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THE EFFECTS OF SCHEDULES AND MAGNITUDES
OF
REINFORCEMENT ON BEHAVIOR

By

Hind Barakat

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Hind Barakat

TABLE OF CONTENTS

Chapter		Page
	<u>Part I</u>	
I	INTRODUCTION	1
II	SUBJECTS	13
III	SUBJECT I AND II--TANDEM FI 30" FR 12	16
IV	SUBJECT IV--CONJUNCTIVE FI 15" FR 12	33
V	SUBJECT V--CONJUNCTIVE FI 30" FR 12	41
VI	DISCUSSION	50
	CONCLUSION	
	<u>Part II</u>	
VII	INTRODUCTION	54
VIII	SUBJECT I AND II--TANDEM FI 30" FR 12	57
IX	SUBJECT V--CONJUNCTIVE FI 30" FR 12	62
X	DISCUSSION	65
	CONCLUSION	

LIST OF ILLUSTRATIONS

Figure		Page
1	Typical cumulative bar pressing response curves of subject I trained under the schedule tandem FI 30" FR 11 with water, 4, 8 and 16% sucrose concentrations as the reinforcing agents	18
2	Typical cumulative bar pressing response curves of subject II trained under the schedule FI 30" FR 11 with water, 4, 8 and 16% sucrose concentrations as the reinforcing agents	20
3	The daily total number of responses emitted by subject I trained under the schedule FI 30" FR 11 with water, 4, 8 and 16% sucrose concentrations as the reinforcing agents	21
4	The daily total number of reinforcement received by subject I under water, 4, 8 and 16% sucrose concentration as the reinforcing agents	22
5	The daily total number of responses emitted by subject II trained under the schedule FI 30" FR 11 with water, 4, 8 and 16% sucrose concentrations as the reinforcing agents	22
6	The daily total number of reinforcements received by subject II under the different reinforcement magnitudes	23
7	The daily mean time taken by subject I to emit a burst of 10 responses under water, 4, 8 and 16% sucrose concentration as the reinforcing agents	24
8	The daily mean time taken by subject II to emit a burst of 10 responses under the different reinforcement magnitudes	24
9	The daily median pause paused by subject I after receiving the different reinforcements of sucrose concentrations	28
10.	The daily median pause paused by subject II after receiving the different reinforcements of sucrose concentrations	29

Figure		Page
11	Typical cumulative bar pressing response curves of subject IV trained under the schedule conjunctive FI 15" FR 12 with water, 4, 8 and 16% sucrose concentrations as the reinforcing agents	35
12	The daily total number of responses emitted by subject IV under the schedule conjunctive FI 15" FR 12 following water, 4, 8 and 16% sucrose concentrations as the reinforcing agents	36
13	The daily total number of reinforcements received by subject IV under the schedule conjunctive FI 15" FR 12 following water, 4, 8 and 16% sucrose concentrations as the reinforcing agents	36
14	The daily mean time taken by subject IV to emit a burst of 10 responses under the schedule conjunctive FI 15" FR 12 with water, 4, 8 and 16% sucrose concentrations as the reinforcing agents	38
15	The daily median pause paused by subject IV after reinforcement following water, 4, 8 and 16% sucrose concentrations as the reinforcing agents	40
15a	Typical cumulative bar pressing response curves of subject V trained under the schedule conjunctive FI 30" FR 12 with reinforcements of water, 4, 8 and 16% sucrose concentrations	44
16	The daily total number of bar pressing responses of rat V under the schedule conjunctive FI 30" FR 12 following reinforcements of water, 4, 8 and 16% sucrose concentrations	45
17	The daily total number of reinforcements received by subject V under the schedule conjunctive FI 30" FR 12 with reinforcements of water, 4, 8 and 16% sucrose concentrations	45
18	The daily mean time taken by subject V to emit a burst of 10 responses under the different reinforcement magnitudes	46
19	The daily median pauses paused by subject V following different reinforcement magnitudes under the schedule conjunctive FI 30" FR 12.	47

Figure		Page
20	The daily total number of responses emitted by subject I under different reinforcement magnitudes following an increase in drive	58
21	The daily total number of reinforcements received by subject I under the schedule tandem FI 30" FR 11 with reinforcements of water, 8, 16% sucrose concentrations following an increase in drive	58
22	The daily median time taken by subject I to emit a burst of 10 responses under the schedule tandem FI 30" FR 11 with different reinforcement concentrations following an increase in drive	60
23	The daily median time taken by subject II to emit a burst of 10 responses under the schedule tandem FI 30" FR 11 with different reinforcement concentrations following an increase in drive.	60
24	The daily total number of responses emitted by subject V under the schedule conjunctive FI 30" FR 12 with different reinforcement magnitudes following an increase in drive	63
25	The daily mean time taken by subject V to emit a burst of 10 responses following an increase in drive under different reinforcement magnitudes	64

LIST OF CHARTS

Charts		Page
I	Percent of total number of bursts of responses emitted within specified time intervals by subject I trained under the schedule tandem FI 30" FR 12 with different sucrose concentrations as reinforcers	26
II	Percent of total number of bursts of 10 responses emitted within specified time intervals by subject II trained under the schedule tandem FI 30" FR 12 with different sucrose concentrations as reinforcers	27
III	Percent of total number of pauses paused by subject I within specified intervals (seconds) under the different reinforcement magnitudes	30
IV	Percent of total number of pauses paused by subject II within specified intervals (seconds) under the different reinforcement magnitudes	31
V	Percent of total number of bursts of 10 responses emitted within specified time intervals by subject IV trained under the schedule conjunctive FI 15" FR 12 with different sucrose concentrations as reinforcers	39
VI	Percent of total number of bursts of 10 responses emitted within specified time intervals by subject V trained under the schedule conjunctive FI 30" FR 12 with different sucrose concentrations as reinforcers	48

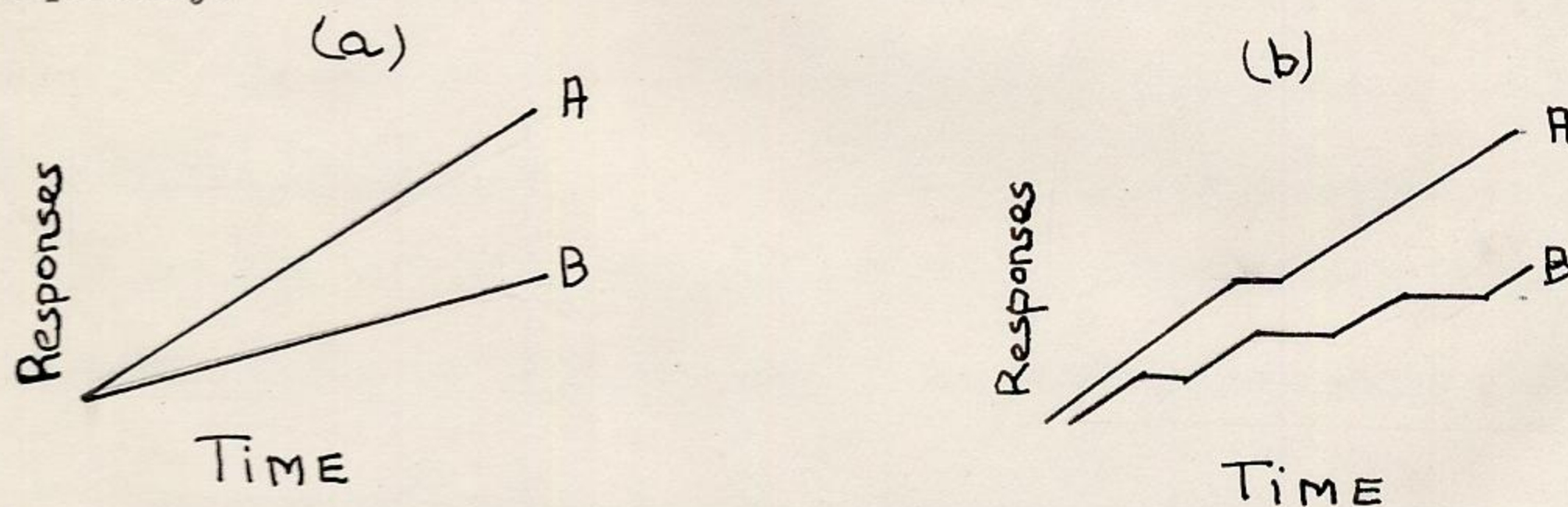
LIST OF TABLES

Table		Page
I	Results of the effects of different reinforcement magnitudes on the bar pressing response of subject I trained under the schedule tandem FI 30" FR 12	17
II	Results of the effects of different reinforcement magnitudes on the bar pressing response of subject II trained under the schedule tandem FI 30" FR 12	19
III	Results of the effects of different reinforcement magnitudes on the bar pressing response of subject IV trained under the schedule conjunctive FI 15" FR 12	34
IV	Results of effects of different reinforcement magnitudes on the bar pressing response of subject V trained under the schedule conjunctive FI 30" FR 12	43
V	Results of effects of different reinforcement magnitudes on the bar pressing response of subject I trained under the schedule tandem FI 30" FR 12 following an increase in drive	57
VI	Results of effects of different reinforcement magnitudes on the bar pressing response of subject II trained under the schedule tandem FI 30" FR 12 following an increase in drive	59
VII	Results of effects of different reinforcement magnitudes on the bar pressing response of subject V trained under the schedule conjunctive FI 30" FR 12 following an increase in drive	62

CHAPTER I
INTRODUCTION

The purpose of the present experiment is to study the effects of different reinforcement magnitudes on the response strength of thirsty albino rats trained to bar press in a Skinner box under different reinforcement schedules.

