The semiautomatic Wisconsin general test apparatus[1]

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A semiautomatic version of the Wisconsin General Test Apparatus is described along with circuitry. Comparison data are provided for the semiautomatic and manual WGTA obtained under comparable procedures and conditions. Response latencies are given for go/no-go object discrimination problems and subsequent retention tests.

The original version of the Wisconsin General Test Apparatus (WGTA), which was in large part designed by Dr. P. Settlage and Dr. W. Grether, was described by Harlow and Bromer (1938). Eleven years later, a modification of this manually operated device for primate learning was reported by Harlow (1949), and since then numerous studies have employed some form of this apparatus (see Schrier, Harlow, & Stollnitz, Vol. 1, 1965). Further modifications of the WGTA, including the use of motorized opaque and transparent screens, were introduced by Schrier (1961). In this report we describe a somewhat more elaborate semiautomatic WGTA which has been in continual use in our laboratory for the past 6 years.

The semiautomatic WGTA shares certain advantages over the manual WGTA with the Schrier apparatus, notably greater control of the trial-to-trial consistency of external cues involved in stimulus presentations and increased reliability of response latency measurements resulting from the use of motorized screens. In addition, the present apparatus provides precise control of various within- and between-trial time intervals and the option of permitting the S to control the initiation of trials. In contrast to the fully automated primate discrimination-learning apparatuses, such as the Ohio State Apparatus (OSA; Meyer, Treichler, & Meyer, 1965), the Wisconsin Automatic Test Apparatus (WATA; Polidora & Main, 1963), and the Discrimination Apparatus for Discrete Trial Analysis (DADTA; Pribram et al, 1962), the semiautomatic WGTA permits the use of three-dimensional object stimuli or any other type of stimuli used in manual WGTA research, requires no special pretraining procedures such as the shaping of facial-mask responses, and is less expensive to construct.

DESCRIPTION OF THE APPARATUS

The semiautomatic WGTA shares the following features with most previous WGTA apparatuses: (1) use of a stimulus tray that is an adaptation of the Klüver (1937) form board; (2) manual placement of food reward by E under one, two, or more objects; (3) the options of permitting or denying S the opportunity of seeing this placement; (4) an observation interval in which S can see the objects but can be prevented from displacing any of them; (5) a subsequent response interval in which S has access to the objects and food reward; and (6) observation of S's behavior during a trial by E through a one-way-vision screen.

An overall view of the apparatus is provided in Fig. 1. This photograph emphasizes the main physical features, consisting of a motorized screen and an auxiliary opaque screen separating the S's restraining cage from the tray area and, beyond the S's reach, the control panel and a row of food incentive receptacles. Unlike the two (one opaque, one transparent) screens that are raised by motors in the Schrier (1961) WGTA, the present apparatus has a single motorized screen that is sectioned into transparent (upper) and opaque (lower) halves, a feature first employed in manual WGTA research by Riopelle (1954). In the present apparatus this screen opens by dropping. (In Fig. 1 this screen is shown in the half-lowered position, with the opaque portion below the tray level and the transparent portion in front of the vertical bars of the restraining cage.) The auxiliary opaque screen is manually operated and is seldom used, but is available for situations in which it is desired to initiate an observation interval by the raising, rather than lowering, of an opaque screen. The third screen, located above the E, is lowered manually during trials to prevent the S from seeing the E and contains a one-way-vision window.

The apparatus is similar to Schrier's in having a stimulus tray that is in a stationary position during trials, rather

