APPARATUS

A MULTIPLE S–R APPARATUS FOR HUMAN LEARNING

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In the study of human learning, it is often desirable, when conducting a variety of experiments, to make use of a highly standardized situation which also permits the manipulation of a number of independent variables. Especially in the study of individual differences in learning, it is important that many experimental parameters be constant throughout variations in the particular independent variables under investigation. It is also essential that there be a high degree of uniformity and dependability in the procedures when many *S*s are put through the same experiment.

To meet these requirements, an electrical apparatus has been constructed which permits a wide variety of uses in experimental research on human learning.[1] It is called a multiple S–R apparatus because of its three essential features: (1) It is capable of presenting, in any desired sequence at any desired time-intervals, a variety of visual stimulus-objects (numbers, letters, words, nonsense-syllables, figures, pictures, colors, etc.); (2) it delimits *S*'s repertoire of responses by having him respond by pressing buttons which can be varied in number and in spatial arrangement; and (3) it delivers 'feedback' or 'reinforcement' on any desired schedule. The procedure for any particular experiment can be unfailingly uniform for every *S*, since the entire experimental procedure (*i.e.* the sequence of stimulus-materials and the schelule of reinforcement) is completely controlled by a program which has been coded on teletype-tape.

The apparatus has all the capabilities of the conventional memory-drum, and many more. For example, the sequence of stimulus-objects may appear in a completely random order for an indefinite number of presentations. A greater variety of objects can be presented, since they do not appear in a narrow aperture, as in the usual memory-drum, but are projected on a screen. Anything that can be photographed can be presented. *S* may respond verabally, as in the conventional memory-drum experiment, but

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often it is desirable clearly to define and delimit *S*'s repertoire of responses. This the apparatus does by requiring *S* to respond by pressing buttons, which can be labeled as desired and varied in number and arrangement. The response-alternatives (push-buttons) are so connected with the stimulus-objects that certain S–R connections will result in 'reinforcement' (either a 'bong' or a green light). The apparatus is especially suitable for experiments on selective trial-and-error learning, schedules of reinforcement, paired-associates learning, serial learning, discriminative learning, recognition of symbols, probability-matching, concept-attainment, simple problem-solving, and, in general, for any type of experiment in which *S* must learn multiple responses to multiple stimulus objects.

The apparatus consists of four units: (1) the teletype-tape distributor, (2) the stimulus-display unit, (3) *S*'s response-panel, and (4) *E*'s control-console. *S* is alone in one room with only the stimulus-display unit and the response-panel, while *E* is in an adjoining room (with an intercom and one-way vision window) containing the teletype-machine and the control-console. The parts of the apparatus to which *S* is exposed are completely silent in their operation, there being no mechanical parts. *S* is thus completely free from any environmental distractions and may concentrate solely on the stimulus-objects and responses essential to the experimental task.

A primary concern in the design of the apparatus was high reliability of performance. This has been achieved. The relays, the teletype 'reader,' and the stimulus-display unit all are of the highest quality commercially available; they were, in fact, perfected for durability and dependability in uses involving much greater stress and strain than would ever be demanded of the present apparatus.

Description of the Apparatus

Teletype-tape distributor. Each stimulus-object presented by the stimulus-display unit is coded on a five-hole teletype-tape. The sequence of stimulus-presentations for the entire experiment is punched on the tape. Reinforcement for the 'correct' response is also programmed on the tape, hence any desired schedule of intermittent reinforcement is possible. The tape holes are read sequentially by a standard Western Union teletype-distributor, shown in Fig. 1. A 4-relay tree provides a 16-character readout code. Holding contacts retain the coded character for a duration that is set on *E*'s control-console.

Stimulus-display unit. This unit, shown in Fig. 2, consists essentially of an In-Line Digital Display unit (Series 80,000) manufactured by Industrial Electronic Engineers, Inc. It has been modified by cutting a slot in the side of it so that the entire set of stimulus-objects may be readily changed by removing the plate of 12 condensing lenses to which the objects are attached.

The objects appear singly on a solid, black background at the center of the 3¼ × 5¼ in. display-screen. They are sharp and clear and, if they are numbers, letters, or words, may usually be read from a distance of up to 100 ft. (The object being presented in Fig. 2 is a blue triangle.)

