TECHNICAL NOTE

A SENSITIVE ACTIVITY TRANSDUCER¹

This note describes a flexible, highly sensitive, and fairly inexpensive apparatus for recording movements of laboratory animals. Unlike many types of stabilimeters, it registers even very small movements, such as an ear twitch or a head turn. An additional advantage is that the magnitude of each movement can be reflected in a polygraph record, allowing an accurate comparison of activity patterns.

This activity transducer was designed to record any increase in small motor movements of a rat, *e.g.*, quivering or sniffing, resulting from an injection of a central nervous system stimulant, magnesium pemo-line, (Beach and Kimble, 1967). Such small movements are not recorded by the usual sort of stabilimeter, for instance, those activated by making or interrupting photoelectric or microswitch contacts, which requires that the animal change location or at least move enough to tip its cage. Later, the present apparatus was used to compare the responses of hippocampally lesioned and normal rats to a buzzer. This was a comparison of habituation in these rats, and systematic observations were made to determine when the rats no longer moved at all when the buzzer sounded. Figure 1B shows the recording of a small ear twitch with which the rats responded to the buzzer just before this final, very small, motor response also disappeared.

Output from the polygraph recordings has been quantified by measuring excursions of the pen with a device used to measure distances on a map (available at stationary stores), or by simply counting squares on the polygraph paper; a Beckman Type 9852 EMG Integrator has also been used. However, there are other, more convenient, but more expensive devices commercially available for quantifying polygraph data that would also be appropriate. The output of this activity transducer can also be used to activate an electronic counter rather than, or in combination with, a polygraph.

The heart of the activity transducer is an RCA Type 5734 Mechano-Electronic Transducer Tube. This

tube is a small (0.5 by 2.5 cm) triode. The plate of the tube is supported by a diaphragm, and the plate shaft extends through this diaphragm outside the tube housing. A small weight on the end of a short glass or metal rod is attached to the plate shaft in order to obtain sensitivity in all three dimensions as the tube housing moves. (A glass tube was used onto which 2 g

Fig. 1. Polygraph record of 350-g rat's responses to buzzer. Initially, rat was lying quietly and did not rise during these recordings. Top trace is event marker recording buzzer presentation; bottom trace records movement. (A) Startle response to initial buzzer presentation followed by sniffing and head turns; second and third buzzer presentations elicited mild orienting responses. (B) Ear-twitch responses as rat approached habituation to the buzzer, *i.e.*, just before that final, very small motor response also disappeared.

¹The activity transducer is now available through Adak Electronics, 988 Baxter Street, Eugene, Oregon 97402. The completely assembled and tested unit sells for \$195.00 F.O.B. Eugene, Oregon. (The total retail cost of material is estimated to be about \$85.00.) I thank Lee Vernon of this company for technical assistance. This research was carried out with the support of PHS grant MH-08545-03, D. P. Kimble, principal investigator. Reprints may be obtained from the author, Psychology Department, Rockefeller University, New York, N.Y. 10021.

of softened wax had been pressed. Fig. 2) A movement of the plate shaft 0.5° from center will produce an output on the order of a 100 mV change within the vacuum tube itself. The principal of operation in this transducer is that of a Wheatstone Bridge in which the RCA Type 5734 Tube is the active element. The dc balance controls, 10 K ohm and 100 K ohm potentiometers, (Fig. 3) are null balancing potentiometers in the Wheatstone Bridge.

Fig. 2. Dimensional drawing of transducer tube and glass rod attached to its plate shaft. Both length and flexibility of rod, as well as amount of wax on the end of rod, can be varied according to individual requirements for balance and sensitivity.

The maximum frequency response is governed by the physical construction of the RCA Type 5734 Tube, and particularly the diaphragm supporting the plate shaft. With suitable mechanical coupling to the external end of the plate shaft, measurements of vibrations up to 12,000 cycles per second are possible. The upper limit of the frequency response in the present application will be determined by the length of glass tubing or metal rod used as a support for the weight. The glass tubing can be attached to the plate shaft with Epoxy, while the metal tubes or rods can be attached with solder or with small set screws. The mass of the cage and the type of resilience of the cage mounting system will also affect the frequency capabilities of the entire system.

The output from the Wheatstone bridge can be led into any recording device containing a differential amplifier, e.g., a polygraph or a cathode ray oscilloscope. Although it is not necessary to use a recording or indicating device with differential input, the sensitivity of the system will be reduced by about one third when a non-differential amplifier is used. For maximum sensitivity, the use of a differential input type pre-amplifier is recommended.

For ease in changing from one cage to another, the tube with its pendulum can be housed in a sealed metal cylinder (about 2 by 10 cm), which can be fastened to

Fig. 3. Circuit diagram for the activity transducer. The RCA Type 5734 tube must be insulated from the metal box in which it is mounted. Potentiometers are null balancing controls of the Wheatstone Bridge whose active element is the #5734 tube. This circuit was designed to be used with a recorder containing a differential amplifier, and, therefore, no dc ground is provided in the circuit.

the cages by spring-clamp fuse holders. Conceivably this cylinder, weighing approximately 50 g, could be attached directly to a collar or harness worn by the animal with the use of adequate shields and suspension for the attached wires. Also, the harness or collar would have to be insulated to protect the animal from the heat of the tube. The tube was mounted in a small metal box that clamped to the outside of the cage.

Any cage can be readily modified for use with the apparatus. The one used was a 27.0 by 20.5 by 20.5 cm wire rat cage. A 30.0 by 30.0 cm false bottom containing a litter tray was attached to the cage. Each corner of the cage rested on a foam-rubber pad 2.5 cm thick and was partially supported from above by a small spring attached to a ring stand.

Depending on the size of movements to be recorded, the sensitivity of the apparatus can be adjusted by using springs or elastic bands of different tensions or by varying the thickness and placement of the foam-rubber supporting pads. More precise adjustments can be made by varying the length of the glass or metal pendulum or the amount of wax with which it is weighted.

Any system used to measure physical movement of a cage containing an animal will have limitations in its linearity. Most of these limitations are found in the suspension methods used to support the cage and still permit movement of the cage when the animal moves. Use of elastic bands or sponge-rubber pads will introduce some non-linearity due to the elasticity of the rubber plus the mass of the cage. However, non-linearity would be a problem with this apparatus only if it

were necessary to record both very large and very small movements simultaneously. Use of the various bridge transducers that are available, requiring physical connection between the transducer mount and the cage, imposes limitations on the physical movement of the cage due to the limited travel allowed in the transducer housing.

Variation in the mass of different animals will affect the frequency and magnitude, but not the registration of vibrations of the present apparatus. The changes in signal magnitude arising from substituting different sized weights on a pendulum type metronome or a similar device, which are suggested for calibrating and adjusting the system as a whole before each use, might be used to estimate changes in signal magnitude with animals of varying weights. However, we simply matched the weights of experimental and control

groups as a control for this variability. If it proves feasible for the animal to wear the transducer tube, the problems regarding signal linearity and also signal variation with animals of different weights would be reduced.

While this apparatus has been used only with rats, it should be appropriate for recording the movements of other animals as well.

REFERENCES

- Beach, G. and Kimble, D. P. Activity and responsivity in rats after magnesium pemoline injections. *Science*, 1967, 155, 698-701.

GARNET BEACH
University of Oregon