INSTRUMENTATION & TECHNIQUES

Two apparatus assemblies for the study of real movement¹

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Two forms of apparatus are described for the study of real movement. The first is characterized as a hydraulic system and is used where the S's rate of movement threshold is to be determined. The basis of the apparatus is a hydraulic cylinder with a piston rod carrying a crosspiece with a visual stimulus attached. The piston-crosspiece assembly is raised by charging the apparatus with oil, which is then discharged back into a reservoir through a finely tapered adjustable needle valve. Velocity of motion may be regulated by varying the needle valve opening or a mass placed on the piston. The second apparatus is useful for determining the displacement threshold, the minimal distance through which a change of stimulus from one position to another can be perceived. The apparatus consists of a cathode ray display of a linear change of voltage from one value to another. Both total displacement and rate of displacement are adjustable. The S views the cathode ray trace through an optical system designed to minimize perception of extraneous motion.

This account describes two forms of apparatus for the study of real movement. The first is characterized as a hydraulic system. It is used where very slow movement and independent illumination of background and test object are appropriate; it is particularly useful where absolutely dark backgrounds are required. The second, a cathode-ray apparatus, is valuable where a great range of speeds is required and the test-object luminance and background luminance can be maintained in constant ratio or readily adjusted by a simple operation, as for example, adding the same luminance to each. The cathode-ray apparatus is extremely useful for determination of displacement thresholds where one would like to measure threshold displacements from a stationary condition, the displacement occurring at different rates and conditions of the stimulus object. (See Graham, 1965.)

THE HYDRAULIC SYSTEM

The hydraulic apparatus, diagrammed in Fig. 1, is particularly valuable as we have used it, where threshold rate of movement is determined by overall adjustment of the velocity of the moving object.

Rate threshold is the determination of the minimum velocity at which a given target under given conditions will be perceived as moving. Apparatus for making such determinations should have the following characteristics: (1) fairly wide range of velocities, (2) smoothness of action, (3) long stroke with uniform velocity, and (4) independent control of background and test-object variables. The basis of the present apparatus is a hydraulic cylinder of 7/8 in. bore and 12 in. stroke with a lapped piston and no packing. The cylinder is mounted vertically with the piston rod at the top. A cross-piece which carries the stimulus target is

attached to the piston rod. Compression is provided by weights varying from 5 to 20 kg suspended from the cross-piece in such a manner that they are below the cylinder assembly. The piston-crosspiece-weight assembly is raised by charging the apparatus with oil by a motor-driven gear pump working through a one-way swing check valve. The oil is then discharged back to a reservoir through a finely tapered adjustable needle valve. Velocity of motion may be regulated by varying the viscosity of the oil, the mass placed on the piston, or the needle valve opening. The principle involved is the opposition of the viscous friction produced by the oil flow through the needle valve to the constant pressure provided by the suspended mass. Aside from regulation, this arrangement provides a large amount of damping which is necessary to obtain smooth motion at low velocities.

Velocity is monitored by a timer operated by two limit switches spaced a known distance apart. The useful range of velocities provided by this apparatus is from about 0.01 in./sec to 2.0 in./sec.

Fig. 1. Diagram of hydraulic system. See text for explanation. E, eye; C, cylinder; T, tube; DP, dove prism; G, reflecting glass; O, opal glass surface illuminated for background; BF, background figure; PO, pair of polaroid sheets; MS, moving stimulus; FR, frame for holding stimuli; LB, light tight box; F, filter box; OG, opal glass; B, brass plate in which is cut the moving slit; P, piston; N₁, overflow for fluid which has leaked past the piston; N₂, neoprene tube for circulation of hydraulic fluid; W, weights; V, ball-check-and-needle valve; R, rod connected with top of piston.

Fig. 2. Electronic circuit for cathode ray apparatus.

The stimulus test object, made photographically on a high contrast plate, is carried on a frame attached to the piston, as is the light that illuminates the stimulus pattern from behind an opal glass plate; the latter "backs" the stimulus plate. Thus, by these arrangements the Ss in the experiments are presented with a vertically descending moving stimulus whose rate of descent can be varied by means of the hydraulic regulating system. A circular background field, 13 deg in diameter, was, in most experiments, presented optically so as to be coplanar with the moving stimulus. The latter appeared on the background as a brighter object in a somewhat dimmer field.

THE CATHODE-RAY APPARATUS

Given an object moving from one stationary position to another, the threshold displacement may be defined as the minimum distance through which this change of position can be perceived.

The present method of measuring such thresholds involves a stimulus which maintains a constant velocity in moving from one point to another. Because of the need for precise control and specification of small distances and times, as well as the high accelerations involved, mechanical devices are not feasible in this application.