Fig. 3 shows the construction of the stimulus-display unit. It is actually a set of

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12 miniature projectors, each of which can be activated, via the teletype-tape distributor, either independently or in combination with the other projectors. Any object that can be photographed can be presented; negatives of the photographically reduced images are fastened to the plate of condensing lenses (G in Fig. 3). Either colored or black-and white images are possible. The projectors are illuminated by twelve 24-v. lamps (II, 12, etc. in Fig. 6). Diodoes (D1 and D2 in Fig. 6) permit the negative 24-v. power from the relay-tree to light the lamps but block the 175-v. positive 'error bias.' The duration of stimulus-display, which can be set on *E*'s console, are controlled by a 6D4 vacuum-tube relaxation-oscillator which closes a relay

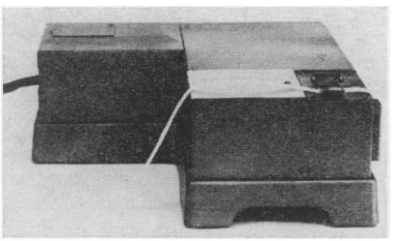

FIG. 1. WESTERN UNION TELETYPE-TAPE DISTRIBUTOR

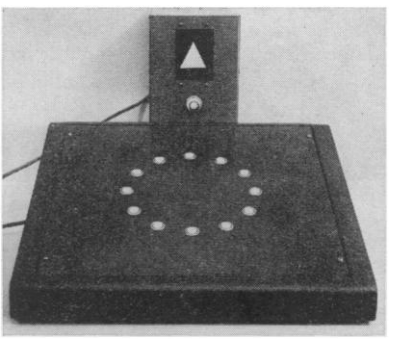

FIG. 2. THE DISPLAY-UNIT

in the 'pacing interval-timer' (Fig. 6). This relay also actuates the 'total stimuli' counter of *E*'s console and advances the teletype-tape.

Directly below the display-screen is the signal of reinforcement, a green light which goes on the instant *S* makes a 'correct' response. With machine-pacing, the light comes on when the button is pressed and stays on until the end of the machine-pacing interval (*i.e.* 2–10 sec.). Under subject-pacing, the reinforcement-light stays on 1½ sec. regardless of the duration of *S*'s response. A single doorbell 'bong' is contained in the display-unit, and the sound of the 'bong' may serve as the reinforcer instead of the light. The mode of reinforcement (*i.e.* visual or auditory) is controlled by a switch on *E*'s control-console.

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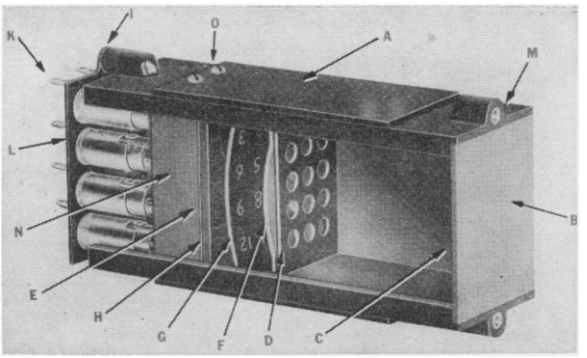

FIG. 3. INTERIOR OF THE DISPLAY-UNIT

(A) Heat-radiator—aluminum alloy. (B) Viewing screen, lucite. (C) Diffusion coating on inner side. (D) Mask to stop stray light. (E) Gasket—commercial grade, gray vulcanized fiber. (F) Projection-lens, lucite. (G) Condensing lens, lucite; stimulus-objects on concave surface. (H) Heat-absorbing glass to remove infra-red rays. (I) Spacer for ventilation of lamp. (K) Stimulus-object terminal (12 available). (L) Socket-assembly. (M) Case—Dow Chemical #440, high-impact, high-heat resistant polystyrene. (N) Metal light-shield and heat-sink. (O) Aluminum screw connects heat-sink to radiator.