Most experiments on the relationship between reward magnitude and rate of responding have shown that responding is faster with larger than with smaller rewards (see below). However faster responding, that is, more responding in a given time may come about in at least two ways, viz: faster uniform overall responding and few pauses between bursts of responses. In the figure animal A makes more responses than animal B in a given time, but in the one case (a) it does this by responding faster all the time and in the other (b) by responding at the same rate more frequently.



In both (a) and (b) the overall response rates of animal A are faster than those of animal B. In (a) its local rate (rate of responding when

the animal is responding) is higher too, but in (b) the local rates of the two animals are the same.

Knowing that increases in reinforcement magnitude increases overall rates our problem is to discover whether this comes about according to (a) or (b), or in some other manner. To this end animals were trained to bar press under tandem FI30" FR11, conjunctive FI30"FR12 and conjunctive FI15"FR12.

A tandem schedule is "a schedule of intermittent reinforcement in which a single reinforcement is programmed by two schedules acting in succession without correlated stimuli."¹ Thus in the present case a reinforcement, according to this particular schedule, occurs only when 12 responses have been emitted after a 30 seconds interval has elapsed.² A conjunctive schedule also requires satisfaction of ratio and interval schedules, but not in succession: the ratio can be satisfied, in this case, during the interval.³ That is according to the present schedules a response is reinforced after either 30 seconds or 15 seconds and after 12 responses whichever is the later.

Experimental Background

In his tentative treatment of the problem of magnitude of reinforcement and performance Hull concluded that habit strength is a positive

¹Ferster, C.B. and Skinner, B.F., Schedules of Reinforcement. (Appleton-Century Crofts, Inc., New York, 1957) p. 415.

²Twelve responses are required in FI30" FR11 because the first response ends the interval.

³Ferster and Skinner, op.cit., p. 725.

function of the magnitude of reward.⁴ This conclusion was mainly obtained from the experiments performed by Grindley, and Wolfe and Kaplon on chicks where the results showed that the response strength varies with amounts of reinforcement.⁵ This hypothesis, that reward operates on habit strength, permitted Hull to predict a gradual deterioration of performance following a decrease in reinforcement and a gradual improvement of the rate of learning following an increase in reward amount.

To test this hypothesis Crespi and Zeaman measured running speeds,⁶ and response latencies⁷ of animals trained to cross a runway for different reward magnitudes. Their results partly supported Hull's formulation by showing differential asymptotic performance according to amount of incentive, faster running occurring with greater reward magnitudes. Hull however, found it necessary to reformulate his postulate, because when reward sizes were changed running speeds altered immediately and not slowly as his habit hypothesis required. Thus instead of arguing that reinforcement acted on performance via habit strength he postulated that reinforcement affects drive, and introduced an incentive motivational factor, K, to account for the differential effects of reward magnitude on behavior.

Spence has also proposed an incentive motivational hypothesis of the effects of different reward magnitudes on behavior, whereby different reward magnitudes are expected to elicit consummatory responses of different

⁴Hull, C.L., Principles of Behavior, (Appleton-Century-Crofts, Inc., New York, 1943).

⁵Pubols, B.H., "Incentive Magnitude, Learning and Performance in Animals." Psychol. Bull. (1960) 57, p. 90.

⁶Spence, K.W., Behavior, Theory and Conditioning, (Yale University Press, New Haven, Conn., 1956) p. 135.

⁷Zeaman, D., "Response Latency as a Function of the Amount of Reinforcement." J. Exp. Psychol. 39(1949) p. 466.

vigor or speed.⁸ According to him classical conditioning of different rgs (anticipatory goal responses) to cues in the apparatus provide different performance levels in the instrumental response under varied reinforcement amounts.

As mentioned above the reason for Hull's adoption of a motivational factor to account for shifts in performance was the abrupt shift in performance as a result of a change in incentive.⁹ Moreover, changes in incentive in Crespi's and Zeaman's experiments led the animals to emit responses either beyond or below the response level of control animals trained under the same incentive amounts throughout. These effects were labelled, the elation effect and the depression effect respectively. Inconsistent observations of these effects are shown in other similar studies. One study reports both the elation and depression¹⁰ effects while another study reports neither effect.¹¹ Moreover, one study observes only the elation effect¹² while another study observes the depression effect only.¹³ The conclusion of the latter experiment is that the elation effect "occurs prior to the attainment of the asymptotic performance" and is therefore an artifact.

Despite these inconsistencies, which may be due to the different length of the runway apparatus and to the amount of competing exploratory

⁸Spence, op.cit., p. 130.

⁹Zeaman, op.cit., pp. 466-483. Crespi, L.P., "Amount of Reinforcement and Level of Performance," Psychol. Rev. (1944), 51 p. 341. Spence, ibid., p. 130.

¹⁰Pubols, op.cit., p. 90.

¹¹Metzger, R., Cotton, J.W. and Lewis, D.J., "Effect of Reinforcement Magnitude and of Order of Presentation of Different Magnitudes in Running Behavior." J. Comp. Physiol. Psychol. 50, p. 180, (1957).

¹²Zeaman, op.cit., p. 130.

¹³Spence, K.W. op.cit., p. 130.

behavior,¹⁴ it is agreed that since the shift in performance resulting from a change in reward magnitude is sudden the effect of incentive amount is on performance and not on learning. However a shift in reward magnitude affects performance levels differently in different situations. An upward shift in reward produces an abrupt change to a faster rate of running in a runway, while a downward shift produces a gradual decrease¹⁵ in running speed, and more variability¹⁶ in responses eventually leading to extinction.¹⁷ Reversal learning, on the other hand, in a discrimination training produces a gradual change in performance level. The competing exploratory responses are held responsible for the retardation of reversal learning which would be expected to be greater in a more complicated situation than a runway.¹⁸

There is evidence showing that learning and relearning, as measured by number of correct responses, "can take place in a T maze by simply manipulating the size of a reward in the end box."¹⁹ However previous

¹⁴Pereboom, A.C., "A Note on the Crespi Effect," Psychol. Rev. 46, p. 263 (1957).

¹⁵Collier, C., Knarr, F.A., and Marx, M.H., "Some Relation Between the Intensive Properties of the Consummatory Response and Reinforcement," J. Exp. Psychol. 62, p. 435, (1961).

¹⁶Young, P.T. and Shuford, E.H., "Intensity, Duration and Repetition of Hedonic Processes as Related to Acquisition of Motives," J. exp. Psychol. 47, p. 298, (1954).

¹⁷Dufort, R.H. and Kimble, G.A., "Changes in the Response Strength with Changes in the Amount of Reinforcement." J. exp. Psychol. 51, p. 185 (1956).

¹⁸Pereboom, A.C., "An Analysis and Revision of Hull's Theorem 30." J. Exp. Psychol. 53, p. 234, (1957).

¹⁹Denny, R.M., and King A.F., "Differential Response Learning on the Basis of Differential Size of Reward." J. Exp. Psychol. 87, p. 317, (1955).

experience with different reward amounts in a different apparatus is not found to have a reliable relationship with performance under a present magnitude reward²⁰ nor does the amount of incentive influence the rate of learning as long as there exists an amount of reward above a certain threshold value.²¹

Animals run in a runway or in a maze in a shorter time for a large reward than for a small one.²² They also run faster for hundred percent reinforcement than for fifty percent reinforcement,²³ and when the reinforcement is constant and not varied between two amount values.²⁴ The relationship between these running speeds and the amounts of reinforcement have been claimed to be monotonic, monotonic and S shaped²⁵ and non-monotonic.²⁶

²⁰Lawson, R. Cross, H.A., and Tarnbet, J.T. "Effects of Large and Small Rewards on Maze Performance after Different Prior Experiences with Reward Magnitudes." J. Comp. Physiol., 57, p. 717 (1959).

²¹Furchtgott, E. and Rubin, R.D., "The Effect of Magnitude of Reward on Maze Learning in White Rat." J. Comp. Physiol. Psychol. 46, p. 9, (1953).

²²Armus, H.L., "The Effect of Magnitude of Reinforcement on Acquisition and Extinction of a Running Response." J. Exp. Psychol. 58, (1959), p. 63.

²³Lewis, D.J. and Cotton, J.W., "Learning and Performance as a Function of Drive Strength during Acquisition and Extinction." J. Comp. Physiol. Psychol. 50, p. 188, (1957).

²⁴Logan, F.A., Beiar, E.M. and Ellis, R.A., "Effect of Varied Reinforcement on Speed of Locomotion." J. Exp. Psychol. 49, p. 266 (1955).

²⁵Goodrich, K., "Running Speed and the Drinking Rate as Functions of Sucrose Concentration and Consummatory Activity." J. Comp. Physiol. Psychol. 53, p. 250, (1960).

²⁶Young, P.T. and Shuford, E.H., "Quantitative Control of Motivation through Sucrose Solution of Different Concentrations." J. Comp. Physiol. Psychol. 48, p. 118 (1955).