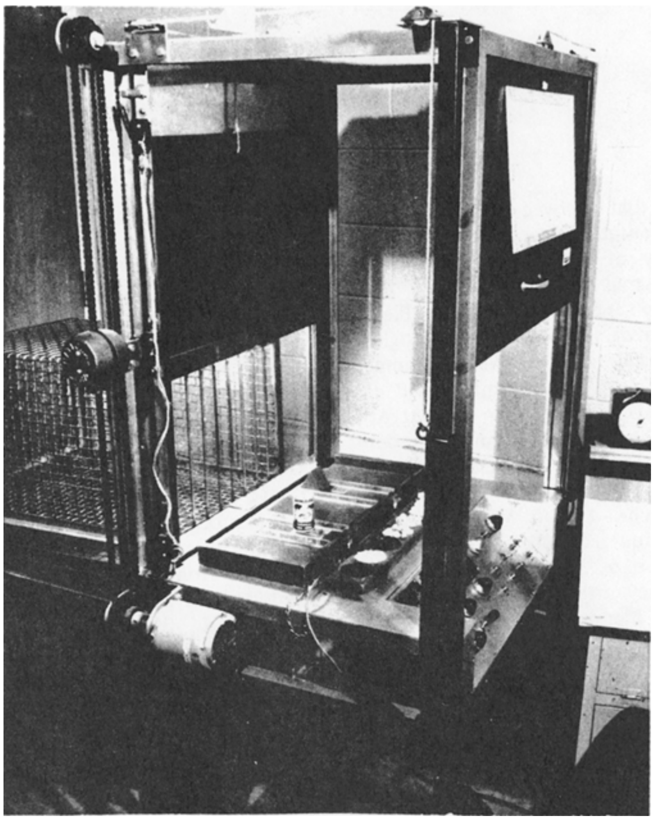

Fig. 1. Overall view of the semiautomatic WGTA.

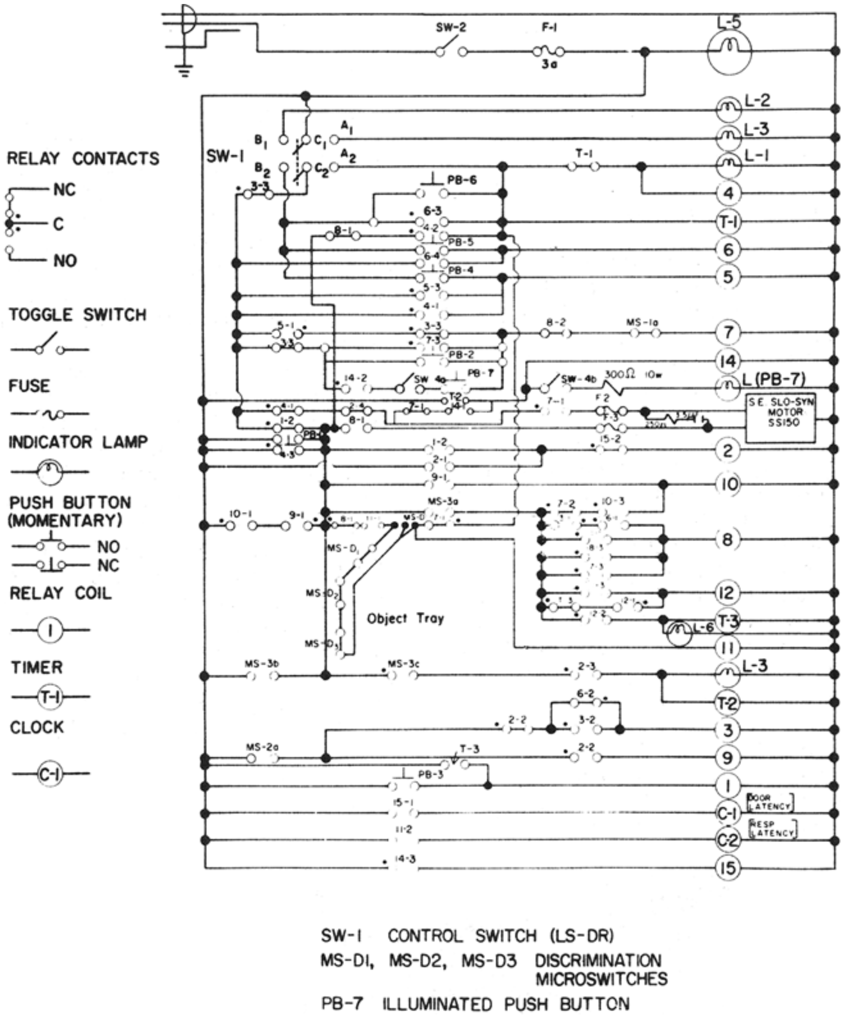

Fig. 2. Circuit diagram of the apparatus.

