Programmed presentation of pure tones of different frequencies using a single oscillator

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A simple and inexpensive method is described for the programmed presentation of pure tones of different frequencies using a single oscillator.

In studies of differential conditioning and stimulus generalization using tonal CSs, the presentation of pure tones of differing frequencies is usually accomplished by (a) handsetting a single oscillator before each presentation, or (b) relay selecting a different oscillator for each frequency to be presented. A simple and inexpensive method is described here for relay selection of different frequencies using only one oscillator. The method is not new but seems to be unfamiliar to psychologists, judging from our survey of techniques reported in psychological journals.

The oscillator (General Radio 1311-A Audio Oscillator, cost: \$215) has a built-in amplifier and features a 1-W output at 11 frequencies, from 50 to 10,000 Hz. It occupies one row of a standard 19-in. relay rack when mounted with the 480-P308 Adapter Plate Set. A front-mounted switch normally selects a particular frequency by connecting one of 11 pairs of matched resistors ($R_{int.}$ in Fig. 1) in an RC Wien-type network.

A three-pole, double-throw switch (S), user inserted between the resistors and the rest of the oscillator circuitry, permits selection of either the resistors ($R_{int.}$) provided in the oscillator (normal mode) or external resistors ($R_{ext.}$) provided by the user (external mode). Since the user provides his own resistors in the external mode, the number of frequencies he can select is limited only by the number of resistor pairs available.

In determining the resistances that produce different frequencies, it is helpful to know the relationship between resistance and frequency in the General Radio oscillator.

Within the range of 50 to 10,000 Hz, $R = 1,605,000/\text{frequency in Hz}$ where R is the resistance in ohms of each resistor in the matched pair. An empirical check on this formula suggests that if 1% precision resistors with a 1-W rating are used, one can predict with 1% accuracy the frequency that the user's resistors will produce. If greater precision is required, resistance can be added to or subtracted from this first approximation and the resultant frequencies checked with an oscilloscope or frequency counter.

A convenient device for holding the user's resistors is the Massey-Dickinson resistor holder (Model ch-94, Massey-Dickinson Co., Saxonville, Mass.). The holder plugs into banana jacks which constitute the wiring points; thus, an entirely new range of frequencies can be set up very quickly by plugging in a different set of resistors.

Figure 1 shows a circuit in which either of two frequencies may be relay selected if Switch S is in the down position (external mode). In this mode, the oscillator circuitry is led through relays (K_1 and K_2) to the user-provided resistors ($R_{ext.}$). If K_1 is operated, the circuitry is connected to $R_{ext.1}$, which determines one of the two frequencies. If K_2 is operated, the circuitry is connected to $R_{ext.2}$, which determines the other frequency. When neither relay is operated, the speaker is disconnected from the oscillator output and is replaced by a dummy load (R_d). Although $R_{ext.2}$ is still connected to the oscillator circuitry when the relays are unoperated, it now serves only as a dummy load across the frequency-determining inputs. Its purpose in this application is simply to maintain a load across these inputs thereby eliminating the delay between relay operation and tone-onset which would otherwise occur. $R_{ext.2}$ is used instead of a new resistor to save parts.

When K_1 is operated, the speaker is connected directly to the oscillator output; but when K_2 is operated, the speaker is connected to the oscillator output through a resistor (R_c). The purpose of R_c is to compensate for speaker nonlinearities,

Fig. 1. Circuit diagram showing method for connecting oscillator to controlling resistors.

which may cause differences in amplitude of the two frequencies. Thus R_c is used only if it is desired to equate the amplitudes of the different frequencies. (One-ohm-per-inch

resistive wire serves well as R_c .) To vary amplitude in discrete steps within one or more frequencies, additional relays and resistors (not shown) can be added.

