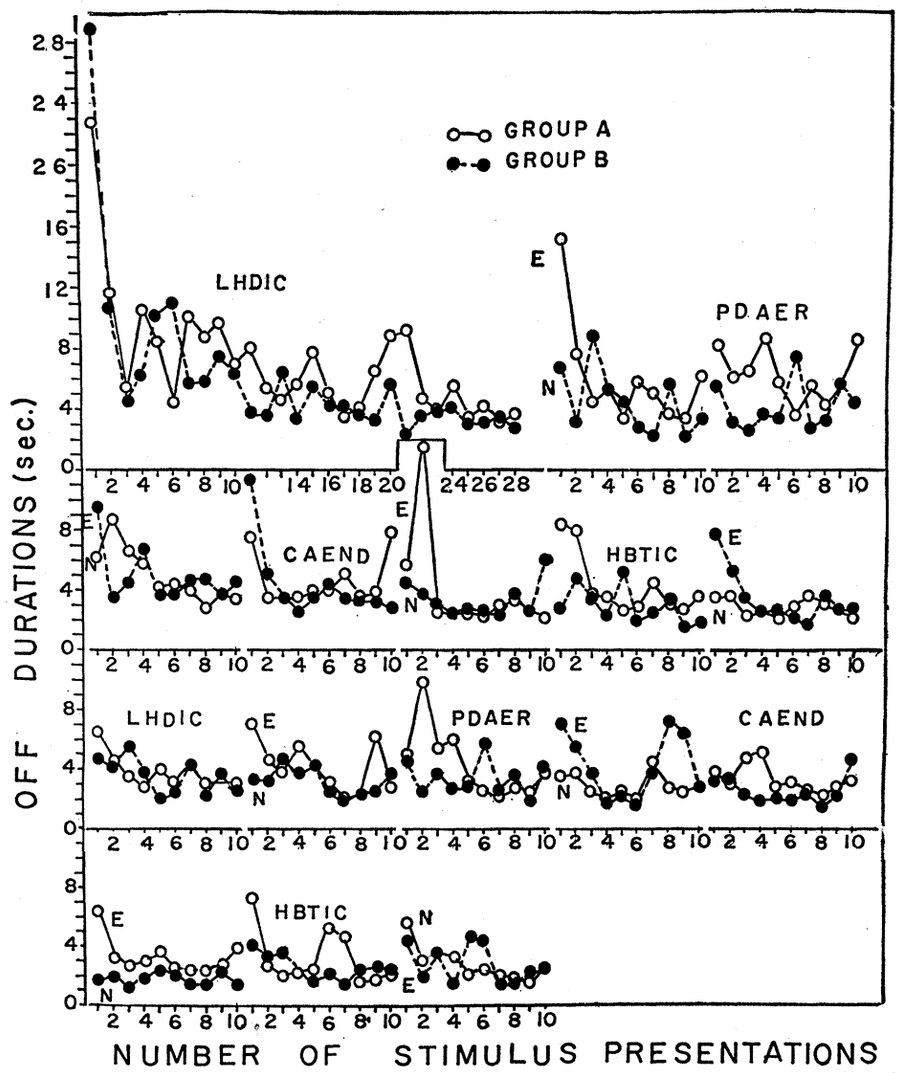

Fig. 1. Average "off" durations for each presentation of each word and each group. Each point is based on ten subjects. *E,* Emotional; *N,* neutral.

was a complex interaction between block, words, and sequence group ($P < 0.5$), which can be illustrated though not easily interpreted.

In Fig. 1, the average "off" duration for each presentation, for each group, and for each word is shown. Without burdening the reader with a detailed description of the illustration, four salient features may be noted. (i) There is a general decline of average "off" durations (Table 1); (ii) the increase of "off" durations at the onset of a different word was evident during the earlier trials and much less during the later trials; (iii) the initial average "off" duration associated with emotional words is greater than that for neutral words with the exception of the last trial; (iv) the initial response to a scrambled word was generally larger if the preceding word was an emotional word.

