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The Inadequacy of Intracranial Stimulation to the Posterior Hypothalamus to Serve as a Reinforcer for Maze Learning in the Rat

John A. Bull
Central Washington University

THE INADEQUACY OF INTRACRANIAL STIMULATION TO THE POSTERIOR HYPOTHALAMUS TO SERVE AS A REINFORCER FOR MAZE LEARNING IN THE RAT

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John A. Bull III

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Thomas B. Collins, Jr., COMMITTEE CHAIRMAN

_____

Jack J. Crawford

_____

Eldon E. Jacobsen

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The effect of intracranial stimulation (ICS) by means of a small amount of electric current as an apparent positive reinforcer was first demonstrated by Olds and Milner in 1954. In a simple bar pressing situation ICS appeared to function as a conventional reward. Since that time the phenomenon has been intensively studied (Olds & Olds, 1965), but there is still disagreement as to the nature of ICS as a reinforcer (Wetzel, 1963). Much of the research is contradictory as indicated in a review by Zeigler (1957). In situations other than simple bar pressing ICS appears to act much differently than conventional reinforcers as suggested in a review by Gallistel (1964). Many questions also exist as to the relation of ICS to motor involvement, sensory changes, general activity or arousal, motivation, and learning. There appears to be some interaction with other drives and other reinforcers suggesting a complex effect rather than a simple reinforcer. For example, in a bar press situation Brady, Boren, Conrad & Sidman (1957) using both cats and rats, found that self-stimulation rates were significantly higher in the septal area after 48-hr.

food deprivation than after zero or 1-hr. deprivation. Hodos and Valenstein (1960) also found significantly higher bar press rates for food deprived rats than for nondeprived rats working for septal ICS.

A correlation between self-stimulation sites and sexual reward sites has been reviewed by Olds (in Ramey & O'Doherty, 1960, pp. 17-51). A general finding was that if the administration of androgens was followed by higher self-stimulation bar press rates, there was at the same sites a tendency for 24-hr. food deprivation to be followed by lower rates. There follows a brief review of the general reinforcing nature of ICS as well as the stimulation parameters affecting behavior. Evidence from maze studies will than be reviewed as a basis for the present study.

General reinforcing effects of ICS. There is little evidence concerning the ability of ICS to reinforce responses other than bar pressing. However, Olds has stated that ICS acts of a "genuine" reward and it will work . . ." in any situation in which a more conventional reward works, from Skinner box through runway, complicated maze and obstruction box; . . ."(in Ramey and O'Doherty, 1960, p.42). Studies involving more complex learning situations, however, give rise to conflicting results and there is still some question as to the "genuineness" of ICS as a reinforcer. It has been

suggested that the effect depends upon the tests employed, and that the effects are fairly short-lived (Deutsch & Howarth, 1963; Wetzel, 1963). In extinction trials the bar press response rates tend to fall off very sharply. Olds (in Jones, 1955, pp. 73-139) noted that animals with electrodes implanted in the septal area abruptly stopped responding when reinforcement was terminated. Extinction was slower for placements in the hippocampas and cingulate gyrus. Seward, Uyeda and Olds (1959) investigated extinction in rats, using both hypothalamic and septal placement. In both cases the response rates dropped sharply to about 20% of the final training level. However, the hypothalamic rats remained significantly higher than on the operant level pre-tests after two weeks while the septal animals did not. The hypothalamic group also had higher self-stimulation rates. Olds (1962) in a general review, cites other examples of extinction but concludes that the rate of extinction is due to the electrode placement. He suggests that normal extinction curves can be obtained depending on the area implanted.

Sidman and co-workers (Sidman, Brady, Boren, Conrad & Schulman, 1955; in Harlow and Woolsey, 1958, pp. 193-235) varied tha average stimulus interval for animals on a variable-interval reinforcement schedule in a bar press

situation. The response rates were higher for shorter intervals between stimulations. The rates of response were also sensitive to stimulus intensity in that higher currents produced higher response rates. The best performance of a fixed ratio response was obtained from a cat which maintained a ratio of 8:1. Brodie, Moreno, Malis, & Boren (1960) attempted fixed ratio schedules on monkeys. Out of ten monkeys, all held a fixed ratio of 10:1, seven a ratio of 20:1 and one a ratio of 150:1. In general high ratios are difficult to achieve.

There are only two studies in the literature attempting to develop secondary reinforcers using ICS as a primary reinforcer. One by Seward, Uyeda & Olds (1959) paired a light with the ICS in a Skinner box. There was no significant indication of the development of secondary reinforcement properties to the light. The second study was by Stein (1958). He implanted eighteen rats in both the septal area and anterior hypothalamus. He than presented two bars, one which produced a tone and one which produced nothing, and recorded the operant levels to the bars over a period of six days. He then paired ICS with the tone for four days with the bars removed. Data from thirteen of the rats which self-stimulated on a post test was used. There was a slight preference (non-significant) for the tone bar over the no-tone bar. The

response rate to the tone bar was significantly higher than the operant level. However, before pairing the operant response level was only about three responses per hour and after pairing was only about ten responses per hour. This seems to be a very slight affect since all rats self-stimulated above a criterion set at 540 per hour.

