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BRIEF COMMUNICATION

A Logic Circuit for Identifying and Reinforcing Operant Response Durations

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SHIMIZU, S. AND K. HASHIMOTO. *A logic circuit for identifying and reinforcing operant response durations.* PHARMAC. BIOCHEM. BEHAV. 6(1) 141–143, 1977. – A simple circuit useful for the study of response duration and timing response in operant behavior in rats was described. Important features of the circuit include: a logic function to identify respondings with the preregistered duration, elimination of the premature reinforcement by the feeder operation during lever-pressing behavior, reinforcement after the complete release of the lever, simple design and inexpensive construction. Experimental results with and without the present circuit were also given.

Logic circuit Operant response duration Timing response Response duration schedule

THE strength of an operant has long been evaluated in terms of the probability of occurrence. It is now recognized, however, that the quantitative properties in which and organism presents a response (force, duration, etc.) or, response topographies are also dependent variables in operant behavior [1,2]. More recently, Shimizu and his collaborators [3, 4, 5, 6] observed with rats under the continuous reinforcement and response duration schedules that the response durations of lever-pressing behavior give a stable behavioral baseline, and are sensitive to the effects of behaviorally active drugs. In the response duration schedule which also has a character of temporal discrimination, it is necessary that the response duration of the limited time-band is identified and reinforced. For such an experimental design focused on the duration of lever pressing, electric current is simultaneously applied to the pellet feeder with release of the operant lever by the rat, since otherwise the sounds of feeder operation and food presentation on the pellet cup during the behavior of the rat interrupt and shorten the response duration. In order to identify the response duration and to eliminate these secondary factors by arranging events following lever pressing as shown in Fig. 1, a simple circuit with logic function was designed and constructed. The whole circuit is composed of Texas Instruments SN type TTLs [7], and its diagram is presented in Fig. 2.

The gate 1 of the circuitry is enabled by lever pressing of the rat to pass the pulse train from the clock-pulse generator, which is counted at the BCD counter 1, and is compared at the magnitude comparator 1 with the minimum criterion of the response duration preregistered at the

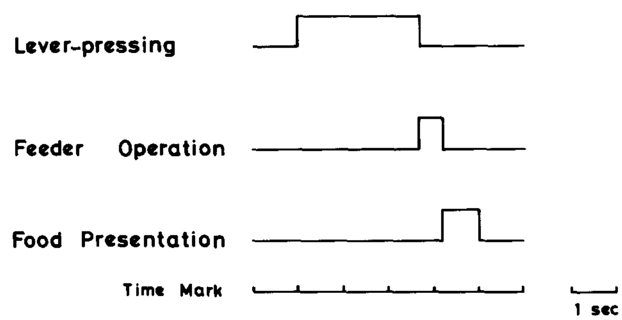

FIG. 1. Schematic illustration showing the temporal interrelationships among lever pressing, feeder operation and reinforcement.

input B by thumbwheel switches through 10-line-to-4-line encoders. Criterion of higher accuracy may be accomplished by connecting more companrators in cascade. When the response duration reaches equal to the minimum criterion, the output A=B of the comparator 1 turns to high level, and the output Q of the J-K flip-flop 1 is inverted from low to high to remain at the same level until the end of lever-pressing behavior. Consequently, the gate 2 is enabled and passes the clock-pulse to count at the BCD counter 2. When the response duration equals the maximum criterion of the response, the output A=B of the comparator 2 turns to high level, and the output Q of the flip-flop 2 is inverted from high to low level. The output Q of the monostable multivibrator 1 is triggered by the transition from high to low level of the input A from the