A convective thermal controller for behavioral experiments

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The Convective Thermal Controller (CTC) is designed to provide rapid and precise control of a thermal stimulus for application to behavioral experiments with small animals. Subjects are bathed in one of two continuously recirculating air systems; two valves determine which of the systems play on S. When the systems are stabilized at different temperatures, actuation of the valves can produce an abrupt and stable temperature change in .3 sec. Behavioral observations indicate that escape learning occurs readily; latency decreases monotonically with drive intensity and increases monotonically with reinforcement duration.

The most general requirement of any device designed to control temperature is that it allow the rate of temperature exchange at the surface of an experimental organism to be varied with speed and precision. Most devices fail to meet this requirement in several ways. The first is speed of action. When a heat lamp or heating coils are used to heat an animal in a refrigerated environment (Weiss & Laties, 1960; Carlton & Marks, 1958), the termination of the radiant energy may be sufficiently abrupt when the heat source is turned off, but the air surrounding the animal has also been heated and it therefore will slow the return of the environmental temperature to the cold condition. A slowly changing thermal stimulus may have some application, but for most conditioning situations, a rapid acting system would be preferred. Another problem arises with the mode of application of a thermal stimulus. Several means of transferring heat to and from an animal have been used: convection with hot and cold air (Thorpe & Corbit, 1968), forced convection cooling (Matthews, 1968), radiant heating, and even evaporative cooling by showering a heated animal with a water spray (Epstein, 1968). Radiant heating and evaporative cooling are useful for changing temperature in one direction, but not in the other. A S can be heated but not effectively cooled by radiant energy. Similarly, it would be impractical to attempt to maintain a cool environment by continuous evaporative cooling. The result of this asymmetry is that comparisons of behavior in the presence of hot and cold conditions are confounded by procedural differences. Furthermore, it is difficult and sometimes impossible to calibrate the cold and hot stimuli on the same scale. A third difficulty involves the stability of the stimulus. A radiant lamp directed at a rat heats not only the rat but the air surrounding him. There is, therefore, an instantaneous and stable effect of the radiant heat, an; a slow increasing convective heating effect through the air. A more serious difficulty, however, is that radiant heat transfer occurs only at exposed surfaces, so that portions of the animal not directly exposed to the lamp will not be heated, except through conduction and convection.

Recently we have developed an apparatus to circumvent these difficulties. Although it is more complicated than previous devices, it satisfies the important requirements of thermal control.

THE APPARATUS

The Convective Thermal Controller (CTC) is essentially a forced convection system in which the animal is bathed in air of a controlled temperature. The application of this principle was suggested by John D. Corbit who found that rats will turn off a fan which circulates cold air around them (Matthews, 1968). In the present application, air circulates continuously over the animal but the temperature of the air is varied. Two continuously circulating enclosed air systems are arranged so that one system is circulating over the animal while another is circulating through a shunt. This arrangement is presented schematically in Fig. 1. When the valves are actuated, the air stream which had been flowing over the animal is directed through the shunt, and conversely, the system which had been circulating through the shunt is rerouted through the chamber. The function of the lower valve is to redirect the air emerging from the chamber and the shunt back into the correct source. The systems are enclosed so that there is neither mixing of temperatures, nor contamination of the room temperature with that of the system. In addition, greater maximum and minimum temperatures can be maintained. When the two systems are at different temperatures, the temperature surrounding the animal can be altered from one stable value to another in the time it takes the valves to change position, and the air to pass from the valve to the animal.

The overall design has several useful features. (1) The rate of change of temperature of the air is independent of the temperatures being presented and is only a function of the wind velocity and valve action time. (2) The temperature surrounding the animal is stable almost immediately after a switch is made and remains so indefinitely. (3) Under all conditions the mode of heat transfer is convection which produces more uniform exchange of heat at the surface of the animal. (4) All stimulus conditions are measured on the same scale, the temperature of the air in degrees. (5) The system is essentially modular. If it is desirable to present more than two temperatures to the animal, this is accomplished by adding an additional pair of valves for each new temperature condition.

Fig. 1. Schematic view of CTC. Solid line arrows indicate flow of hot system, dashed line arrows indicate cold system flow.