After an initial habituation by the first word, there was a partial recovery of the activation response with presentation of a different word. This result is completely consistent with previous findings. However, the average activation response to successive different words decreased. The initial recovery of activation when a different word was presented also decreased. These results are consistent with Sokolov's hypothesis. They show that habituation occurring over the series of different stimuli is not necessarily specific to a particular stimulus. The interpretation of this result as reflecting a generalized decline of response to all kinds of stimuli is not likely to be valid. The fact that one group of words from the start produced significantly briefer activation responses which remained briefer throughout the experiment reflects a differential response to that group of stimuli which could not occur on the basis of a generalized decrement of response to stimuli of all kinds. Previous research on the EEG has shown repeatedly that decrements of the activation response with repeated presentation are not due to generalized lowering of responsiveness such as might be produced by fatigue. In fact, the common interpretation of the decrement in responding after repetition of the same stimulus is that the decrement is specific to that particular stimulus. Our experiment does not indicate the extent of the class of different stimuli which are associated with briefer activation responses with repeated presentations. The subjects may be treating all "flashed words" as similar after a while, the specific response thus being reduced. However, this explanation assumes a decline of specificity, an increased generality, which is the point to begin with.

Though the response to the emotional words was similar to that given to scrambled words, the underlying process of activation may have been different. The emotional words, by reason of an overlearned autonomic response, could produce activation which would reflect some combination of the orienting and so-called defensive reflex. The response to scrambled words was perhaps due to a heightened orientation associated with the subjects' attempt to "unscramble" the words. All subjects reported this kind of activity.

In conclusion, habituation, defined here as a decrease in the duration of EEG activation, is not necessarily specific for a particular repeated stimulus (*6*). The complexities of the stimulus generalization which are implied await further research.

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Monaco: The Shallow Continental Shelf

The water-covered sediments that have been deposited during past ages can be studied by coring (or boring) techniques. The results are limited to the small area where each of the samples is taken. Erroneous conclusions about a sediment situation may be made if the area sampled is not typical.

Detailed small-scale boring and coring efforts in a large area are seldom made because of the time and money required. For such situations seismic profiling offers an advantage, for a quick survey from a small, slowly moving boat can cover a large area in a relatively short time. However, the system is effective only where there is sonic reflection from the different layers of sediment; the layers that give a signal must be identified on the record.

The two sediment exploratory systems, coring and sonic profiling, are thus complementary. Profiling should be used first to map the area so that the cores can be taken in significant spots. Then the profiling data should be identified with the geological layers from the core sample. Next the extent of the layers established by the coring results should be extrapolated with the sonar to complete the survey.

The results we now report were obtained during a preliminary profiling effort that was made from the deck of the *Winnaretta Singer* in the bay out of Monaco. We used sonar and recording gear made available to Jacques Y. Cousteau's effort by the research committee of the National Geographic Society.

We now present one sample of a seismic profile to illustrate the detailed information obtained with a sonar boomer designed to utilize a short pulse without producing cavitation. We also call attention to a "knee" in the shelf off Monaco at a depth of about 110 m; the "knee" is clearly evident in the sonar record. Several layers become visible on the record when a short-pulse boomer is used; the slanted sediment layers can be identified some 100 m beneath the bottom.

The profile we obtained is shown in Fig. 1. The record (compressed about 10 to 1 in length) was made, with a precision boomer as a sound source, in an area east of Monaco harbor as indicated on the map (Fig. 2). A "knee" in the slope starts at a depth of 110 m (148 msec) and ends at about 150 m (200 msec). Similar knees are located at the positions marked on the map, and similar formations were found at about the same depth off Cap Ferrat near Nice and near Menton. We believe that the knee line runs along a considerable length of this coastline.

The sonar source that was used for this work was a special boomer excited from 48 microfarads at 3500 volts. A 4-mm aluminum plate was solidly