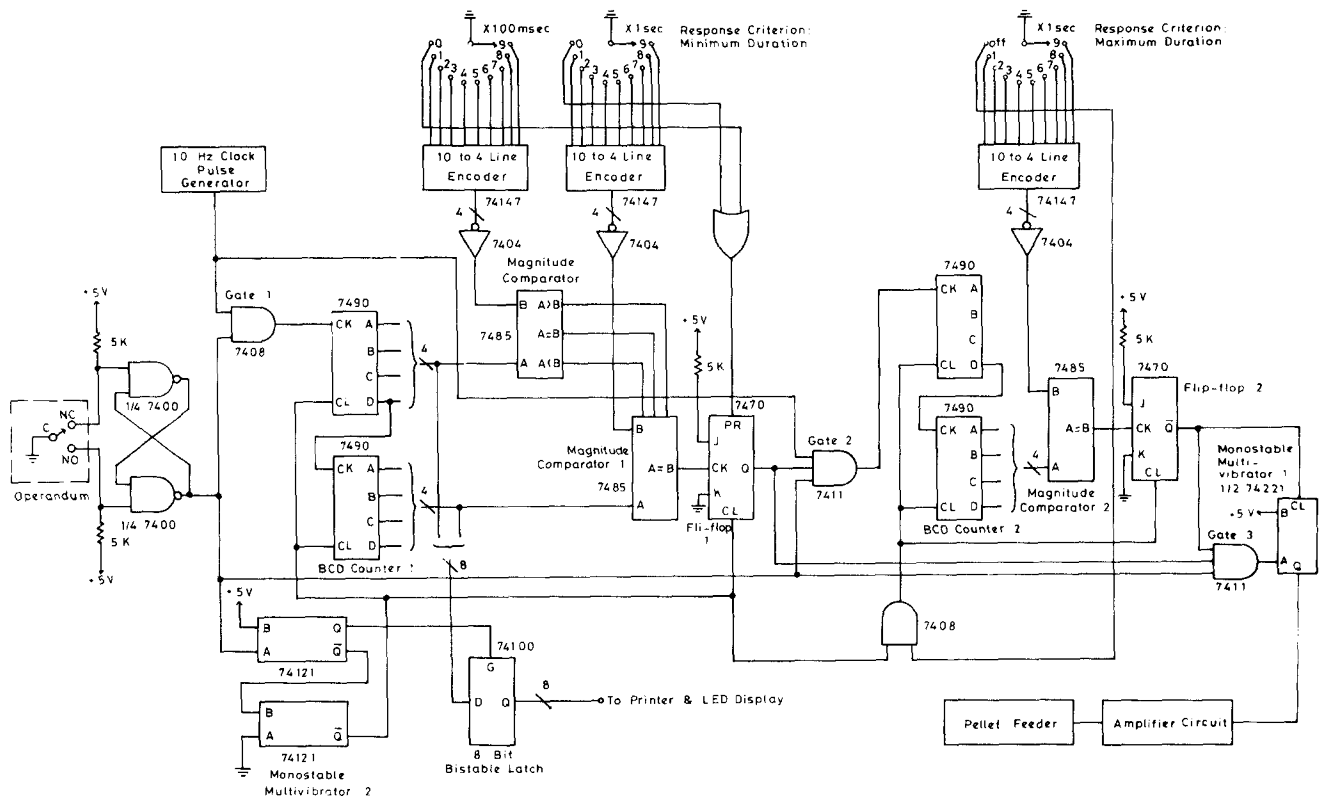

FIG. 2. Logic circuit diagram used for identifying, recording, displaying and reinforcing response durations. The integrated circuits included are Texas Instruments SN type TTLs. The power supply of +5V @ 200 mA is required.

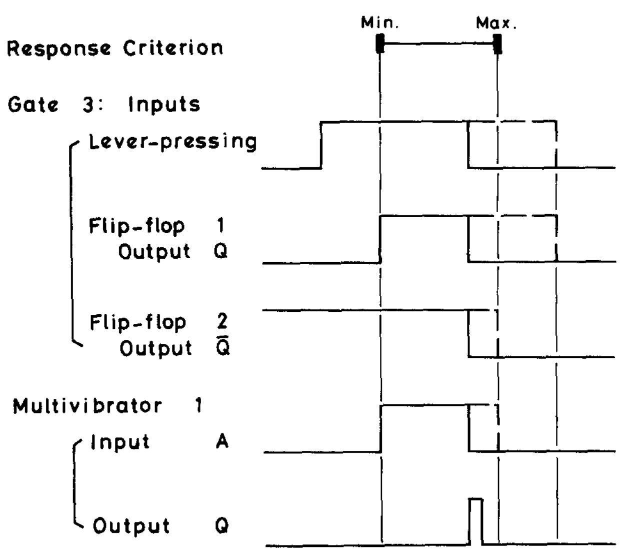

FIG. 3. Timing diagram of data inputs of the gate 3, input A and output Q of the multivibrator 1. Broken line indicates a sequence by an unreinforced response over the maximum criterion of the duration.