Olds, Travis and Schwing (1960) tested bar press responses as a function of current intensity in the rat hypothalamus. They found that as current intensity increased rat response rates also increased. The current was varied from 50 to 160 microamperes. This study was an attempt to map the self-stimulation areas of the rat brain. They found reliable self-stimulation when placing electrodes at the coordinates 3.5 mm. posterior to bregma suture, 1.5 mm. laterial to the midline, and 815 mm. deep to the skull surface or calvarium which will put the tip in the posterior hypothalamus. ICS, then, seems to be an effective reinforcer in the Skinner box situation when simple bar press learning is studied with currents of 30-160 microamperes. However, from the appearance of extinction curves and attempts to establish bar pressing for fixed ratio reinforcement, ICS seems to be a relatively ineffective reinforcer.

Maze studies. If ICS is a genuine reinforcer it should act as other rewards in that it will be sufficient for

learning a more complicated task than bar pressing. There have been only a few experimental studies involving maze running for ICS reward. The first study of this type was performed by Olds (1956). He compared self-stimulation with food as a reward for a straight alley and a complicated (Lashley III) maze, involving three correct turns to the goal box. The trials were massed (15 trials per day) and all animals learned within three days. The animals learned faster for ICS in the straight alley but faster for food in the maze. There was also an overnight decrement in the stimulation group but this was balanced by extreme day-to-day first trial improvement.

Newman (1961) found that trials spaced by 1.5 minutes led to poor running performance in a straight alley running for stimulation which did produce bar pressing. Seward, Uyeda and Olds (1960) compared massed and spaced trials in straight alley and found that although all animals learned, the massed group learned much better than the group spaced at 15 minute intervals. All subjects were given 10 trials per session and received 5 ICS pulses in the goal box. Mean running speeds increased in both groups over 12 days. Only the massed group improved within sessions.

Wetzel (1963) compared rats running for food with rats

running for ICS down a straight alley. She also compared rats which were "primed" with ICS beforehand to rats which ran without "priming." "Priming" was defined as 2½ minutes of self-stimulation. The rats ran once a day for 28 days. It was found that rats running for ICS which were "primed" with pretrial ICS ran faster than "unprimed" rats running for ICS. Rats running for food were also faster than "unprimed" rats in the ICS group. There was no significant difference between the "primed" rats running for ICS and the food rats. There was no difference between "primed" and "unprimed" rats running for food. The running speeds of rats which were "unprimed" and running for ICS were similar to a group of rats which were "primed" but received no reward. The author suggested the results were due to after affects of the ICS. The mean times from the end of the "priming" to the rats entering the goal box were about two to seven seconds for the "primed" groups.

Thus it can be seen that there is still some question as to the effect of ICS as a reinforcer in the runway and maze situation. If Olds' theory is correct and ICS acts as a "genuine" primary reinforcer then rats running for ICS should be comparable in performance to rats running for a food reward. ICS delivered at current levels producing high bar press rates should be a sufficient reinforcer for maze

learning if trials are massed. Such conditions would suggest the following experimental hypothesis: rats running for ICS under "optimum" stimulation conditions will perform as well in a T-maze as do control rats running for food. Therefore, delivering ICS as a reinforcer under such "optimum" conditions to the posterior hypothalamus, which produces high bar press rates and is in a part of Olds' system of the "underlying substratum," should maintain highly motivated maze running behavior in rats. The purpose of this experiment was to investigate this hypothesis.

METHOD

Subjects. The subjects were eighteen male Sprague-Dawley rats approximately 100 days old and weighing approximately 300 gms. when operated. These rats were selected from twenty-three implanted rats on the basis of bar press rates. Those selected met a criterion of over 500 bar presses per hour as extrapolated from a 10 minute measure. Five rats failed to meet this criterion and were eliminated. The remaining rats were divided into blocks according to their bar press rates in accordance with a randomized block design. They were then assigned randomly to two groups, group I receiving ICS as a reward and group II or the control group receiving food as a reward. (See Table I).

Electrodes. Bipolar electrode assemblies were constructed using 0.01 inch diameter stainless steel wire. The wire was insulated with three baked coats of General Electric Formvar enamel, except about ½ mm at the tips, which were separated by 0.5 mm or less. The electrodes were cemented together with one coat of Insul-X and soldered to the male halfs of two 3/0 size rustless dress snaps as described by Miller, Coons, Lewis & Jensen (in Sheer, 1961, pp. 51-54). They were then embedded in a small block of dental acrylic material (Bull & Collins, 1965a).

TABLE 1

STIMULATION DATA FOR EACH RAT

		Subject No.	Pre-test (r.p.m.)	Post-test (r.p.m.)	Current Intensity (microamperes)	Current Duration (seconds)
Experimental Group	Block 1	8	10	11	54	0.2
		20	20	18	54	0.2
		7	30	35	39	0.1
	Block 2	16	37	38	39	0.1
		19	50	55	54	0.1
		2	58	75	54	0.1
	Block 3	11	68	64	39	0.1
		12	89	80	109	0.1
		6	100	98	39	0.1
Control Group	Block 1	9	12	16	39	0.1
		17	29	38	80	0.1
		13	30	50	39	0.2
	Block 2	15	40	37	39	0.2
		4	48	49	44	0.1
		5	60	59	42	0.1
	Block 3	3	68	65	80	0.1
		10	88	75	54	0.1
		1	94	20	54	0.1

The dress snaps were then attached to small alligator clips (1.1 in. by 0.2 in.) leading from the stimulation source.