The concentration of sucrose solution has been found to be not only the main determinant of the strength of the instrumental running response but also an important determinant of the strength of the consummatory response itself.²⁷ On the other hand, Spence cites an experiment by Czeh where the size of the reward is varied but the exposure time to the reinforcement is held constant. Accordingly "the results of the learning period clearly reveal that speed of starting in the runway varied with consummatory time in the goal and was not a function of the size of the pellet per se."²⁸ This is not always the case, for in one experiment running speeds did not vary systematically with either the amount of reinforcement or with the time spent in the goal box.²⁹

Most of the available evidence does show a relationship between response speed and reward magnitude, although the evidence is not always consistent and the details are not clear. It is possible that more precise measures are required than overall times to perform a given response complex; for example as far as the drinking behavior of rats is concerned, the local licking rate is constant, depending on neither

²⁷Kraeling, D., "Analysis of Amount of Reward as a Variable in Learning." J. Comp. Physiol. Psychol. 54, (1962), p. 560.

²⁸Spence, op.cit., p. 135.

²⁹Fehrer, E., "Effects of Amount of Reinforcement and of Pre- and-Post Reinforcement Delays on Learning and Extinction." J. Exp. Psychol. 52, (1956), p. 167.

reinforcement magnitude nor on the deprivation time.³⁰ The overall response rate of licking does change with these variables but this measure does not represent accurately the animal's drinking behavior because it does not indicate possibly important measures such as the temporal distribution of pauses and the time spent in drinking.

Equally, overall measurements of alley running speeds show different and misleading results, for animals do not follow a uniform speed of running throughout the alley. The effect of reward seems to be strongest in the middle part of the runway.³¹ This means that animals run faster in the middle part than at both ends of the alley. Different amounts of incentive produce different running responses. With a large reward running speed declines from the beginning to the end of the runway showing that performance away from the goal is superior to performance near it, while a small reward produces constant running speed throughout the runway with a slight decline at the end.³² However, the amount of reward does not seem to affect the running speed as such, instead it appears to affect the amount of irrelevant responding, which increases

³⁰ Davis, J.D. and Keehn, J.D., "Magnitude of Reinforcement and Consummatory Behavior." Science, 130, (1959), p. 269. Also, Stellar, E. and Hill, J.H. "The Rat's Rate of Drinking as a Function of Water Deprivation." J. Comp. Physiol. Psychol. 45, (1952), p. 86.

³¹ Weiss, R.F., "Deprivation and Reward Magnitude Effects on Speed throughout the Goal Gradient." J. Exp. Psychol. 60, (1960), p. 384.

³² Collier, G., Marx, F.A. and Marx, M.H., "Some Relation between the Intensive Properties of the Consummatory Response and Reinforcement." J. Exp. Psychol. 62, (1961), p. 485.

as reinforcement magnitudes are reduced.³³

The different results presented by different investigators make it difficult to draw firm conclusions from studies using the runway technique, and a similar variety of conclusions are obtained from bar pressing behavior. According to Spence, who cites Swisher's³⁴ study, performance is affected by time of consummation but not by the size of reward. Similarly the pecking response rate of pigeons on periodic reinforcement schedules with different reinforcement exposure times is faster with a longer duration than with a shorter duration, and the upward shift to the longer duration has a greater effect on performance than the downward shift.³⁵

On the other hand the overall rate of responding is an increasing function of the size of reinforcement³⁶ and a shift from continuous reinforcement to periodic reinforcement makes the relation between magnitude of reward and performance change from non-monotonic to monotonic.³⁷

³³ Pereboom and Crawford, op.cit., p. 82.

³⁴ Spence, op.cit., p. 135.

³⁵ Jenkins, W.O. and Clayton, F.L., "Rate of Responding and Amount of Reinforcement." J. Comp. Physiol. Psychol. 42, (1949) p. 187.

³⁶ Hutt, P.J., "Rate of Bar Pression as a Function of Quantity of Food Reward." J. Comp. Physiol. Psychol. 47, (1954) p. 239.

³⁷ Guttman, N., "Operant Conditioning, Extinction and Periodic Reinforcement in Relation to Concentration of Sucrose Used as Reinforcing Agent," J. Exp. Psychol. 46, (1958) p. 224.

However even on a schedule an increased reward to 50% sucrose concentration produces a non-monotonic relationship.³⁸ This non-monotonicity of the rates under different concentrations is attributed to the length of the interval between reinforcements.³⁹ Thus low concentrations are more effective if delivered with short intervals while high concentrations are less effective if delivered close together.

On a variable interval schedule the local rate of lever pressing of monkeys was not dependent on the magnitude of reinforcement⁴⁰ although the overall rate under a fixed interval schedule appeared to be directly related to the magnitude of reward with sucrose concentrations up to 50% amount.⁴¹ However the rate is not always consistent, because the amount of reinforcement is of relative importance once a stable rate of responding is attained and only as long as the experimental conditions are not changed.⁴²

³⁸Stebbins, W.C., "Relation of Amount of Primary Reinforcement to Discrimination and to Secondary Reinforcer Strength." J. Comp. Physiol. Psychol. 52, (1959) p. 721.

³⁹Collier, G. and Siskel, M., "Performance as a Joint Function of Amount of Reinforcement and Inter Reinforcement Interval." J. Exp. Psychol. 57, (1959) p. 120.

⁴⁰Conrad, D.C. and Sidman, M., "Sucrose Concentration as Reinforcement for Bar Pressing by Monkeys." Psychol. Rep. 2, (1956) p. 384.

⁴¹Stebbins, W.C. Mead, P.B. and Martin, J.M., "The Relation of Amount of Reinforcement to Performance under a Fixed Interval Schedule." J. Exp. Anal. Beh. 2, (1959) p. 355.

⁴²Keesey, R.E. and Kling, J.W., "Amount of Reinforcement and Free Operant Responding." J. Exp. Anal. Beh. 4, (1961) p. 132.

Overall and Local Rates

Most of the above studies examined the overall rates of responding where the major concern was the measurement of the time required either for a run through a runway or for a number of bar presses in a Skinner box, without consideration of whether subjects responded for all or only part of the measured time. Details of their subjects' behavior were observed by Pereboom and Crawford who studied both the instrumental (forward running) responses and the non-instrumental (competing) responses in a runway under a two different reward magnitudes. The results as stated above show that "the major component of runway behavior is the time involved in irrelevant behavior and not the speed of the instrumental response itself."⁴³ This conclusion is confirmed by other studies which measured the drinking behavior of rats in terms of the number of laps and amount consumed per second as a function of deprivation time,⁴⁴ and reward magnitude.⁴⁵ Through the use of a drinkometer these investigators found that the local rate of drinking is constant. However the alternations between pauses and drinking is dependent on deprivation time and reward magnitude, for as drive or amount of reinforcement is increased, the length of the pauses decrease and the frequency at which bursts of drinking occur increases.

⁴³Pereboom and Crawford, op.cit., p. 85.

⁴⁴Stellar and Hill, op.cit., p. 100. See also, Cotton, J.W. "Running Time as a Function of Amount of Food Deprivation." J. Exp. Psychol., 46, (1953), p. 198.

⁴⁵Davis and Keehn, op.cit., p. 271.

The present experiment was designed to study the effects of different reinforcement magnitudes on both the overall rates and local rates of responding of thirsty rats run under different reinforcement schedules. According to the above mentioned results it was expected that increased reward would not alter local rates of responding but would either eliminate or reduce the length of the pauses between reinforcements. This study, therefore, aims to answer the following questions:

1. Do local rates of responding change or remain constant as reinforcement magnitudes are varied?
2. Do the overall rates of responding change or remain constant with changes in reinforcement magnitudes?
3. And if they do so, do they change as a result of the pause length changes or local response rate changes *or both* ?

CHAPTER II

SUBJECTS

Four male albino rats about 200 days old at the beginning of the experiment were trained to bar press for water reinforcement. They were given several daily training sessions lasting between 30 to 60 minutes on schedules which started from continuous reinforcement and then were gradually built up to one of the following schedules: tandem FI 30" FR 11, (this schedule requires at least 12 responses for reinforcement since the first response after 30 seconds ends the interval component), conjunctive FI 30" FR 12 and conjunctive FI 30" FR 12. The building up of the schedules began with the introduction of the fixed interval, and then the fixed ratio schedule was gradually introduced in addition to the fixed interval.

The animals were adapted to a 22 hours water deprivation rhythm before the experiment was started. The daily sessions were presented during the same period of the day when the animals were 22 hours thirsty. The subjects had free access to food (Purina pellets) which was always found in their home cages except during the experimental sessions. After each daily session the subjects were given water for 30 minutes after the experimental session.

Apparatus

The experimental box was a Skinner box measuring 9.5 by 8.5 by 8.25 inches. The box was enclosed in a light proof and sound reducing ventilated chamber, and was illuminated by a 6 watt lamp. The bar was 2 inches long and 2.25 inches above floor level, 2 inches to the left of the dipper, and was activated by a pressure of about 20 grams. At the appropriate times, the dipper presented .05 cc of the reinforcing substance for 2 seconds.

The bar pressing responses were recorded by means of a graphic cumulative recorder, and the times required to emit the specific number of responses before each reinforcement were recorded on an electronic timer.

The specific reinforcing schedules were as follows:

1. Tandem FI 30" FR 11 where the twelfth response after the elapse of a 30 seconds interval is reinforced.
2. Conjunctive FI 30" FR 12 where reinforcement is given after the passage of 30 seconds and 12 responses concurrently.
3. Conjunctive FI 15" FR 12 where reinforcement is given after the passage of 15 seconds and 12 responses concurrently.