than one that is moved toward the S during trial presentations, to enhance further the constancy of external stimulation from trial to trial. The tray shown in the photograph is equipped with clear Plexiglas tracks between which flat rectangles of Plexiglas slide over foodwells. Planometric stimuli may be presented on these rectangles, or (as illustrated) three-dimensional objects may be mounted on them. The use of these sliding bases provides a convenient means of activating microswitches (called MS-D switches in Fig. 2), mounted under the tray, for the termination of response latency intervals. The latency measures, recorded manually from a Standard Electric timer, are initiated by the tripping of a microswitch that is mounted inside the channel from the motorized screen when the transparent portion of the screen is approximately midway through its downward excursion. Adjacent to the front edge of the tray, and centered with respect to it, is an illuminated switch by means of which the S may initiate trials, if permitted to do so by the E.

Except for the wooden stimulus tray, the Masonite manually operated screen, and the motorized screen, the apparatus is constructed of stainless steel and aluminum. The stimulus tray (22.5 x 60 cm) rests on a 76-cm-wide platform that is 4 cm higher than the floor level of the restraining cage (45 x 60 x 38 cm, 78 cm above the room floor). The position of the stimulus tray on the platform is variable, but it is usually positioned so that the foodwells are 18 cm from the front of the restraining cage. The motorized screen (79 x 64 cm) is made of clear ¼-in. Plexiglas, with the lower 39 x 64 cm area opaqued by flat black paint on both sides. This screen runs in a channel in which three position-sensing microswitches (MS-1, MS-2, and MS-3) are mounted in bottom, middle, and top positions of the channel, respectively. It is energized by a Superior Electric Slo-Syn SS-150 motor. The shaft of the motor is connected to the screen by means of a counterweighted bicycle chain looped around two 6-cm-diam sprockets. The S's switch is a Switchcraft 27206 illuminated Lever-Lite.

The one-way-vision window is constructed of vector board, painted glossy aluminum on the surface toward the S. A window of this type functions effectively when the only major source of illumination in the test room is the standard fluorescent fixture mounted over the tray area and eliminates any reflection of the S's image.

The circuitry, diagrammed in Fig. 2, is designed primarily for studies of object-quality discrimination learning set (LS) and delayed response (DR), but can be used in as many other learning paradigms as the manual WGTA. The main control switch (SW-2), mounted on the upper right portion of the control panel (Fig. 1), determines whether the appropriate circuitry for LS (and other standard discrimination procedures) or DR is operational. Other switches and Industrial Timer Corporation control timers (T-1, T-2, and T-3) on the panel permit control of the durations and screen positions of observation intervals, delay intervals, response-time limits, and intertrial intervals. Switches are also provided to stop movement of the motorized screen at any point (PB1), to close the screen at the end of trials (PB3), and to make S's switch functional in starting trials (SW-4) after intertrial intervals have elapsed.

In LS testing, the E arranges the stimulus and reward conditions on the tray during the intertrial interval (controlled by T-2), when the motorized screen is completely closed. If an "enable" switch (PB2) is depressed before the end of this interval, the trial starts automatically with the lowering of the opaque portion of the screen. (If PB2 is not depressed during the intertrial interval, that interval continues beyond the timing out of T-2 until PB2 is activated or, depending on the position of SW-4, until the S's switch, PB7, is depressed.) When the screen reaches the transparent-only position, the observation interval (controlled by T-1) begins, after which the transparent portion of the screen lowers, permitting the S to respond to the tray. Usually the trial ends by E's activation of PB3, raising the screen completely, but a maximum trial-time limit can be imposed by means of T-3, the output of which closes the screen.

In DR testing, the procedures and options for initiating trials are the same as in LS, but the observation interval is