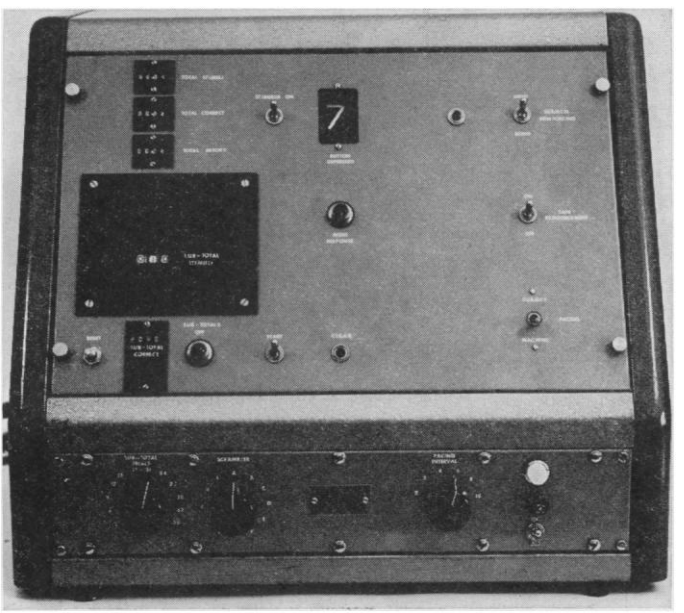

FIG. 4. EXPERIMENTER'S CONTROL-CONSOLE

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S's response-panel. *S* responds to each presentation of a stimulus by depressing one button in an array of push-buttons. A circular array of 12 buttons is shown in Fig. 2, but the panel into which the push-buttons are plugged can readily be removed and replaced by other panels having different arrays and different numbers of buttons. Each button can be plugged into a panel resembling a PBX telephone-

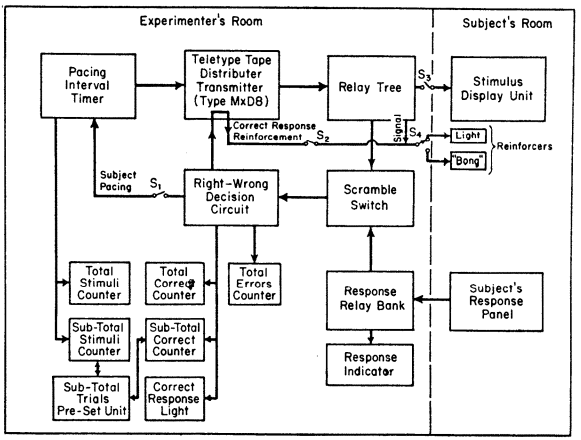

FIG. 5. MAIN COMPONENTS OF THE APPARATUS

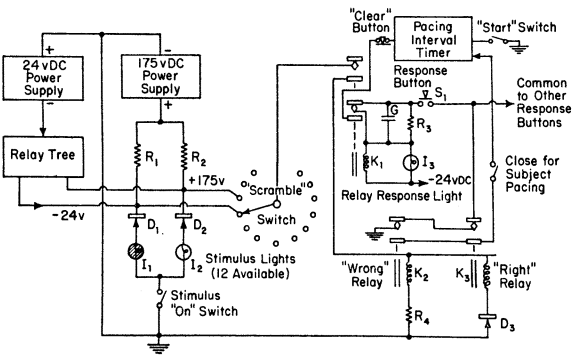

FIG. 6. THE MULTIPLE S–R CIRCUIT

switchboard underneath the response-panel. The push-buttons are flat-topped that labels may be easily attached. When *S* presses the 'correct' button for a given stimulus, there is immediate reinforcement (either a green light or a 'bong' but only if the program calls for reinforcement). If *S* presses a 'wrong' button for a given stimulus, there is of course no reinforcement, and all other buttons go 'dead,' *i.e.* there are 12 holding relays (K1, Fig. 6, for example) which prevent the activation of more than a single button after any one presentation of a stimulus. Thus, if *S*

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makes an incorrect response, he cannot correct it and receive reinforcement on the very same trial. For example, suppose that a button (*e.g.* S1 in Fig. 6) is depressed; this completes a circuit from the —24-v. supply through the coil of K1 and contacts of K1, K3, and K2 to ground; the relay K1 closes and breaks the circuit from its coil to S1. At the same time K1 picks up a holding circuit to ground via the 'clear' button (on control-console), the 'pacing interval-time,' and the 'start' switch. Relay K1 remains closed until this holding circuit is broken. When K1 closes, it completes the circuit from the —24-v. stimulus supply throughout the relay-tree and the scramble-switch to the 'right' and 'wrong' relays. The 'right' relay closes and breaks the ground-return of all response-buttons, thus preventing the possibility of recording a second response during the presentation of the stimulus. When the machine is set for subject-pacing, the 'right' relay grounds the 6D4 cathode through the 'subject-pacing' switch, thereby advancing the tape. If *S*'s response is wrong, the 'wrong' relay closes; this relay will not close on less than about 35 v. Diode D3 prevents the 'right' relay from closing with positive potentials. All the circuits of the stimulus-lamps, except the one energized by the relay-tree, are biased by the +175-v. 'wrong' bias-supply.