Once the animals reached a stable rate of responding under the specified schedules with water as the reinforcing substance the experimental sessions under the different sucrose concentrations were begun. Under the same conditions, the animals were ran for 3 days in 30 or 60 minutes sessions under each of the following sucrose concentrations: 4, 8, 16, 8 and 4%. In order to decrease any interaction effect between

the different solutions one 30 or 60 minutes session with water as the reinforcing agent was given between each sucrose concentration.

Response Measures

The response measures were as follows:

1. The overall rate of responding which was measured by the total number of responses within each experimental session divided by the number of minutes in the session.
2. Local rates of responding or the time taken for the last 10 responses before reinforcement.
3. The total number of reinforcements received each day under each concentration.
4. Pause lengths from reinforcement to the first response.

CHAPTER III

SUBJECTS I AND II

Tandem FI 30" FR 11

Two animals were run under the same schedule, Tandem FI 30" FR 11. They were trained to bar press under the same experimental procedure both before and after the introduction of the different sucrose concentrations. The animals received 28 successive daily sessions with the exception of the first 6 sessions when the training periods were every other day. The 28 sessions, comprising the gradual building up of the schedule to FI 30" FR 11 included:

1. Three sessions of 30 minutes each under continuous reinforcement.
2. Six sessions of 60 minutes each, under an interval schedule gradually built up to FI 60".
3. 14 sessions of 60 minutes each, with the additional schedule of fixed ratio in which the overall schedule was gradually built up to tandem FI 30" FR 11.
4. 5 such sessions under the schedule tandem FI 30" FR 11 to stabilize the rate of responding with water as a reinforcer before the introduction of the different magnitudes of reinforcement.

The measurement of the overall rate of responding, the local rate of responding and the pauses after reinforcement began on the last 2 sessions before the introduction of the different sucrose solutions.

Results

The results summarized in Table I, clearly indicate that the different reinforcement magnitudes do not influence the local bar pressing response rate of Rat I ran under the schedule tandem FI 30" FR 11.

TABLE I

Reinf.	Mean No. Reinf.	No. of Sessions 60 min.	Mean overall rate in R/min.	Mean Local Rate R/sec.	Av. Pause seconds	% of Pauses within 30" interval
Water	36	6	9.2	2.4	55.48	35.88
4%	35	5	9.4	2.4	47.6	33.54
8%	27	6	6.6	2.2	68.75	24.84
16%	37	3	8.7	2.2	60	27.4

Table I: The summary of the results obtained from rat I trained to bar press in a Skinner box under the schedule tandem FI 30" FR 11, with water, 4, 8 and 16% of sucrose concentration^{as} reinforcements.

The typical responding of rat I after stabilization, as presented in Fig. I, shows that the subject emits bursts of responses followed by a pause immediately after the reinforcement and that the rates during the response bursts are irrespective of the reinforcement amounts.

The daily overall rates of responding are not steady; the subject tended to emit more responses with the introduction of a new concentration and then decline over the remaining days on that solution. Neither the mean overall rates nor the mean number of reinforcements under each concentration is affected by the different reinforcement magnitudes.

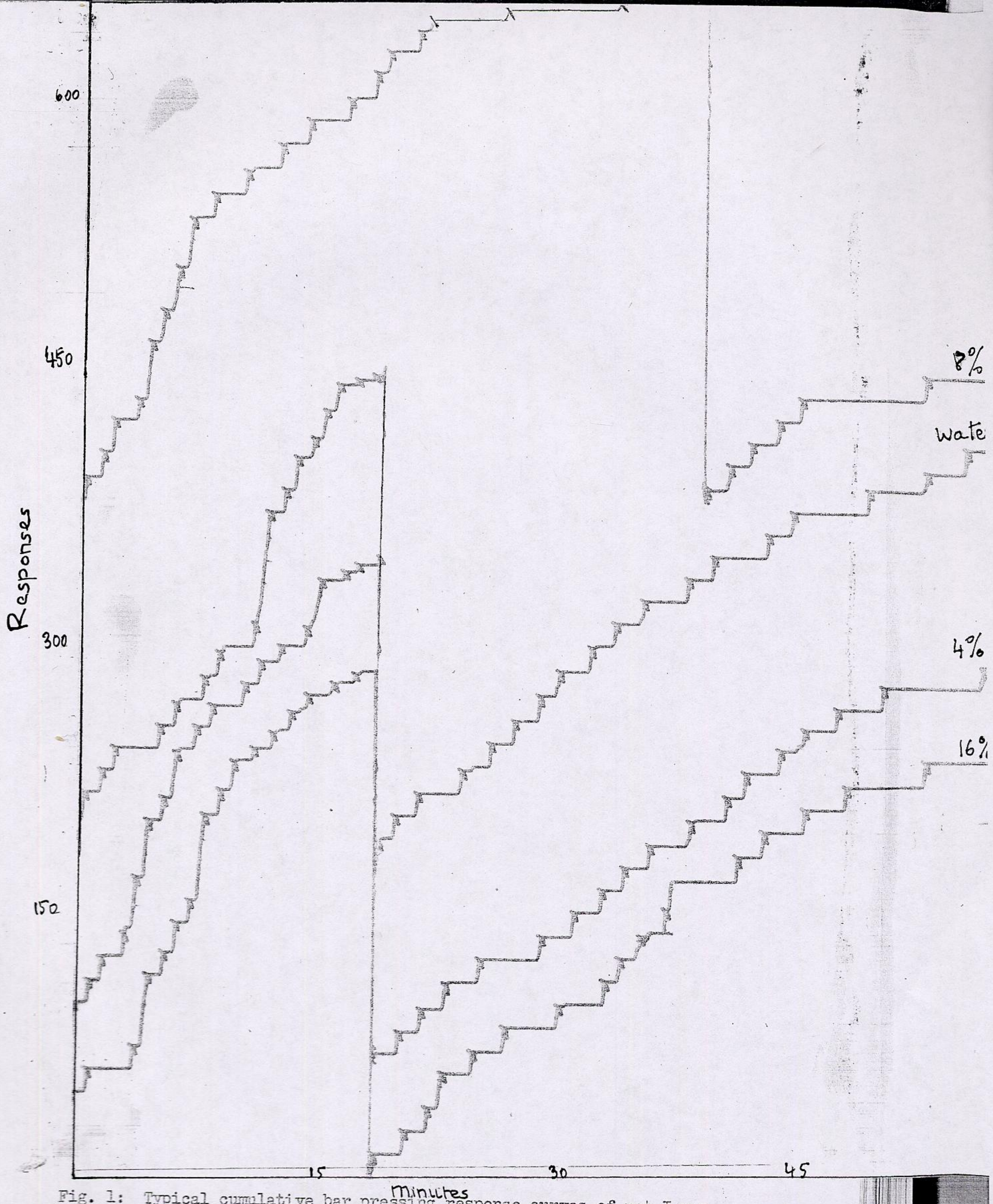


Fig. 1: Typical cumulative bar pressing response curves of rat I ran under the schedule tandem FI 30" FR 11 with different reward

The mean overall rates of responding under the water, 4, 8 and 16% sucrose solutions are 9.2, 9.4, 6.6 and 8.7 responses per minutes respectively, while the respective mean reinforcements are 36, 35, 27 and 37 reinforcements.

The findings from rat II are shown in Table II, below. The local response rates are almost constant at about 2.4 responses per second with all reinforcement concentrations, and variations in overall rates are neither large nor systematic.

The mean overall rates of rat II are not affected by the different reinforcement magnitudes. The mean rates and the mean reinforcements under the water, 4, 8 and 16% sucrose concentration are 3.97, 4.2, 3.5 and 3.1 responses per minute and 18, 19.5, 14 and 14 reinforcements respectively.

TABLE II

Reinf. Sucrose Solution	Total No. of sessions	Mean reinf.	Mean over-all rate in Resp./min.	Mean local rate in Resp./sec.	Av. md. pause seconds	% of pauses within the 30" interval
Water	6	18	3.97	2.5	98.7	10.92
4%	5	19.5	4.2	2.4	67.32	15.6
8%	6	14	3.5	2.3	125.37	17
16%	3	14	3.1	2.5	91.88	22.4

Table II: Results obtained from rat II ran under the schedule tandem FI 30" FR 11 following different reinforcement magnitudes.