Implantation. Operations were performed under pentobarbital sodium (diabutal) anesthesia and the electrode assemblies implanted by means of a stereotaxic instrument (Bull & Collins, 1965b). The electrode assembly was firmly attached to the skull by means of dental acrylic and .084 in. diameter optical screws. Stereotaxic coordinates used were 3.5 mm. posterior to the bregma suture, 1.5 mm. lateral to the midline, and 8.5 mm. deep from the skull surface. This location in the posterior hypothalamus was reported by Olds, Travis and Schwing (1960) to yield reliable, positive rewarding effects. In the present study, high bar press rates were obtained with few motor effects at low current and duration thresholds.

Histological examination indicated that all electrodes were within approximately the same area ($\pm$ ½ mm.) in the posterior hypothalamus. The three rats with the lowest bar press rates had the most posterior placement and the electrode tips were in contact with the anterior part of the mammalary body of that hemisphere. The mammalary bodies are not part of Old's reward system. The other six electrodes were approximately ½ mm. anterior to the mammalary bodies

and between one to two mm. lateral to the midline. This is well within Old's reward system (Olds, Travis & Schwing 1960). There was little or no observable damage in the area of the electrode tips. Little damage was evident from the surgery and implantations in general except for subject #8 which appeared to have a partially deteriorated thalamus.

Apparatus. Tests for self-stimulation were given in a 9 in. by 13 in. plexiglass box, 13 in. high. It had an open top and bottom and rested on a table covered with a sheet of heavy brown paper. A weight of approximately 10 gms. was required to depress a flat lever, 4 in. by 3/4 in. which projected from one end of the box. Overhead leads of fine flexible hearing aid wire approximately 10 in. long extended from the rat to a shielded coaxial cable which hung from the ceiling and was connected to the stimulator. The stimulus current was a 60-cycle sine wave separated from the wall circuit by a 1 to 1 isolation transformer and reduced by a resistance which was variable from 1 to 4 megohms. Stimulus duration was set by means of a Hunter Timer. Response rates were recorded by means of a digital response counter. Current was continuously monitored by an oscilloscope in a series with the rat across a one thousand ohm. resistor. The high resistance of the stimulator made individual differences in the rats' resistances negligible.

Current was calculated assuming all animals' resistance to be equal to one thousand ohms. The current intestity delivered to each rat is listed in Table 1.

A T-maze painted flat grey with each arm and the stem 32 in. long was used for training. The alleys were 4 in. wide and the sides were 10 in. high. The maze was equipped with five doors which slide up from the floor and prevented the rat from "backtracking" in the maze. One door was placed 8 in. from the choice point in the stem. Two were placed 2 in. on each side of the arms past the choice point and two were placed 8 in. from the entrance to the goal boxes. The goal boxes were 9 in. by 12 in. by 10 in. high. Three boxes were constructed exactly alike from 3/8 in. plywood and used interchangeably as start and goal boxes. This made it unnecessary to handle the rats during the learning trials. The boxes were unpainted. One cue for the correct response consisted of a strip of ¼ in. hardware cloth 3 in. by 10 in. placed on the floor of the correct alley.

Procedure. The original group of twenty-five rats was divided into two living cages and placed on a twenty-three hour deprivation schedule one week before the surgical operations. Two days before the operations each cage of

animals was given a fifteen minute familiarization trial. This consisted of placing all rats from a cage in the start box of the maze in a group and allowing them fifteen minutes of exploration with the doors open. One day before the operations a second familiarization trial was given just as before except that the doors were closed for the tenth minute of the trial to allow the rats to become accustomed to the doors. Twenty-three rats were them implanted. After the operations all rats were placed in individual wood cages 9 in. by 10 in. by 12 in high covered by a hardware cloth top.

Each rat was given a five minute preliminary self-stimulation trial in the Skinner box, on the third post-operative day. During this time they were shaped to the bar by the experimenter with ICS reinforcement. On each of the fourth and fifth post-operative days all the rats received a ten minute session in the Skinner box. Bar press rates were taken during the last session and those rats not reaching the criterion of ten responses per minute were rejected. Eighteen rats having stable bar press rates (those with rates that did not vary markedly from minute to minute) were selected from the twenty-three implants.

The eighteen subjects were than given two individual fifteen minute familiarization trials in the T maze on the seventh and eighth post-operative days. During these trials

each rat was placed in the start box and allowed to run freely in the maze. At the end of the session the rat was forced to a goal box randomly selected by a toss of a coin. The subjects were then removed to a detention box for one half hour before being returned to the home cage. At the end of the second session the rat was forced to the opposite goal box from that of the first session. The second session differed from the first only in that the electrode wires were attached to the rats with the current turned off. After the familiarization trials had been completed the rats were divided into two groups in accordance with the randomized blocks design as described earlier.

