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AN AUTOMATED DISCRIMINATION APPARATUS FOR DISCRETE TRIAL ANALYSIS (DADTA)

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The range, precision, and speed of behavioral testing is often facilitated through automation. At present most automatic equipment available is of the operant conditioning type (1). *S* repeatedly moves one or two manipulanda in response to the scheduled appearance of discriminative and reinforcing stimuli. A record of responses and reinforcements is accumulated either on a moving paper roll or on a battery of counters. The rates of responses and the configuration of their temporal distribution thus become the most readily accessible dependent variables for study. However, the results of many experiments depend on a more intimate analysis of changes in the relation between response, discriminative and reinforcing stimulus on successive discrete trials. Also, as task complexity is increased, the operant type of equipment must be considerably modified if it is not to become too cumbersome in construction and operation.

To overcome these limitations of operant equipment, the following

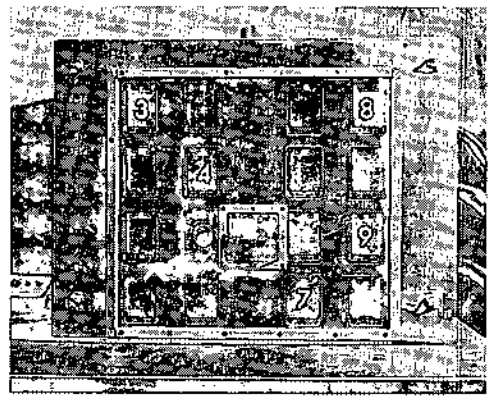

FIG. 1. Display unit

[1]We wish to express our appreciation for their help in programming to Ronald Davis, Robert Gordon, Robert Cole, and Jeanetta R. Peters of the Stanford Computer Center and to Dr. Daniel Kimble for undertaking the risk and perseverence necessary to the performance and completion of the initial experiment with the DADTA. The apparatus was built with funds granted by The Ford Foundation and the National Institutes of Health (My-3732); an earlier model had been constructed with the support of the Department of the Army (MD-401).

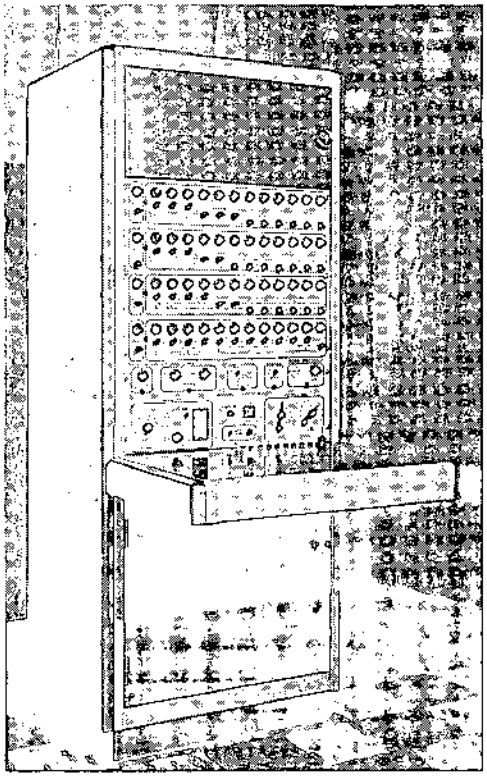

FIG. 2. Control console

device was designed and has already proved in use to be a powerful laboratory instrument. Simple or complex, single or multiple choice tasks can be programmed and both stimulus and response events are recorded trial by trial ready for analysis by any general purpose computer.

The apparatus consists of two sections, the display unit (Fig. 1) and the control console (Fig. 2); these may be separated by as much as 50 ft. through the use of three interconnecting cables. The display unit consists of 16 clear plastic windows and a feeder mechanism and tray. Behind each window is placed a commercially available removable electronic projection unit which can display 12 different patterns. Any set of patterns can be made available by using inexpensive special projection masks for these units. The machine at present is equipped with units which project 10 white numerals, a red disc, and a green disc. The plastic windows, through which the projected patterns are visible, are hinged and activate a microswitch when pressure is applied to the window surface. The entire panel of windows is protected from soiling by a replaceable mylar cover. The operation of the display unit

is controlled remotely by the console. In addition, for initial training and shaping of behavior, manual control of trial presentations and of reinforcements is provided.

