A wood-gnawing sensor for recording collateral behavior emitted by rats on differential reinforcement of low rate schedules

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The difficulties in measuring the idiosyncratic collateral behavior emitted by rats on a DRL schedule are overcome by providing woodblocks attached to a sensor. Wood gnawing is recorded by stylus transducer signals. An audio amplifier raises these signals to a suitable level for the operation of a threshold control unit. A pulse former operates the final relay amplifier for 150 msec from the onset of disturbance to the transducer.

It has frequently been reported that where rats are required to space responses in time to gain food reinforcement, as in the differential reinforcement of low rate (DRL) schedule, stereotyped collateral behaviors are also emitted (Laties, Weiss, Clark, & Reynolds, 1965; Laties, Weiss, & Weiss, 1969; Segal & Holloway, 1963; Tierney, 1975). A number of reports demonstrate that collateral behavior mediates successful timing behavior (Laties et al., 1969; Segal & Holloway, 1963; Tierney, 1975).

While most reported collateral behavior has involved the rat's gnawing some element in its environment, the idiosyncratic nature of these behaviors has been a hindrance to research into the role of collateral behavior in mediating successful DRL performance. It was for this reason that a gnawing sensor for recording movement of a block of wood mounted on a fixed steel rod was developed. Gnawing of such a woodblock was found to occur very frequently as a collateral behavior.

DESIGN

The wood-gnawing sensor was designed to be compatible with a Lehigh Valley rodent test cage (Catalog 143-22); this cage was housed in a sound-attenuating cubicle (Lehigh Valley Catalog 132-02).

The device is in three parts: A steel rod 33.0 cm long, .3 cm in diameter, inserted at one end into a block of untreated beech wood (4 x 2.5 x 2 cm) is passed to the outside of both the environmental space and the enclosing sound-attenuating chamber, leaving the block of wood inside the experimental space (Figure 1).

The rod fits into a Plexiglas block mounted on the outside of the sound-attenuation box and is held in place by a retaining screw (Figure 2). Mounted

within the Plexiglas holder is a stylus transducer. A Motorola MFC 8040 audio amplifier raises the transducer signal to a suitable level for the operation of the threshold control unit. A pulse former operates the final relay amplifier for 50 msec from the onset

POSITION OF SENSOR IN TEST CAGE

Figure 1. Position of sensor in test cage.

Figure 2. Detail of transducer mounting in plexiglas block (see legend to Figure 1).

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Figure 3. Momentum required to produce reliable signals with weight on the woodblock.

of a disturbance to the transducer. Such disturbances are labeled "gnaws."

The wood used is beech (*Fagus sylvatica*), a close-grained, short, staple-length hardwood that prevents large strips of wood from being removed from the block, thus permitting unrecorded wood gnawing. Villareal (Note 1) reported that monkeys on a fixed-time schedule of reinforcement chewed strips off of a pine block and ingested them. In the present experimental situation, the wood chips fell through the bar floor onto the refuse tray. It was possible, by carrying out weight comparisons, to conclude that the subjects did not eat the beech wood chips.

CALIBRATION OF GNAWING SENSOR

Initially, the sensitivity control of the threshold control circuit is set at a level that results in collateral wood gnawing being recorded at approximately 2.0 gnaws/sec across the session.

At this sensitivity level, it is possible to calibrate the device using a procedure based on the one reported by Altman and Hull (1973). Using a pendulum (25 cm

long with .5-g mass of putty suspended), the minimum momentum required to operate the device with increasing weight resting on the block is a function represented by the graph in Figure 3. This function is the result of 10 tests at each weight-on-block level. In each test, 10 pendulum swings are made at any selected distance (h) from the block of wood. Providing the sensor operates, more than five but less than nine times this distance is used to calculate the momentum. (Momentum = $m \times 2gh$, where $m = .5$ g and $g = 980$ cm/sec².) The rod is removed and replaced after each test and the mean momentum from the 10 test momenta is taken as representing the average momentum required to operate the sensor.

ADVANTAGES OF THE WOOD-GNAWING SENSOR

The wood-gnawing sensor is unaffected by movements or vibrations other than those that impinge directly on the woodblock or steel rod. Minimum alteration to a standard Lehigh Valley test environment is required. The woodblock and steel rod are easily removed from the Plexiglas holder, thus freeing the test environment for other uses. The beech wood avoids injury to the rat that might otherwise occur if large splinters were broken off.

DISADVANTAGES OF THE WOOD-GNAWING SENSOR

Daily removal of the steel rod results in slight differences in sensitivity level between sessions. This means that very detailed comparisons of wood-gnawing sessions between which the apparatus has been removed are not advised.