On the ninth post-operative day the training trials began. The rats were run in random order with the electrodes connected to the stimulator leads. The leads to the food group were shorted across each other with the stimulator off to insure that they received no extraneous current. The experimental group received twenty pulses of ICS spaced one second apart in the correct goal box, each pulse not exceeding 0.2 sec. (see Table 1). The control group received three sugar-coated puffed rice (Rice Honeys) as a reward in the correct goal box.

Each rat was placed in the start box at the beginning

of each day's session. The electrode leads were connected and the start box door opened. As the rat passed the sliding doors they were closed behind it. When the rat reached the goal box, the goal box door was closed. The box was then removed after twenty seconds to be exchanged with the start box. The door was then opened to allow the rat to run again. Each rat was given ten trials per day and then removed to a detention box for thirty minutes before returning to the home cage.

The correct goal box position was selected randomly for each trial by tossing a coin. The cue indicating the correct response (right or left turn) was a wire mesh placed on the floor of the correct arm of the T-maze. The edge of the wire mesh nearest the choice point was lined up with a line midway down the stem of the maze. If the rat remained at the choice point for more than two minutes he was forced to make a random choice determined by a coin toss. This was necessary for 53 of the 450 trials for the experimental group and only three times during the 450 trials of the control group. Examination of the raw data indicated no pattern to this difference between the experimental and control groups.

Running times were taken from the rat's exit of the

start box to its entering of the goal box, by means of a stop watch operated by the experimenter. A response consisted of the rat entering the goal box with all four feet. Both correct and incorrect responses were tabulated for each animal. After the experimental trials were completed a post-test for self-stimulation in the Skinner box was taken on all rats. All had bar press rates nearly equal to the pre-test except rat #1 in the food group which dropped considerably. This may have been due to electrode failure between pre-test and post-test.

Histology. After the experiment the rats were sacrificed and perfused with approximately 50 c.c. of isotonic saline solution followed by approximately 50 c.c. of formalin. The brains of the rats were then grossly examined to determine the placement of the electrode tips.

RESULTS

A chi square test of significance was run on the total errors of the last day's trials for each group. The food group obtained a chi square value of 12.844 which is significant ($p < .01$). The chi square value for ICS group was .40, a non-significant value. This indicates that the food group's performance was better than chance while the ICS group continued to perform at a chance level after fifty trials. Thus we can conclude that the food group learned over the five days of trials while the self-stimulation group did not. (The sum of the errors plotted over days for each group is represented in Figure 1. The sum of the running times plotted over days is represented in Figure 2.

An analysis of variance of trend was performed on both the running times and total errors for both groups. In order to see if there was any significant change in performance within each day's session for either group, the data was compressed over days providing tables with each subject's performance given over trials summed for all days. (See Figures 3 and 4). The only significant effect found was the treatment effect of ICS as a reinforcer compared to food as a reinforcer. This had an F of 56.29 which is significant ($p < .01$). It was noted that running times generally remained