The apparatus consists of a cathode-ray display of a linear change in voltage from one value to another. The trace is at first stationary, then moves with a constant velocity to another point, at which it again becomes stationary. Both total displacement and rate of displacement are adjustable. The trace, of course, appears

against a background of phosphorence. A P-11 phosphor is used to provide high luminance with fast decay.

The essential components of the electronic circuit controlling the cathode ray trace are shown in Fig. 2. When S_2 is opened a capacitor (C_2 to C_{10}) is charged through a constant current source, V_a . As the potential across the charging capacitor increases, the grid of V_a goes increasingly positive, increasing the conductivity of the tube and thus compensating for the normal charging of a capacitor, transforming it to a straight-line function. The rate of charging (deflection) is adjusted by r_3 in conjunction with C_2 - C_{10} . Provision is made for an external capacitor, either to provide extremely low deflection rates, or to be left unconnected, so as to provide the fastest possible rate of deflection for a given scope rise time and connecting cable capacitance.

Closing S_2 discharges the capacitor, resetting the circuit.

The output voltage is regulated by V_b , diode-connected with the cathode positively biased. When the plate voltage reaches the cathode potential the tube conducts, thus limiting the plate voltage. Total potential change is controlled by helipot r_5 in conjunction with r_6 or r_8 .

The device is connected to the vertical deflection system of a scope. Initially, the S presented the stimulus to himself by pressing a microswitch, S_2 . In order to reduce autokinetic effects resulting from manipulation of the switch, a time-delay was incorporated at S_2 to provide a short interval (0.1 sec) between switch closure and stimulus onset. A shutter blanks the stimulus during the reset cycle.

Fig. 3. Optical arrangement and stimulus field for experiments on displacement thresholds. L_1 & L_2 , objective lenses; L_3 , field lens; L_4 & L_5 , condensers; L_6 , eye lens; D , diaphragm; S , object (scope face); I , image plane; G , beamsplitter; f , background field stop; A , background pupil stop (conjugate with iris); C , colored glass (color temperature correcting); O , opal glass; B , light bulb; F , neutral filter; E , eye.

The stimulus light can be either a round dot or a line with axis parallel to the direction of motion. The line is obtained by feeding the output of a linear sweep generator into the appropriate deflection plates of the CRT, and using a high repetition rate (1323 sweeps per sec). The line length is varied by altering the peak voltage of the sweep generator.

The (nominal) luminance of the fused stimulus was measured by an SIE photometer, which has the advantage of making matches in a very small illuminated area. The final calibration of the excursion rate during displacement was made directly on the scope display. The external deflection signal to be calibrated was left attached to the vertical input. A sine wave from a calibrated oscillator was fed into the horizontal plates. The frequencies of such signals were properly chosen and the wave amplitude increased to facilitate wave-number counting. A mm scale was

taped on the scope face vertically beside the signal. Photographs were then taken of single operations of the ramp function generator. By counting the number of waves extending over a given distance in mm, the rate of excursion could be computed. Rates so obtained were used to state the rates of excursions of the stimulus.

In order to calibrate the chosen sweep frequency which formed the visual signal appearing as a fused line, an external sinusoidal signal from an oscillator was introduced through the Z-input to modulate the line intensity.

When the frequency of this external signal was set at an integral multiple of the chosen sweep frequency, a standing wave pattern of bright lines and dark interspaces was present.

By measuring the synchronized signal with an electronic counter, the chosen sweep frequency was computed to be 1323 ± 2 cycles per sec. At this frequency the sweep was, for all stimulus lengths, seen as "fused."

The S views the stimulus S through the optical system of Fig. 3 [with its various lenses (L_1 to L_6)] designed to minimize the possibility of extraneous perceived motion. The image of the target I is in the same optical plane as the field stop F , thereby eliminating parallax. This arrangement has the result that a 15 deg circular background of white light (color temperature 5500 deg K) is seen after reflection by the mirror G in the same plane as the CRT trace. Baffles are used to reduce stray light, so that the lens mounts and barrels cannot be seen. The exit pupil of the surround is 12 mm; that of the target is slightly larger. The large exit pupils are used so that small movements of the S's head do not result in apparent changes in the visible field. A mouthbite locates and supports the head. Positioning adjustments are carried out with a small diameter diaphragm, D , at the objective lens, which decreases the exit pupil and thereby assures centering of the eye.

REFERENCES

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NOTES

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Operant behavior in the great horned owl¹

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An apparatus and method successful in producing free operant behavior in a Great Horned Owl are described. Key pecking responses were reinforced with balls of ground beef. Some sample data are shown.

The owl is a potentially interesting S for operant studies of vision and audition, since both of these senses appear to be involved in food-getting behavior under nocturnal conditions. Hecht & Pirenne (1940), Walls (1942), and Dice (1945) have