Minutes
Fig. II: Typical cumulative bar pressing response curves of rat II ran under the schedule tandem FI 30" FR 11 with different reward magnitudes

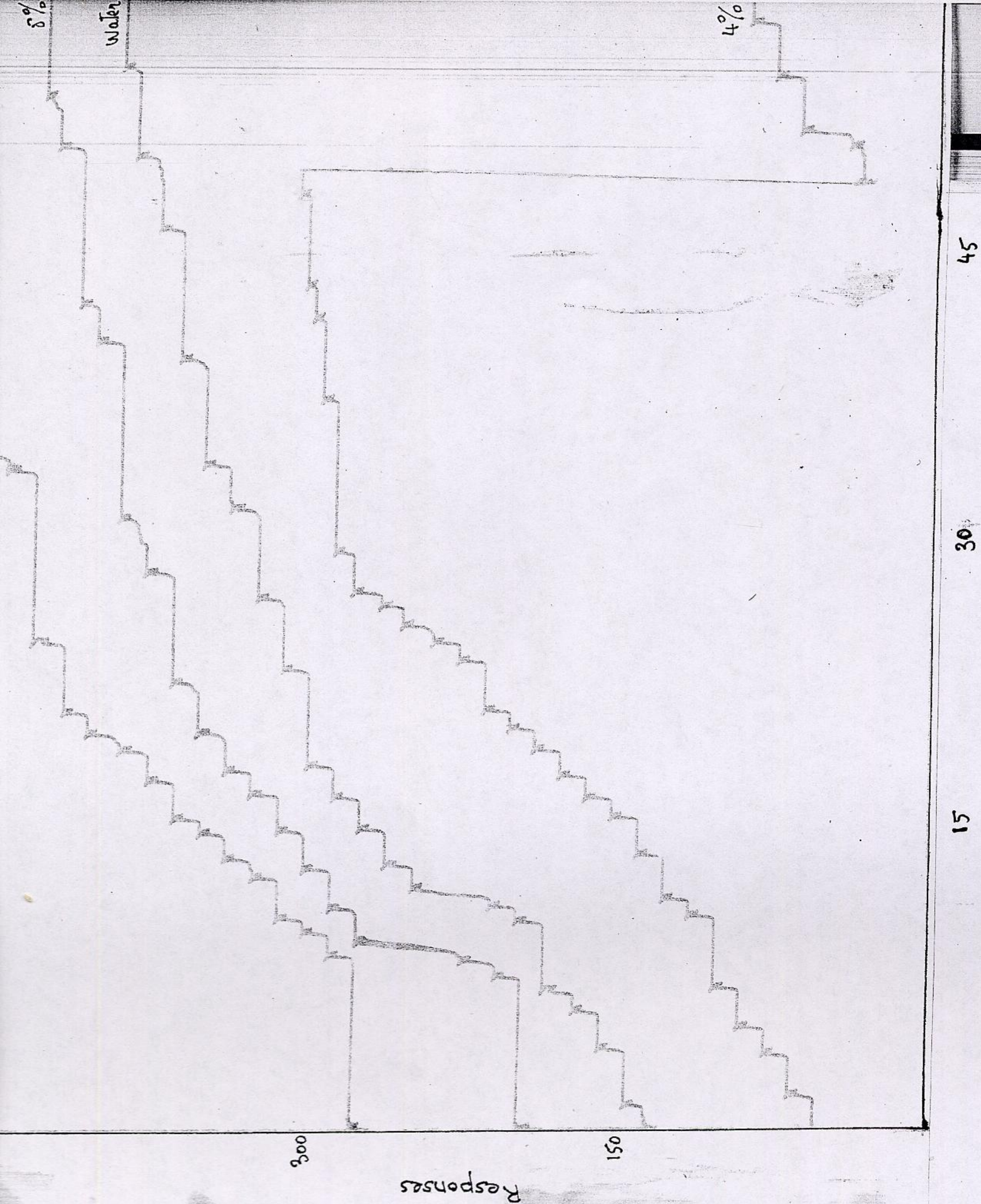


Fig. II: Typical cumulative bar pressing response curves of rat II
 ran under the schedule tandem FI 30" FR II with different
 reward magnitudes

15

30

45

Minutes

300

150

Responses

Water

8%

4%

Fig. 2, shows the typical cumulative curves produced by animal II under the different reward magnitudes. The response times are almost the same irrespective of the reward magnitudes, although the pauses after reinforcement are longer than the pauses of rat I.

Figures 3, 4, 5 and 6, show the daily number of responses emitted and the total number of reinforcements received by subjects I and II respectively under all the different reinforcement concentrations during the whole experimental sessions.

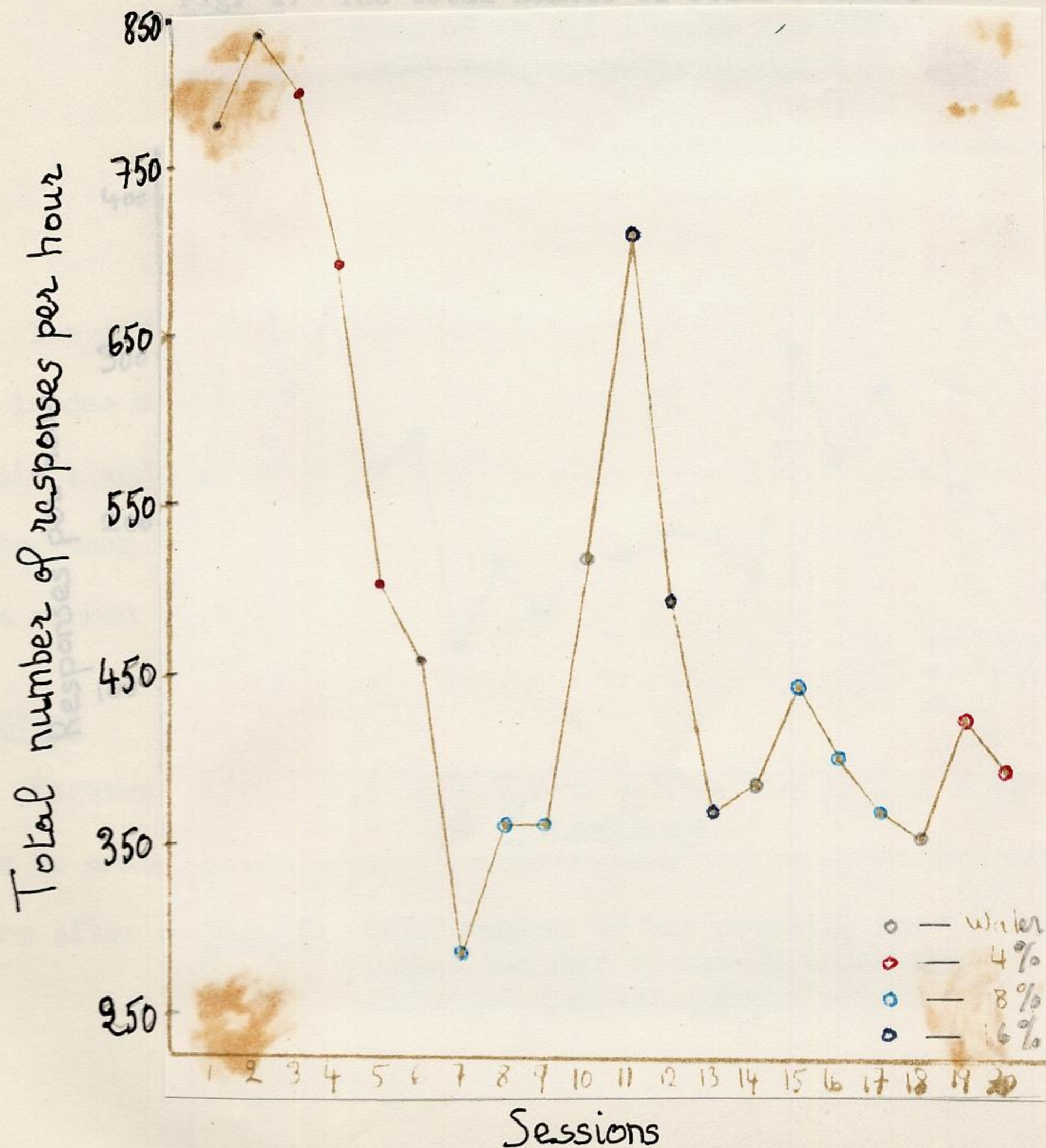


Fig. 3: Total number of responses emitted by rat I under the water, 4, 8 and 16% sucrose concentration following the schedule tandem FI 30" FR 11.

