*A METHOD FOR CARDIAC RECORDING FROM
SURFACE ELECTRODES IN THE RAT DURING
FREE-OPERANT PROCEDURES¹*

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While cardiac records in the rat may be taken by subcutaneous electrodes (Word, Stern, Sines, and McDonald, 1959), we have been using in some studies (Snapper, Ferraro, Schoenfeld, and Locke, in press) an adaptation of the belt or body strap electrode technique employed with larger animals (Wenzel, 1961; Gantt, 1964). The technique has been used with 15 rats for periods ranging up to 11 months and has been found to be a simple, reliable, and inexpensive EKG pick-up method. An important advantage of the method is its suitability for use during free-operant conditioning experiments.

The belt holds stainless steel electrodes against the thorax after depilation of the skin. Hair removal is done either by shaving or by use of a cream, although shaving has been found to be preferable because it is fast (1 min with electric razor), less irritating to the skin (which may be reddened by creams), and easier to do (no washing away of cream is involved). For long term experiments, shaving usually need not be done more often than once a week. At first, the animal may need to be restrained by one lab worker; after a time, animals become docile enough to be handled and shaved by one person alone. Shaving is done in a band, about $\frac{1}{2}$ in. wide, completely around the body between the shoulder blades and the end of the rib cage (the back is shaved to avoid catching hair in the belt buckle).

The belt is a nylon wrist watch strap, and is affixed with the buckle at the animal's back. The pick-up electrodes are small (11.0 by 3.0 by 0.45 mm) Michel wound clips cinched into the strap. Wires soldered to the backs of the wound clips are led along the back of the strap and taped down with waterproof electrical

tape to prevent shorting due to saturation of the belt by electrode paste. A length of coil spring is soldered to the belt buckle and is attached to an overhead swivel point in the roof of the experimental chamber. The wires are led through the spring, providing freedom of movement and protection for the leads. Shielded cable is advisable between the leads and the input of the EKG amplifiers. The two electrodes are placed in the middle of the belt about 1 in. apart, and, if desired, a third (indifferent or ground) electrode may be added at one end of the belt. The strap is positioned so that the electrodes are equidistant from the thoracic midline. While optimal electrode placement may vary a bit from animal to animal, heart position in the rat is close to midline and does not shift as much with bodily movement as it does in the dog. We have been using a standard EKG paste as electrode jelly; it is used sparingly to avoid smearing along the belt or skin with subsequent short-circuiting between input leads.

The strap is held firmly against the skin, but not so tightly as to squeeze the animal unduly. This prevents the two difficulties of animals fighting the belt, and of recording artifacts of respiration or bodily movement. The animals readily become accustomed to the process of placing the belt, and to wearing it, so that the belt can be fastened by one person in less than a minute. Some animals even learn to cooperate in the process (*e.g.*, by standing up and resting their forepaws against a wall to facilitate belt fastening) somewhat in the manner of dogs when placed into the typical harness used in Pavlovian conditioning experiments. Reliable EKG signals can be obtained for 48 hr following belt placement. After this time, dehydration of the electrode paste may cause a high resistance contact between the electrodes and skin surface with a subsequent loss of signal.

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RAT 63 BASAL LEVEL **RAT 67 DRL 1Min**

Fig. 1. Typical EKG waveforms obtained from two male albino rats about 110 days of age using the belt technique described in the text. A Grass EEG machine (model 3D) was used to record from left to right at a paper speed of 60 mm/sec. The top record was obtained during resting conditions and the bottom record during a DRL 1-min reinforcement schedule. The arrow at R indicates the point at which a lever press response was made.

To prevent noise interference or signal loss when recording during operant procedures, several precautions should be observed: (a) manipulandum, box walls, reinforcement dispenser, and any other surfaces with which the animal may come in contact, should be made of non-conducting material or covered with an insulator such as sprayed plastic coating; an exception is the grid floor of the experimental chamber, if the grids are small enough and are not connected to shock conductor cables; (b) the experimental chamber should be enclosed in a grounded metal shell for shielding. It may be noted that if this is done, the indifferent electrode mentioned above is no longer necessary. Care should be taken to shield any ac wires (such as those leading to lights or ventilators) near the box.

Signal amplitude picked up by this method from a mature rat is of the order of 0.50 to 0.75 millivolts, and is comparable to that obtained from implanted or subcutaneous electrodes. Amplification by about 1000x provides a signal suitable for digital recording; we used a standard BRS Schmitt trigger, but many alternatives are possible.

Typical EKG waveforms obtained using the belt technique are presented in Fig. 1. The

record segment for Rat #63 was taken on the 30th day of basal cardiac level observation under constant conditions during successive daily exposure to an experimental chamber (Snapper *et al.*, in press). The record from Rat #67 was taken after behavioral stability had been reached on a DRL 1-min schedule for milk reinforcement. The suitability of the belt technique for use during free-operant conditioning experiments is indicated by the noise-free records obtained and by the lack of recording artifacts during lever pressing activity.

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