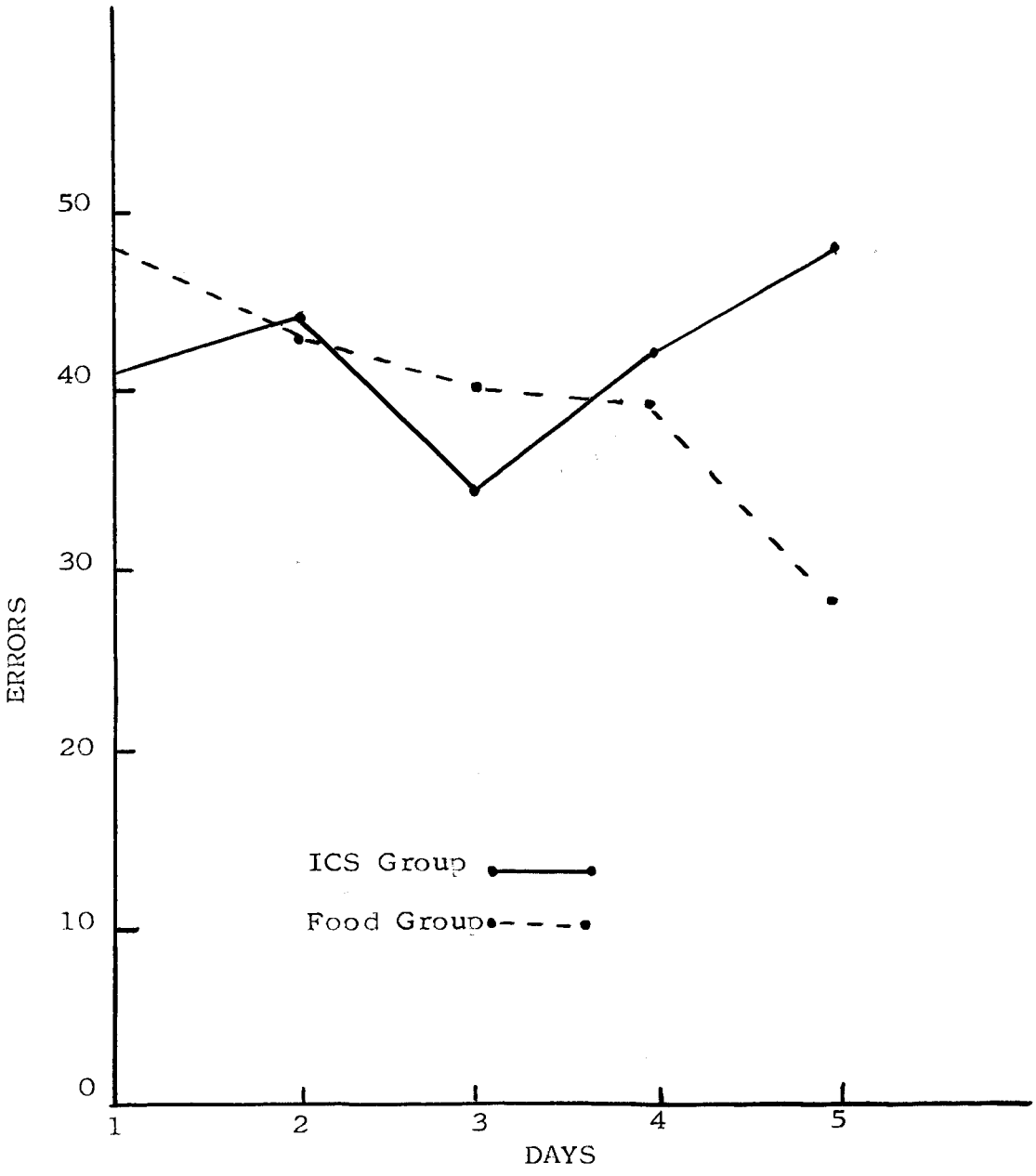

Fig. 1. Sum of errors plotted by days

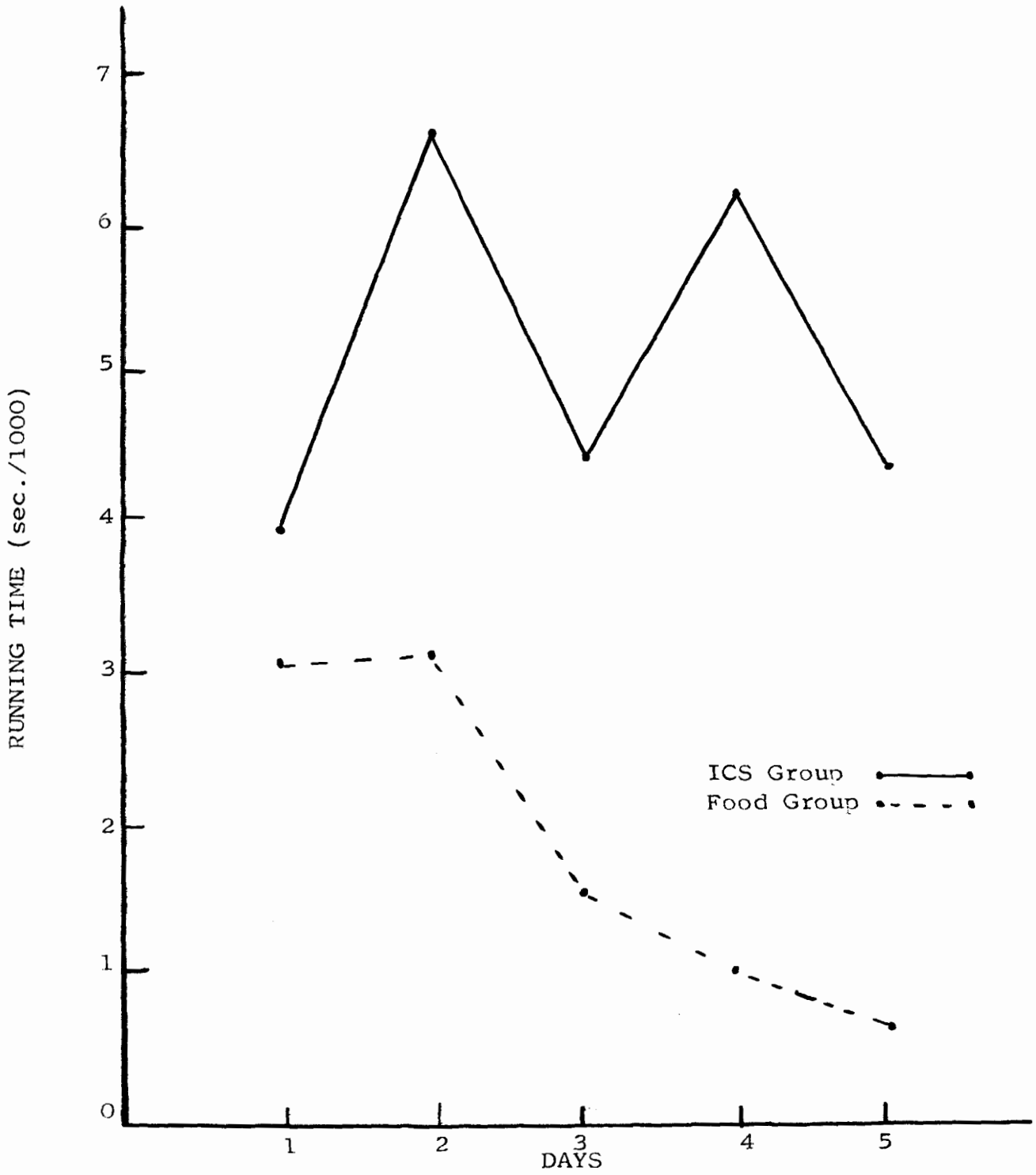

Fig. 2. Running times plotted by days

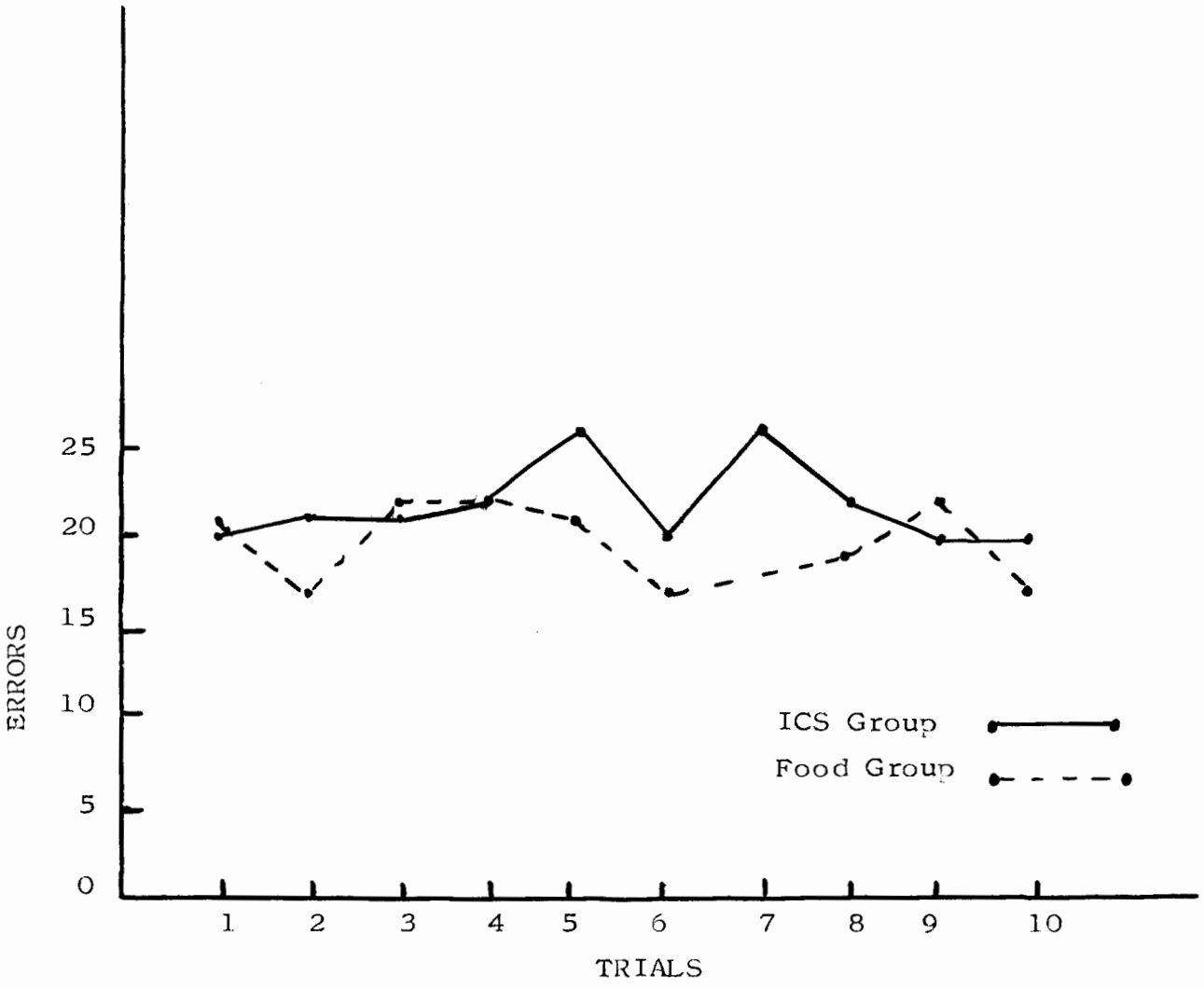

Fig. 3. Errors compressed over days

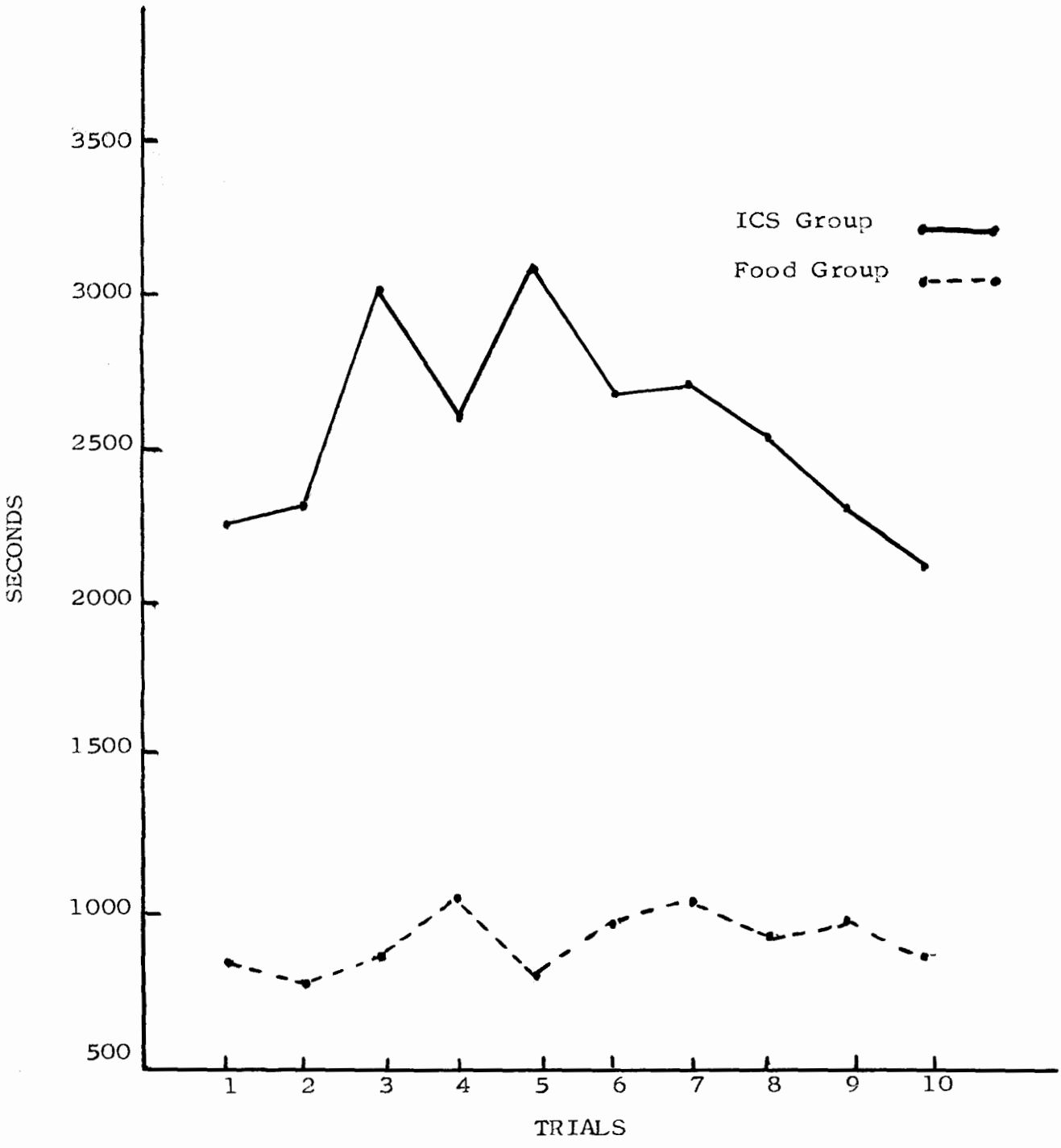

Fig. 4. Running times compressed over days

high for the ICS group with large fluctuations between individual trials and individual rats, while the running times for the food group quickly decreased. This difference was tested by comparing the variances of the two groups and found to be significant ($p < .01$) with an F of 4.675. There was no significant difference between blocks or the treatment times blocks interaction. The F values for all comparisons of running times are reported