gate 3, the state of which is decided by lever pressing, and the output Q and $\bar{Q}$ of the flip-flop 1 and 2, respectively (Fig. 3). The downward transition of the output $\bar{Q}$ of the flip-flop 2 also operates as a reset-pulse for the multivibrator 1, and makes the transition at A ineffective to avoid an abortive response due to premature reinforcement,

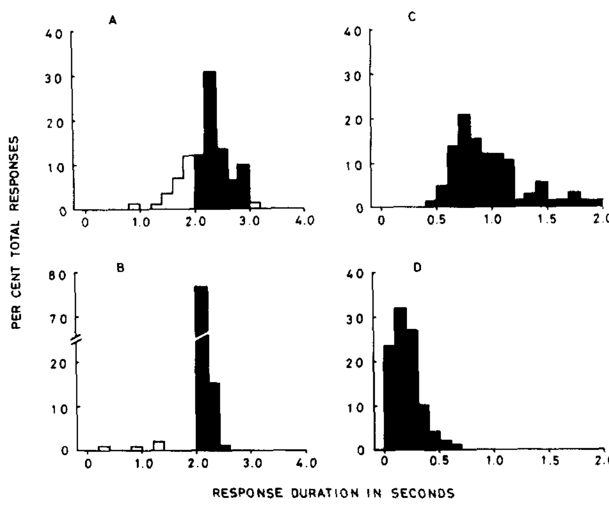

FIG. 4. Relative frequency distributions of response durations of lever pressing during a 10-min performance under (A & B) the 2.0–3.0 sec response duration schedule, and (C & D) the continuous reinforcement schedule. In A and C, the present circuit was used, and in B and D, electric current was simultaneously applied with the beginning of lever pressing. Note wide distributions in A and C, and skewed histograms in B and D. The extremely high probability of occurrence in the class of 2.0–2.2 sec in B, and the shift of distribution to shorter durations in D show contaminated effects of premature reinforcement of lever-pressing behavior. Filled area indicates the reinforced response durations. The class intervals of the histograms are 0.2 sec in A and B, and 0.1 sec in C and D, respectively.

when lever pressing exceeds the maximum criterion of the duration. The output pulse of TTL level from the multivibrator 1 is amplified to a working voltage at the amplifier circuit for driving the conventional pellet feeder. Thus, only the qualified response is reinforced on release of lever pressing of the rat. After each response, the response duration is displayed and recorded through an 8-bit-bistable latch, and the whole circuitry is reset to the initial state by a pulse from $\overline{Q}$ of the multivibrator 2 for the following response. Provided that the minimum and maximum criteria are set to 0 and off, respectively, the circuit is available for the continuous reinforcement schedule. For circuit isolation from mechanical noise caused by frequent contact of the microswitch, an SR latch is inserted between an operandum and the circuit, and feeder-generated electrical noise is absorbed through an attached circuit composed of diodes, condensers and resistors.

Figure 4 shows the relative frequency distributions of response durations under the continuous reinforcement and response duration schedules using the present circuit, and those under the same schedule conditions with immediate reinforcement after the beginning of lever pressing.

Although sets of logic modules available on the market could probably do the similar procedures, the present circuit will provide simpler and less expensive solution to achieve the same purpose. Use of the circuit for two years yielded no trouble and easy handling.

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REFERENCES

1. Margulies, S. Response duration in operant level, regular reinforcement and extinction. *J. exp. anal. Behav.* **4:** 317–321, 1961.
2. Notterman, J. M. Force emission during bar pressing. *J. exp. Psychol.* **58:** 341–347, 1959.
3. Shimizu, S. and R. Kishi. Effects of chlorpromazine and diazepam on operant response duration in rats. *Jap. J. Pharmac.* **23:** Suppl., p. 97, 1973.
4. Shimizu, S. and R. Kishi. Effects of atropine and scopolamine on the timing response in rats. *Jap. J. Pharmac.* **24:** Suppl., p. 76, 1974.
5. Shimizu, S. and K. Hashimoto. Response topographies and their modification by drugs. Sixth Int. Cong. Pharmacol. Abstract: 620, 1975.
6. Shimizu, S. and R. Kishi. Differential sensitivity of response duration and response rate to imipramine during operant behavior in rats. *Jap. J. Pharmac.* **25:** Suppl. 51–52, 1975.
7. *TTL Data Book for Design Engineers.* Dallas, Texas: Texas Instruments, Inc., 1973.