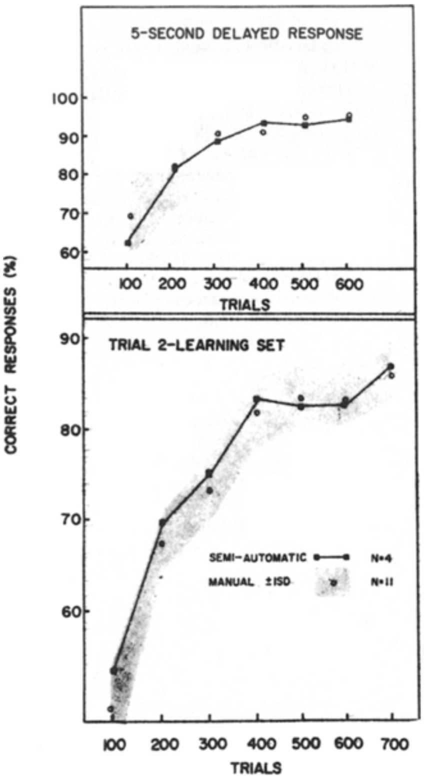

Fig. 3. Choice performance of rhesus monkeys in the semiautomatic WGTA compared with that obtained in a manual WGTA, in DR (upper graph) and LS (lower graph).

terminated by a manual switch (PB5) which initiates a delay interval (controlled by T-1), during which the screen returns to its starting (opaque) position. At the end of the delay interval, the screen descends completely in a single uninterrupted excursion, permitting response to the tray by the S. If no delay is desired, depression of PB6 during the observation interval prevents the return to the starting position and lowers the screen when the observation interval terminates.

When the option of S-initiated trials is used, the time between the onset of illumination of S's switch (when it becomes functional) and S's switch response is recorded (on Clock C-1), as well as the latency of S's response to the tray (C-2) during a trial.

EXPERIENCE WITH THE APPARATUS

Over 100 rhesus and stumptail macaques have been tested in the semiautomatic WGTA. We had anticipated some difficulty in adapting monkeys to the apparatus because of the rather loud noise made by the motorized screen, but this has proven to be an extremely minor problem. More than 95% of all the animals that have been in the apparatus have readily adapted. In this respect, our experience has been less frustrating than that reported by Schrier (1969). But most of our Ss have been much-handled and well-socialized laboratory-reared rhesus monkeys, feral rhesus with histories of previous adaptation to learning apparatuses, or feral stumptails, in contrast to Schrier's balky, uncooperative rhesus monkeys imported from remote forest regions of India. Many of our laboratory-reared monkeys were adapted in pairs, a procedure that appears to be quite facilitative. In agreement with Schrier's (1965, 1969) findings, we have found stumptails to be considerably more adaptable than rhesus.

One difficulty with our apparatus has been the tendency by a few Ss to push the screen down. This behavior, which is rapidly extinguished, can be eliminated by the installation of solenoids, or, as we have done, by a rubber-tipped bar that E can press against the screen.

Figure 3 illustrates data obtained from both the semiautomatic and manual WGTA under comparable procedures and conditions. The data in the top half of this figure are from a 5-sec portion of a 0-5 sec DR task, and those in the bottom half are from a two-object, noncorrection, six-trial object discrimination LS problem. The curves for the four monkeys in the semiautomatic WGTA are representative of many other Ss tested in this apparatus and are comparable to the manual WGTA data. Finding no important difference in choice data between the apparatuses in these two learning situations, we have come to regard the semiautomatic as preferable on the basis of its advantages in terms of stimulus control, temporal precision, and ease of testing.

Figure 4 presents some individual rhesus monkeys' response latencies on individual trials in 30-trial go/no-go object discrimination problems and subsequent 10-trial retention tests. These unusually regular data are typical for highly practiced rhesus monkeys and only slightly smoother than the latency measures we have obtained in naive rhesus and stumptail macaques in the semiautomatic WGTA. In comparison with the notorious variability of monkeys' latency data in the manual WGTA and in discrete barpressing situations, these data suggest that the enhanced stimulus constancy provided by the semiautomatic WGTA's motorized screen and stationary tray yields a distinct benefit in terms of the smoothness of individual latency measures. Thus the present apparatus seems to be well suited to primate studies analogous to simple runway experiments with rats and to more complex paradigms, e.g., successive-presentation sameness-difference problems, in which inhibition of response to a single object is the performance criterion.