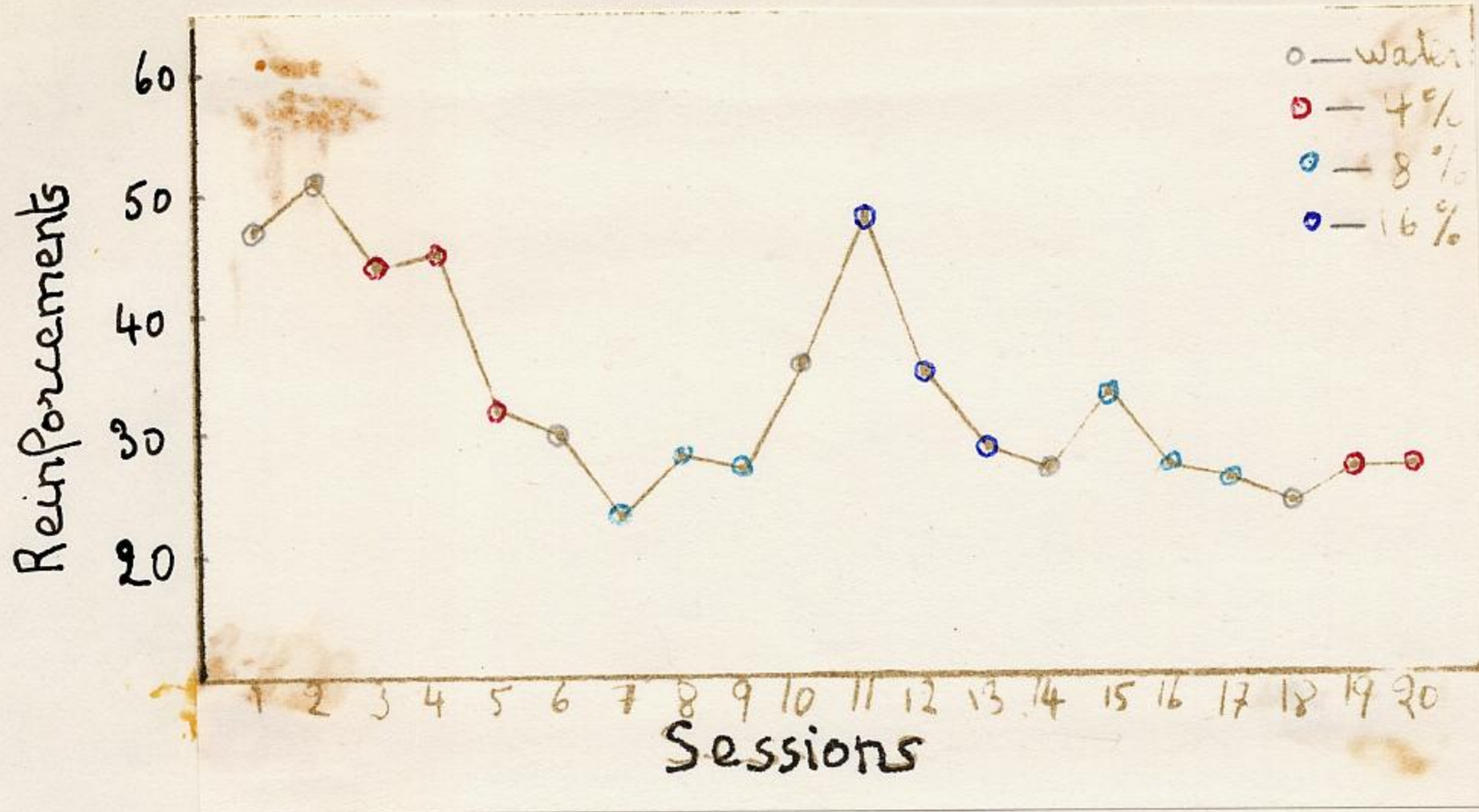


Fig. 4: The total number of reinforcements received by rat I under the different reinforcement magnitudes

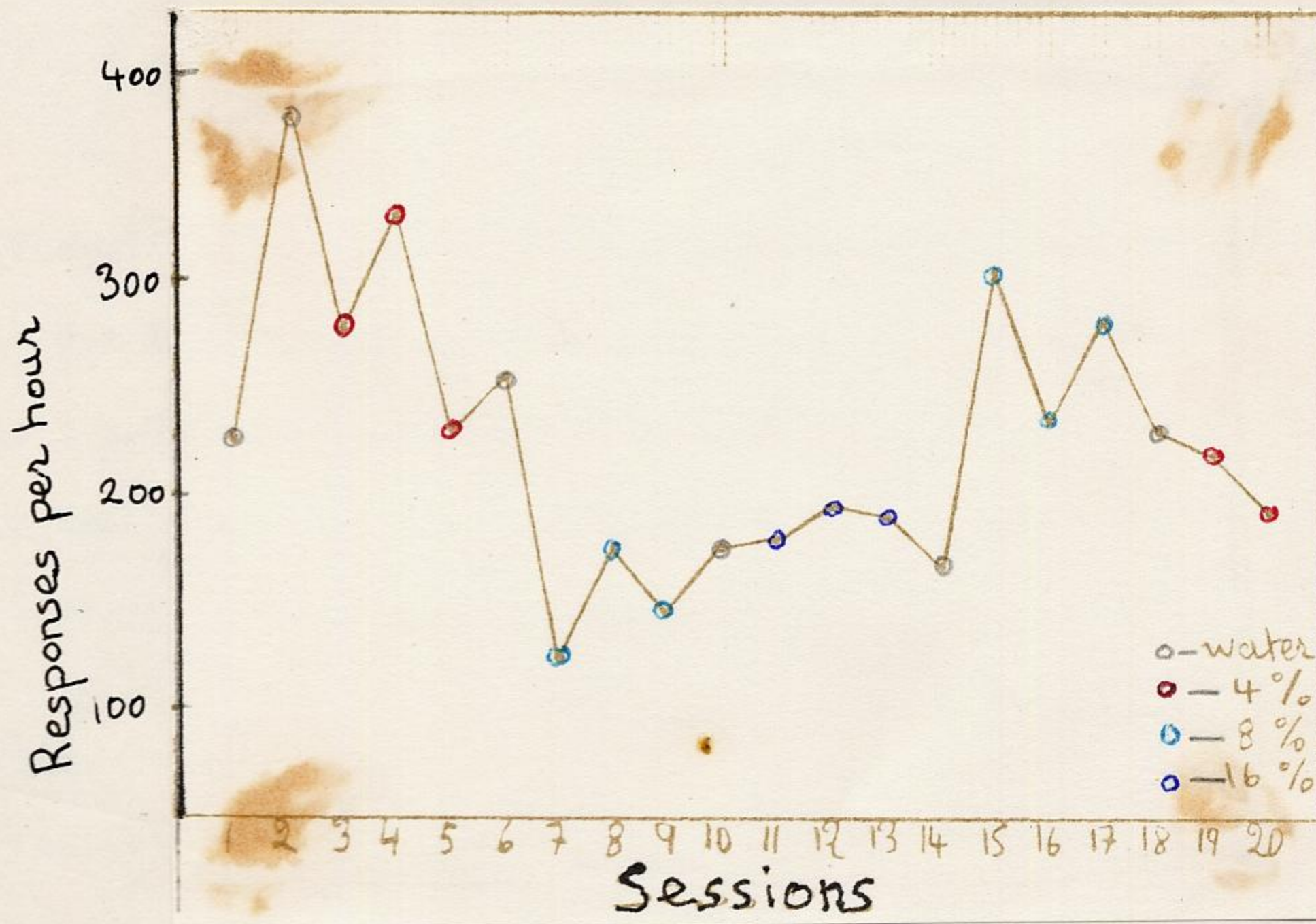


Fig. 5: Total number of bar pressing responses emitted by rat II under the different sucrose concentrations

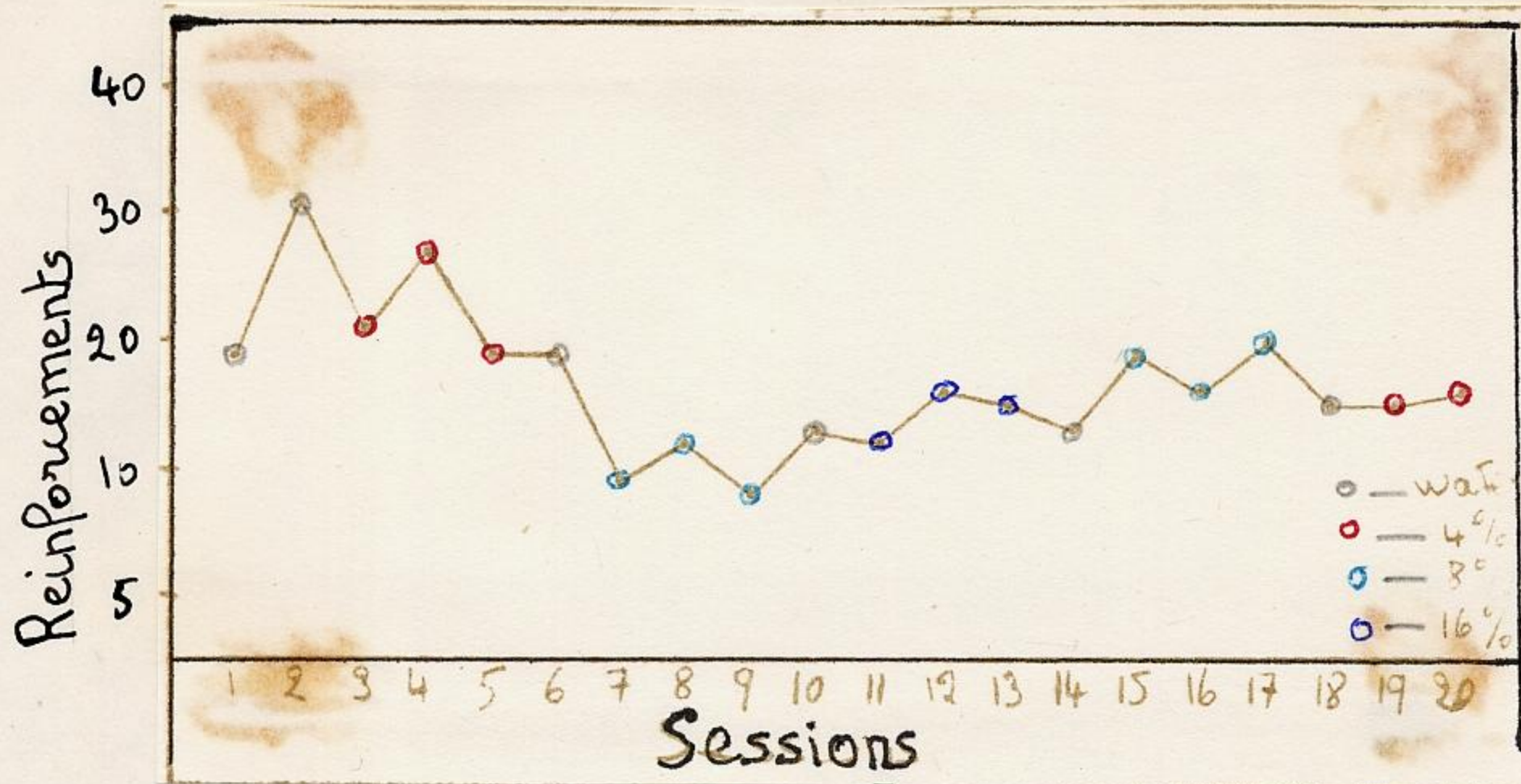


Fig. 6: Total number of reinforcements received by rat II during the experimental sessions under the different sucrose concentrations

The difference in the overall rate of responding between rats I and II is due to perseveration--the proportion of time spent responding. Both rats I and II responded a little more under the 4% sucrose solution and water than under the 8 and 16% concentrations. However this tendency is more marked in rat I than in rat II.