in Table 2. The treatment X blocks X trials interaction approached significance which was apparently due to an increase in running speeds during the middle of each day's trials for some rats. The second trend analysis, run on the total errors, indicated a significant ($p < .05$) treatment effect with an F of 5.262. No other effects or interactions approached significance. These results indicated no difference in the learning between self-stimulating rats with a high bar press compared over blocks with rats having a low rate. There was no significant learning within each day's massed trials for either group. Only the food group learned over days. A t-test was performed comparing the running times of the rats in Block 1 with the rats in Block 3 on the last day's trials for the ICS group only. There was no significant difference between the blocks ($t = 1.463$) indicating that the rats in

TABLE 2

ANALYSIS OF VARIANCE SUMMARY TABLE
RUNNING TIMES OVER TRIALS

Source of Variation	Sum of Squares	d.f.	Mean Square	F
Treatments	1,536,058	1	1,536,058	56.293*
Blocks	216	2	108	
Treatments x Blocks	58,292	2	34,390.5	1.26
Error (a)	327,440	12	27,286.68	
Trials	52,804	9	5,867.11	1.310
Treatments x Trials	53,084	9	5,898.22	1.317
Blocks x Trials	64,841	18	3,602.28	
Treatments x Blocks x Trials	130,416	18	7,245.33	1.618
Error (b)	483,641	108	4,478.16	
Total	2,706,792	179		

*Significant: $p < .01$

the ICS group with the highest bar press rates were no faster on the last day than the rats with the lowest rates in the same group.