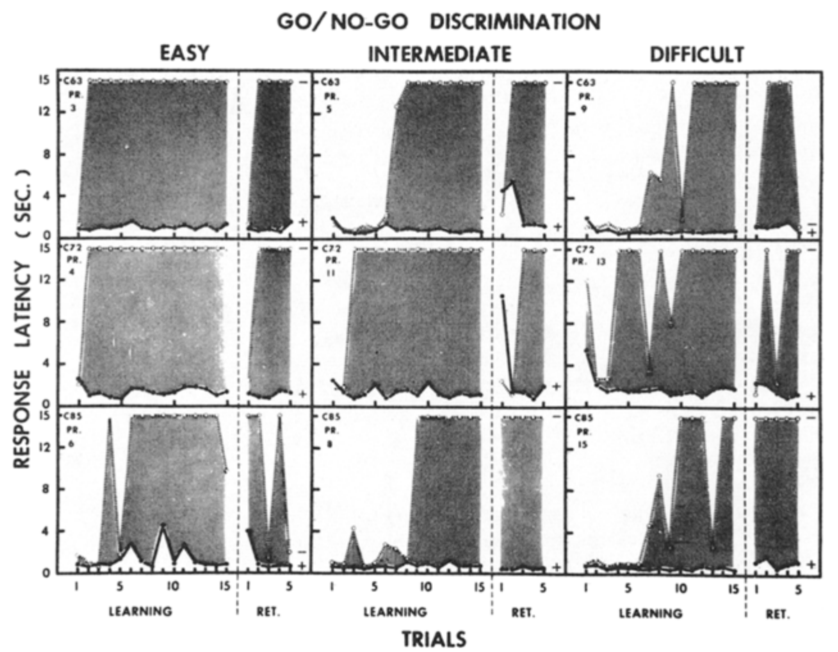

Fig. 4. Individual-trial latencies by three rhesus monkeys to successively presented rewarded (+) and nonrewarded (–) objects in go/no-go problems of varying difficulty. The learning and retention phases were separated by 24 h.

Additional examples of data obtained in the apparatus may be seen in an extensive dissertation on retention of object discriminations (Bessemer, 1966), Livesey's (1969) study of spatial alternation learning, and in forthcoming reports of long-term studies on the behavioral effects of induced phenylketonuria and malnutrition conducted at the Wisconsin Regional Primate Research Center.

REFERENCES

BESSEMER, D. W. Retention of object discriminations by learning set experienced monkeys. Unpublished doctoral dissertation, University of Wisconsin, 1966.

HARLOW, H. F. The formation of learning sets. Psychological Review, 1949, 56, 51-65.

HARLOW, H. F., & BROMER, J. A test-apparatus for monkeys. Psychological Record, 1938, 2, 434-436.

KLÜVER, H. Certain effects of lesions of the occipital lobes in macaques. Journal of Psychology, 1937, 4, 383-401.

LIVESEY, P. J. Double- and single-alternation learning by rhesus monkeys. Journal of Comparative & Physiological Psychology, 1969, 67, 526-530.

MEYER, D. R., TREICHLER, F. R., & MEYER, P. M. Discrete-trial training techniques and stimulus variables. In A. M. Schrier, H. F. Harlow, and F. Stollnitz (Eds.), *Behavior of nonhuman primates.* Vol. 1. New York: Academic Press, 1965. Pp. 1-49.

POLIDORA, V. J., & MAIN, W. T. Punched card programming and recording techniques employed in the automation of the WGTA. Journal of the Experimental Analysis of Behavior, 1963, 6, 599-603.

PRIBRAM, K. H., GARDNER, K. W., PRESSMAN, G. L., & BAGSHAW, M. An automated discrimination apparatus for discrete trial analysis (DADTA). Psychological Reports, 1962, 11, 247-250.

RIOPELLE, A. J. Facilities of the Emory University Primate Behavior Laboratory. Journal of Psychology, 1954, 38, 331-338.

SCHRIER, A. M. A modified version of the Wisconsin General Test Apparatus. Journal of Psychology, 1961, 52, 193-200.

SCHRIER, A. M. Pretraining performance of three species of macaque monkeys. Psychonomic Science, 1965, 3, 517-518.

SCHRIER, A. M. A possible change in the behavior of imported rhesus monkeys. Laboratory Primate Newsletter, 1969, 8, 1-5.

SCHRIER, A. M., HARLOW, H. F., & STOLLNITZ, F. (Eds.), *Behavior of nonhuman primates.* Vol. 1. New York: Academic Press, 1965.

NOTE

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