During two early experiments of 12-month duration, three subject deaths occurred. Pathological examination of the casualties revealed extensive hemorrhages in the lungs. A nonbacterial pneumonia of chronic nature was diagnosed; it was believed to be caused by prolonged inhalation of wood dust. After the introduction of

Figure 4. Cumulative records of DRL performances (see text for details).

shorter sessions (30 min) and fewer sessions per experiment, no animals died or showed signs of the lung damage.

WOOD GNAWING AS A COLLATERAL BEHAVIOR

In experiments with this apparatus, 35 out of 42 rats exposed to DRL schedules of reinforcement developed stereotyped wood gnawing as a collateral behavior. It was crucial that the wood be introduced into the test chamber on the second day of exposure to the DRL schedule requirements. It was usually during this session that the basic type of the collateral behavior was established. Subjects consistently spent between 92% and 95% of their nonbarpressing time emitting the collateral behavior, once DRL performance had stabilized. Wood gnawing occurred at a high rate and in a very stereotyped manner, both within and between sessions. Disturbances to the woodblock caused by behavior other than gnawing occurred almost exclusively in the first few sessions and were easily identifiable as disturbances that occurred at a very low, irregular rate.

Figure 4 shows a section of the cumulative record of a rat after 46 daily 30-min sessions on DRL 18 sec. The upper record shows the wood-gnawing behavior. Each gnaw stepped the pen up one step. The pen reset after every response. Two consecutive leverpress responses without intervening wood gnawing did not appear on the upper record but did show on the lower record, where each leverpress response steps the pen up one step. A downward "hatchmark" indicates that the response has been reinforced.

This apparatus and a second identical unit have been

Figure 5. Preamplifier circuit (see components list).

Figure 6. Threshold setting and pulse former circuit (see components list).

Table 1

Specification of Cartridge			
ACOS Type GP91		2SC (Mono), Ceramic	
Sensitivity		360 mV at 1.2 cm/sec	
Loading		5-10 g	
Compliance		2 × 10 dyne-cm	
Components			
R1	75 kohm	1/8 W	C1 1.0 microfarad
R2	270 kohm	1/8 W	C2 100 microfarad 6 V
R3	100 ohm	1/8 W	C3 .05 microfarad
R4	110 kohm	1/8 W	C4 .1 microfarad
R5	1 kohm	1/8 W	C5 1.0 microfarad
R6	1.5 kohm	1/2 W	C6 .01 microfarad
R7	270 ohm		C7 .01 microfarad
R8	15 kohm	1/8 W	C8 2.0 microfarad Polycarbonate
R9	2.7 ohm	1/8 W	C9 2.9 microfarad 40 V
R10	1.5 kohm	1/2 W	C10 .1 microfarad Disc Ceramic
R11	40 kohm	1/8 W	D1, D2 IN4002
R12	10 kohm	1/8 W	Relay Coil 28 V, 700 ohm
R13	650 ohm	1/2 W	Relay Points SPST
T ₁ , T ₂	2N929		RV1 5 kohm LIN 1/2 W
555	IC Timer		ZD 15V Zener 800 mW
MCF 8040 IC Preamplifier			

used continuously for a period of 3 years without any failure due to apparatus malfunction. The data accumulated using the device includes information on the effect of increasing the wood-block size, removing the woodblock during a session, the effect of extinction on wood gnawing, and the effect of a multiple DRL 18-sec/DRL 9-sec schedule on wood-gnawing patterns (Tierney, 1975).

SPECIFICATION AND CIRCUIT DIAGRAMS

The sensor used was a standard phonograph cartridge, Ascoco Type GP21-2SC (Mono). A signal output was produced by this device when disturbed by gnawing activity transmitted to it along the length of the steel rod. The signal was amplified by a Motorola MCF 8040 audio amplifier IC (Figure 5) and a 40-msec pulse produced by a 555-IC monostable (Figure 6) for those gnaw signals that exceeded a threshold controlled by RV1 and the Schmitt circuit T₁, T₂.

The cartridge is of the ceramic type that provides a high output and is more resistant to mechanical damage than dynamic cartridges. Ceramic construction provides better temperature stability of output than the older Rochelle salt-type crystal cartridge and has the advantage of being stiff, so that variations in playing weight (i.e., adjustments of the mounting block) have a lesser effect on the output produced.

The MCF 8040 provides a 60-dB gain. This type of amplifier and the use of discrete transistors for the threshold detector allows the unit to operate from a single-polarity standard 28-V dc supply. Cartridge specifications and components are listed in Table 1.

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