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A BEHAVIORAL PROCEDURE AND 60 HERTZ EXPOSURE SYSTEM FOR DETERMINING FIELD DETECTION BY RATS *

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A new system has been constructed to determine the threshold for detecting 60 Hertz electric fields by the rat. A variant of the Method of Constant Stimuli, which has been studied intensively by other investigators for determining the thresholds of animals to a variety of stimuli, will be used in the present study. The present report describes significant features of both the exposure system and behavioral paradigm designed to study the sensitivity of the rat to 60 Hertz electric fields.

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DISCLAIMER

Detection is generally defined as responding differentially to the presence versus the absence of a stimulus. The differential responding should be under control of the contingencies rather that a direct outcome of exposure to the stimulus itself. The questions "Can an animal detect a 60 Hz electric field?" and "What is the threshold for detecting a 60 Hz electric field?" are not the same as "Does exposure to a 60 Hz electric field affect behavior?" and "What are the parameter values of exposure to 60 Hz electric fields required in order to affect behavior?". Some behavioral effects of exposure to 60 Hz electric fields may involve detection of the field, but there is no logical requirement that a behavioral effect involve detection. The designs of detection experiments generally are different from those demonstrating other behavioral effects. The extent to which other behavioral effects depend on detection of the field has not been examined.

Environmental events can affect behavioral endpoints in many ways. An event can function as a signal or cue for some other event of significance to the animal, and thereby serve to alter the behavior. The present research is designed to determine the sensitivity of a mammal, the rat, to a 60 Hz electric field functioning as a cue. In contrast to other experiments with non-human species that report behavioral effects of exposure to 60 Hz electric fields, in this experiment there is a payoff for detecting the field, and the payoff is under experimental control. This control provides a basis for more adequately determining the sensitivity of the rat to 60 Hz electric fields. Accurate mapping of the psychophysical function provides information needed to interpret other reports of behavioral effects of exposure to 60 Hz electric fields, and to design subsequent studies focusing on mechanisms of action.

This report describes the apparatus and procedure which we will use to study the sensitivity of the rat to 60 Hz electric fields. The procedure, the Method of Constant Stimuli, has been used extensively to determine the sensitivity of humans to stimuli of different modalities including vision, hearing, vibrotactile sensations, and others. In recent years, the Method of Constant Stimuli has been used for mapping the sensitivity of animals such as monkeys and rats to stimuli from different modalities. The procedure we will use is quite similar to that used by Gourevitch [In W.C. Stebbins (ed.), Animal Psychophysics. Englewood Cliffs, New Jersey: Prentice Hall, 1970]) to study the auditory sensitivity of rats and monkeys; basically, it is a detection task. In the absence of a 60 Hz field, a food-deprived rat will engage in one activity which sometimes produces onset of a 60 Hz field, with the rat located in the center of the field. During such a trial, the task of the rat is to engage in a different specified activity which will be interpreted as the "Yes, I detect the field" response. A correct detection response produces a small pellet of food as the payoff for the food-deprived rat. During the initial training, the field strength will be sufficient for easy detection. This will facilitate the rat's learning the task. Then new, lower field strengths will be presented on some of the trials. Eventually, five different strengths will be used during each session. The values will be adjusted until a range of values is determined between those producing almost no detection to those producing almost 100 percent detection. The resultant psychophysical function is one way of describing the sensitivity of the rat to 60 Hz electric fields. The threshold for detection is defined as the field strength at which correct detections are expected to occur on 50 percent of the trials.

Subjects.

Long-Evans male rats, about 90 days old at the beginning of training, will be food deprived and maintained at 80 percent of their free-feeding weight.

Apparatus.

The design of the exposure system is based partially on the system currently in use at Battelle Pacific Northwest, Richland, Washington.

The apparatus consists of a conditioning chamber containing the rat, three aluminum plates with the conditioning chamber centered on the center one, the high voltage power supply with controls, and a computer for on-line control of the experiment and subsequent data analysis. The apparatus has been designed to control events which could occur concomitantly with the field presentation, and thereby serve as cues redundant with the electric field presentation, or in other ways affect responding. Such confounding variables that must be considered when investigating behavioral effects of exposure to 60 Hz electric fields include the following: noise, corona, vibration, and spark discharge.

Conditioning chamber: A 20.3 cm x 20.3 cm x 10.2 cm high chamber containing two levers with a food cup recessed into one wall between them was constructed out of 0.3 cm Lexan and nylon screws. When a lever is pressed, light transmission through a fiber optic cable to a photodetector circuit located outside the 60 Hz electric field is interrupted. When scheduled, a pellet dispenser located above and outside the field drops a 0.045 g pellet through Tygon tubing to the food tray.

Plates: Three 1 m x 1 m aluminum plates are horizontally mounted above each other with a 0.5 m separation. Four acrylic plastic posts support the plates. A 7.6 cm diameter aluminum tube is welded to the perimeter of each plate to provide a corona shield. The conditioning chamber is located at the center of the middle plate.

Isolation chamber: The plates with the conditioning chamber in place are mounted inside a 2.13 m cube (outside dimension) constructed out of plywood and wall board with fiberglass between the walls. The interior walls and ceiling of the chamber are lined with acoustic tiling. The entire chamber, with the exception of the plate electrodes, cables from the transformer, and a small food-pellet dispenser mounted from the ceiling, is metal-free. Windows allow changing ambient light levels and television monitoring of the experiment.

High voltage power supply: The Megavolt Corporation (110 Hobart Street, Hackensack, N.J. 07601) custom built the power supply. A California Instruments LC 1201B 115 VAC line corrector will provide voltage regulation and transient suppression for the high voltage supply. The output of the Megavolt supply will range between 0-60 KV RMS with the value set by using an 8 bit digital-to-analog converter and a motor-driven variac requiring a maximum of 1 sec setting time. The high voltage output will be turned on by digital logic which operates a zero-voltage switch, thus preventing initial transients and undesired waveforms.

Computer: A Digital Equipment Corporation PDP8/A 32K minicomputer system controls the experiment through the use of SKED, a state language.

Densitometry: A field strength meter will be used to calibrate the system and map the field. In addition, a representative of the National Bureau of Standards will provide independent measurements of the system.

Procedure.

The procedure consists of a set of contingencies designed to have the rat report the presence of the 60 Hz electric field. Since the rat is food-deprived, food can be used to train and maintain the desired behaviors. In addition, removal of the opportunity to obtain food can be used to punish incorrect responding.

The chamber contains two levers. Pressing one lever (each of these responses will be called "Rproduce") will produce trial onset with a specified probability. The requirement that Rproduce turn on the field serves three purposes. First, it partially controls the position of the rat at the time of field onset; consistency of orientation reduces one potential source of variance. Second, it may be considered similar to an observing response. Just as a radar operator must watch the scope if blips are to be reported, the rat must "prepare" for field onset. Third, changes in the rate of Rproduce responding may be considered as an index of the value of the payoff, which may change if exposure to the electric field is unpleasant or aversive to the rat. When the rat is in the 60 Hz electric field, pressing the other lever (each of these responses will be called "Rreport") will deliver a food pellet and turn off the electric field. Rreport is the detection response; the "I sense the field" response. If an Rreport response occurs when the rat is not in the field, a pellet will not be delivered; in addition, Rproduce responses will not be effective for the next several seconds. These two contingencies reduce the likelihood of Rreport responses when the rat is not in the field. Although this task is rather complicated for a rat, the final set of behaviors can be established by proceeding through the steps of a well defined training sequence.