Local Rates

Figures 7 and 8, represent the daily mean times for the respective animals to emit a burst of 10 responses, from the third to the twelfth response after each reinforcement.

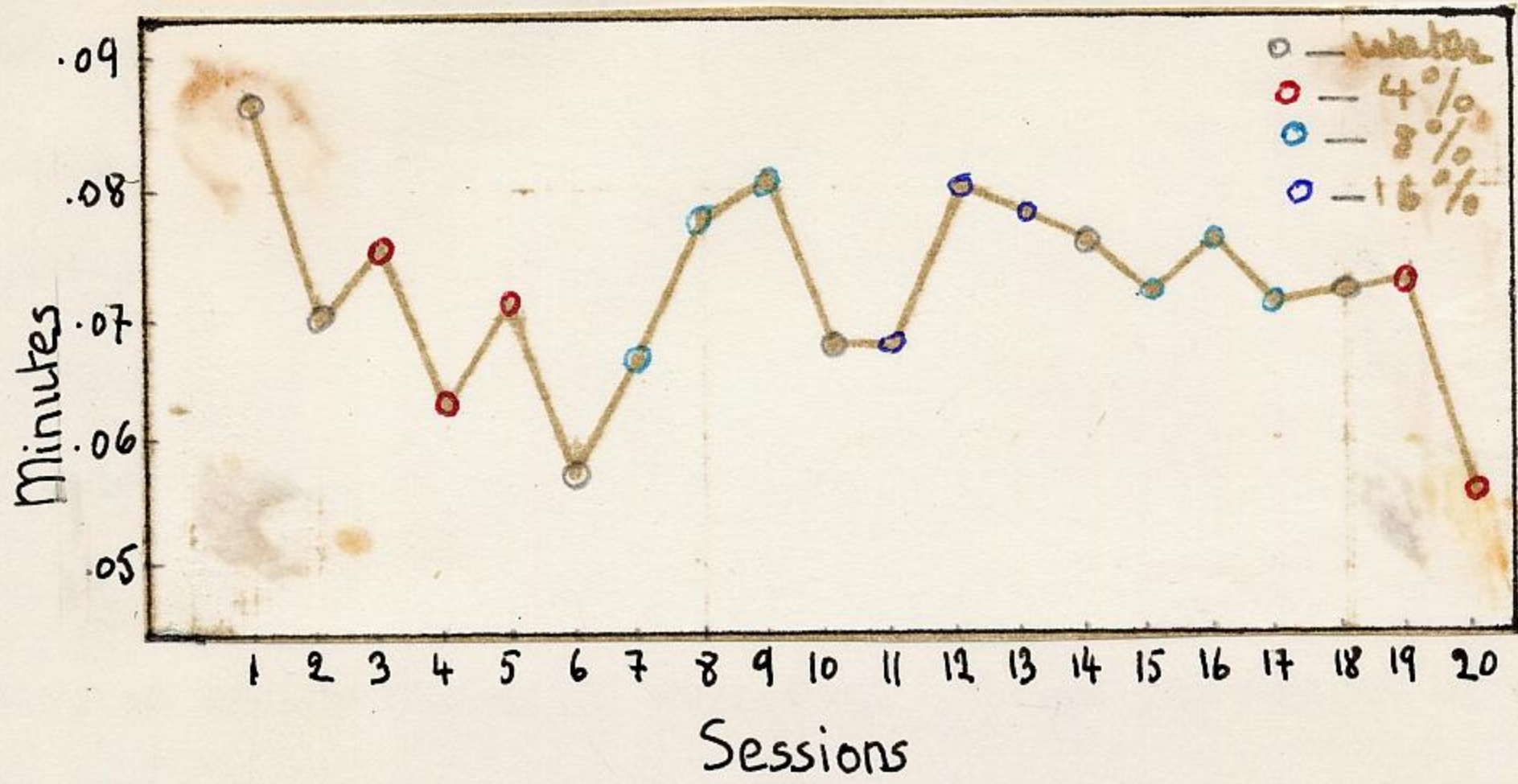


Fig. 7: Mean daily time taken by subject I to emit a burst of 10 responses under the different reinforcements

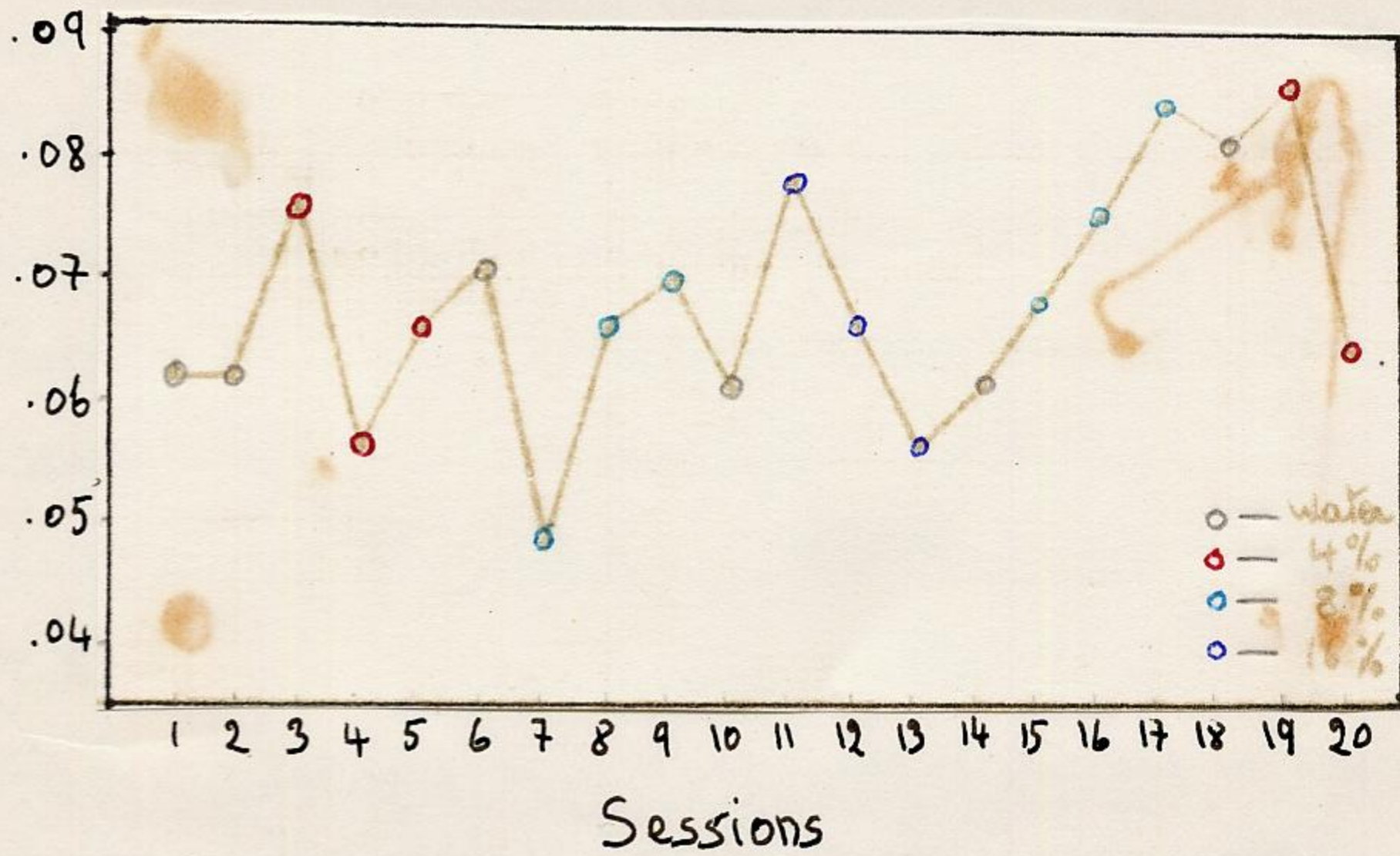


Fig. 8: Mean daily times to emit a burst of 10 responses under the different reinforcement magnitudes by rat II

Though neither rat's local response rate is constant from day to day fluctuations are small and unsystematic with regard to reinforcement magnitude. Rat I particularly shows little variability in local responding, on the average, .07 minutes to run off 10 responses. On the other hand the daily local rate of rat II tends to decrease under the 8% sucrose concentration in both the up series and down series. However, mean local rates, as measured by the number of responses emitted per second of all the bursts of 10 responses under each concentration, are not influenced by the magnitudes of reinforcements. The mean local rates of rats I and II under the water, 4, 8 and 16% sucrose concentrations are 2.4, 2.4, 2.2, and 2.2 and 2.5, 2.4, 2.3 and 2.3 respectively.