DISCUSSION

The data indicates a failure of ICS to provide sufficient reinforcement for T-maze learning in this situation. This result is difficult to explain in terms of Olds' statement that ICS acts as a "genuine" reinforcer. Since the rats showed the reinforcing effects in the bar press situation in both pre-test and post-test trials, ICS should have been effective in the maze situation, according to Olds' position. The ICS group, however, did not perform better than chance during the five days of trials. They also failed to show the within session improvement reported by Olds (1956). The running times of the ICS group remained high throughout the experiment compared with the food group and showed no within session decrease. Such a decrease would be expected due to the "priming" or energizing effect reported by Wetzel (1963). Instead the ICS rats showed a slight (non-significant) increase in running times during the middle of each day's session which decreased to the beginning times by the end of each day's trials (see Figure 2). Wetzel's rats showed the "priming" effect after 2½ minutes of self-stimulation during a running trial within a few seconds after such "priming." In the

present study the rats would have received ICS for two minutes total after the sixth trial each day, if they made no errors. If periods of ICS of about two minutes are required to show the "priming" effect than this would account for the failure to get a significant effect within sessions, as well as the decrease in running times near the end of the sessions. One test of this would be massed trials of twenty or more trials per session should be given. In the present situation the rats were moved from the goal box to the start position about ten seconds after receiving ICS if they made a correct choice. Making 50 per cent errors, however, would increase time between stimulation to an average of about three to four minutes. Such a delay might have a significant effect upon learning as the "priming" may have "worn off."

The failure to show within session improvement also may be due to the different type of maze than that used by Olds. Olds used a maze in which the rat could shuttle back and forth receiving self administered ICS at the end of each run. The situation has the following advantages over the present: (1) ICS is received regularly at both ends of the maze, (2) the rat is allowed to correct errors and to continue to the goal box, and (3) the maze allows for very short intervals between goals and subsequent ICS. In the T-maze the rats

would receive ICS only after a correct choice. The correct choice being indicated by a cue rather than the rats simply learning a position or series of position responses. Thus the T-maze problem is probably more difficult to learn and provides the subjects with less reinforcement particularly during the early stages of learning. Since the food group did learn it is suggested that ICS is not as efficient a reinforcer as food for a more complicated task such as the present situation. This would explain the failure of the rats to learn over days and as well as within daily sessions. However, Olds' rats were allowed to respond by pressing a bar to receive ICS. Such a distinctive response in the goal box on the part of the subjects which was always reinforced, may somehow enhance performance more effectively than the response of entering one of two similar boxes with no guarantee of reinforcement.

Olds' suggestion of a "substratum of reward" which is the neuroanatomical and physiological basis for all reinforcement seems contradictory to the evidence of the present study. However, the operation of a negatively reinforcing system as suggested by Olds (1962), the effects of which may be initially weak but longer lasting than the positive aspects, may be responsible for the failure of ICS

to be rewarding after a period of time if it is involved. Another explanation may be that prior learning associated with eating, secondary reinforcing properties of the eating response, and a strong drive condition makes the eating response of the rat more reinforcing than passively receiving direct stimulation of a "reward center." The fact that self-stimulation can occur without any detectable drive existing would suggest that the effect of ICS may be short lived compared to a strong drive such as hunger. Differing electrode parameters as well as electrode sites and stimulus presentation also may account for the difference between the experimental and control groups.

Deutsch (1960) suggests that ICS produces simultaneously a rapidly decaying drive as well as reward. Thus behavior is maintained in simple situations such as bar pressing but the effect declines rapidly in a more complex situation. Such an explanation may handle the problem of the failure of ICS group to equal the food group better than the theory put forth by Olds. Such a view is set forth by Gallistel (1964). In the present situation the experimental rats received ICS after about three to four minutes delay on half the trials by making errors 50 per cent of the time. This may have been ample time for any drive produced by ICS

to decay as Deutsch suggests it would. Thus the rats would not continue to "seek" ICS reinforcement. Also the length of the maze and the relatively long running times of the ICS group of about one to two minutes might allow for a good deal of decay even if the rat made the correct choice 100% of the time. Thus in the more complicated learning situations ICS would tend to be an ineffective reinforcement. This also explains the results cited earlier of massed vs. spaced trials, rapid extinction and "priming" effects. This could be tested in Olds' maze situation by comparing extinction curves for rats which are allowed to extinguish immediately with curves for rats which are extinguished after an overnight delay. Deutsch would predict a difference in the curves while Olds would not.

Observations of the rats during the experiment seemed to indicate that the Ss were energized or activated by the ICS in that their activity in the goal box after ICS appeared to increase. However, this activity seemed to quickly decrease and apparently did not affect running time.

It may be that with careful selection as to individual general performance in response to ICS, as well as bar press rates for ICS, a group of rats could be selected from a much larger group of self-stimulators which would perform as well

for ICS as did the food group. If this were true, the result would be consonant with Olds. However, such a procedure would be experimentally dishonest. There may be important variables in the rats behavior or temperament which affect the success of ICS as a reinforcer. However, any selection on such a basis must be carefully reported and controlled. Although existing theories explain much of the behavior exhibited in ICS studies, there are many variables yet to be isolated and much behavior yet to be explained. Although ICS does appear to be strongly reinforcing in some situations such as for a bar press response, the nature of this reinforcement and the efficacy of ICS as a reinforcer in basic learning problems is still an open question.

SUMMARY

Eighteen, 23 hour food deprived, self-stimulating rats were divided into two groups. One group received 20 ICS pulses as a reward for a correct response in a T-maze while the second group received a food reward. The subjects learned for food over 5 days of 10 massed trials per day, but failed to show learning for ICS either within sessions or over days. There was no difference in learning between rats with high bar press rates and those with low rates in either group.

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