E's control-console. E's console, shown in Fig. 4, has the following features.

(1) Power-switch. The main power-switch turns on the entire apparatus. A pink bulb over the switch is the pilot-light.

(2) Pacing-timer. The pacing-timer controls the rate of presentation of stimuli, which can vary from 2 to 10 sec. per stimulus. A sequence of stimuli separated by 'blank' intervals may be programed on the teletype-tape.

(3) Pacing-switch. The pacing switch can be put on machine-pacing or *S*-pacing. When the switch is set on *S*-pacing, the stimulus does not change until *S* makes a response (*i.e.* presses a button). The stimulus remains on the display-screen for 1½ sec. after *S* has responded (whether 'correctly' or 'incorrectly'), thereby permitting the reinforcement to appear (or to be heard) while the stimulus is still in view.

(4) Tape-switch. The tape-switch turns off the reinforcement even though it is programed on the tape. Thus *E* can stop reinforcement at any time in the course of the experiment.

(5) S's switch. S's switch determines whether the reinforcement shall be auditory (a 'bong') or visual (a green light below the stimulus-display screen). A button to the left of the *S*'s reinforcing switch permits *E* to deliver reinforcement that is not programed on the tape.

(6) Scrambler. The scrambler-dial changes the connections between the stimuli and the push-buttons on the response-panel. There are 12 sets of S–R connections, all of which are random in relation to one another, so that *S* cannot systematically 'transpose' from one set of connections to another. Thus there can be 12 'equivalent forms' of any learning task programed on a single tape.

(7) Stimulus-switch. The stimulus-switch turns the lamps in the display-unit 'off' and 'on.' It permits *E* to eliminate the stimuli while the tape continues to advance through the distributor.

(8) Start-stop switch. This switch starts and stops the movement of the tape through the teletype-tape distributor.

(9) Right response. The correct response is indicated by a green light which turns on when *S* makes a correct response, whether or not he received reinforcement.

(10) Buttons depressed. The button-depressed screen consists of a 1⁹⁄₁₆ × 2⅝ in. In-Line Digital Display Unit (Series 10,000, manufactured by Industrial Electronic Engineers, Inc.) which indicates the number of the response-button *S* has pressed. The number remains in view for 1½ sec. after *S* has pressed a button or for the remainder of the machine-pacing interval, permitting *E* to record *S*'s responses throughout the experiment. In the present apparatus there is no automatic permanent recording of *S*'s responses. This feature could easily be made possible by attaching a

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recording device to the same circuits that activate the response-indicator ('Button Depressed') and the 'Right Response' light in the control-console.

(11) Electrical counters. There are five electrical counters, each with a reset switch. (a) One gives the number of correct responses (whether reinforcement or not) made by *S* throughout the experiment. (b) A second gives the total number of stimulus-presentations throughout the experiment. (c) A third gives the number of incorrect responses made by *S*. His failures to respond = Total stimulus-presentations −(Total correct responses + Total errors). (d) and (e) The fourth and fifth counters give, respectively, sub-totals for the number of stimulus-presentations and the number of correct responses made by *S*. Both of these counters are connected with the Sub-Total Dial and they serve primarily as criterial counters. The Sub-total Trials counter is set for any number of trials (*i.e.* stimulus-presentations) from 3 to 36. Say, for example, it has been set for 12. Then, after 12 stimuli have been presented, the Sub-total Stimuli counter will register 12 and the Sub-total Correct counter will indicate the number of correct responses *S* made to the last 12 stimuli. At this instant, a red indicator lights up Sub-totals Off (see Fig. 4). *E* can record the Sub-total Correct and press the Reset button, which instantly resets all the sub-total counters back to zero. If the criterion in this experiment is 12 consecutive correct responses, *E* will turn off the apparatus with the main power-switch the moment both sub-total counters register 12, which is signaled by the flashing on of the red light.

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