The control console provides the following operations: (1) programs the display of cues on the display unit as determined by settings made manually on the console panel; (2) processes the response information received from the display window microswitch according to instructions entered on the program panel and so provides reinforcements and program changes automatically; (3) records for each trial, on punched paper tape suitable for analysis by a general purpose digital computer, the cue pattern and position to which response is made, as well as the outcome of the response.

E can enter four separate programs on the console panel; on each program he selects which patterns are to be displayed, which of these is to be a "correct" choice, and the criteria that are to indicate problem solution. Four behavior modes are available: the "correct" cues selected in sequence; as one of a group; or, response must be made to the entire group without regard to sequence. In the fourth mode, reinforcement is contingent only on a preselected percentage of responses made independent of the cues displayed. The machine automatically changes programs when the criterion entered on the program panel is met. Between successive trials, the cues disappear for a few seconds; this intertrial interval can be adjusted. The same set of symbols then reappears but in different positions. The positions in which each cue is displayed are determined by information stored on a continuous punched tape loop in the console. At present the sequence of positions is made to appear random, however, special sequences can be provided by replacing the tape loop.

The punched tape record contains the displayed pattern and its position, the response and its outcome for each trial. For most purposes these data are sufficient to analyze the course of problem solution when appropriately processed by a digital general purpose computer. In addition, the complete display information for each trial can be obtained by including into the computer program, panel settings and the information stored on the position tape loop.

The machine incorporates nonsynchronous switching techniques in which the individual operations are timed by electronic multivibrators. Short term data storage of the display arrangement is provided by a 192-point (12×16) crossbar switch; long term storage is provided by the program panel, punched tape loop, and tape reader. Counting and sequencing is performed by four stepping switches, and the switching functions are performed by 100 4-pole-double-throw relays. A standard tape punch is used to code the output tape.

DADTA has been successfully used in testing subhuman primates for

over four months. Mechanical difficulties have been minimal and easily corrected.

The advantages over manual testing which have made operant equipment so valuable are maintained: testing time is reduced, experimenter bias is eliminated and an accurate, complete record of behavior is available for analysis.

We have given approximately 200 trials per hour (four *S*s, 50 trials each run). To date some 50,000 trials (1,000 runs) have been completed, even though the apparatus has been busy only about 2 hr. per day. Obviously, the power of the instrument has only begun to be explored.

An additional advantage over manual testing in apparatus such as the WGTA should be mentioned. Ordinarily place and discriminative stimulus are confounded. The trial-to-trial change of stimuli over 16 positions, shapes *S*s' response to the discriminative stimuli rather than to place. Position habits do not occur. Our experience shows that in a two-choice situation, normal rhesus monkeys will quickly make discriminations, e.g., of the arabic numerals 4 versus 6, in DADTA within 250 trials (five runs) that are next to impossible to achieve in manual testing. For certain types of problems such as multiple choice, response to ordered sequences, massed versus spaced trial learning, DADTA has also proved superior to the usual operant type of equipment since the discriminative and reinforcing stimuli are flexibly, yet intimately coupled to each response on a trial-to-trial basis.

Data analysis has been handled by us in various ways depending upon the particular behavior being studied. Simple discrimination, i.e., 6 versus 4, has required only the recording of a daily score of number of reinforcements by a simple counter attached to the reinforcement dispenser. In a non-ordered sequential task, data generated over several days or weeks have been conveniently analyzed using a Flexiwriter write-out of the array of individual trials. Finer grain analysis of an ordered sequential task has been obtained from the Burroughs 770 computer. In all cases results are written out by the computer in clear English and the information obtained on the paper tape is stored simultaneously for permanent record in a magnetic tape file. When daily computation is needed, tape submitted by 5:00 P.M. is processed overnight and the analysis is available in the laboratory by 9:00 A.M.

The unqualified success of these initial, comparatively simple applications of DADTA form a firm base for more extended explorations now in progress.

SUMMARY

To overcome certain limitations of operant conditioning equipment, the DADTA was developed. Description of the general construction, actual use, and advantages are given.

REFERENCE

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