Distributions of times taken to run off 10 responses are shown in charts I and II for subjects I and II respectively. The charts represent the percentage of the total number of bursts of 10 responses emitted within each of the specified intervals.

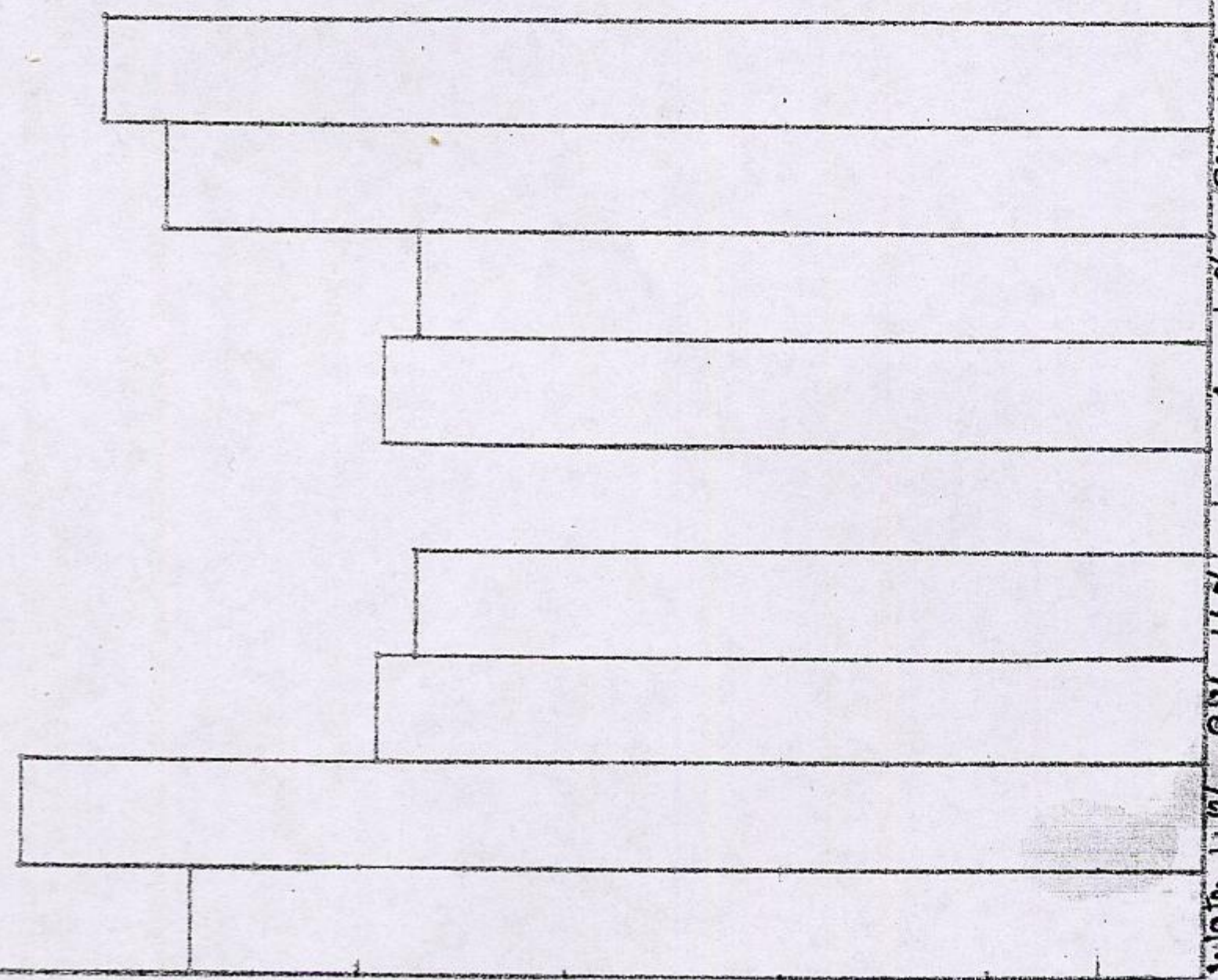
The percentage of the total number of responses emitted by rat I within the interval of a .03-.06 minute under the water, 4, 8 and 16% sucrose solutions are 48, 56, 39.3 and 37.5%. The second interval includes 39, 37.5, 49.5 and 52.5% of the total number of bursts emitted under the .07-.10 minutes interval. Thus about 90 percent of the total sum of bursts fall within these two intervals under each reinforcement magnitude.

On the other hand chart II, shows a somewhat higher local rate of responding on the part of animal II. The highest percentage of bursts of 10 responses under the water, 4, 8 and 16% solutions were within the

26

9b
88
70
69
50
40
30
20
10

Percent number of bursts of 10 responses



Water 4% 8% 16% 16% 16% 16% 16% 16% 16% 16% 16%
 .03-.06 .07-.10 .11-.14 .15-.18 .19-.22
 Minutes

Chart I: Percent of total number of bursts of 10 responses emitted by subject I falling within each time interval under the different reinforcement magnitudes.

27

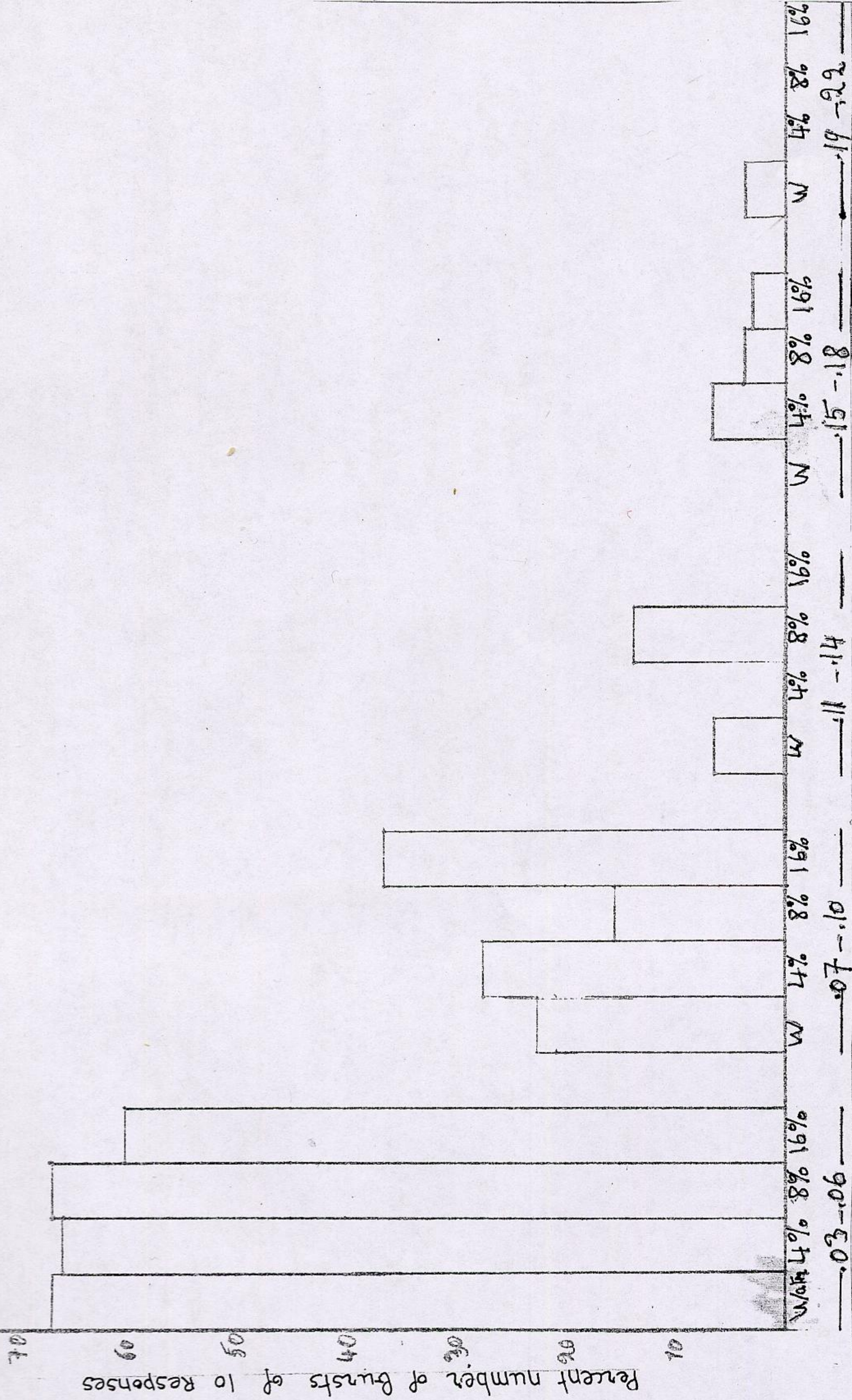


Chart II: Percent of total number of bursts of 10 responses emitted by Subject II falling within the time interval under different reinforcement magnitudes

.03-.06 minute intervals. The interval included 66.78, 65.75, 66.66 and 60% of the total number of bursts. The almost constant percentage under the different reinforcement concentrations indicates that the local rates are not only unaffected by the reward magnitudes but are also not dependent on the overall rates of responding.

Pauses after Reinforcements

Figures 8 and 9, show that there is no consistent and systematic relationship between the length of the median pause after reinforcement and the amount of reinforcement.

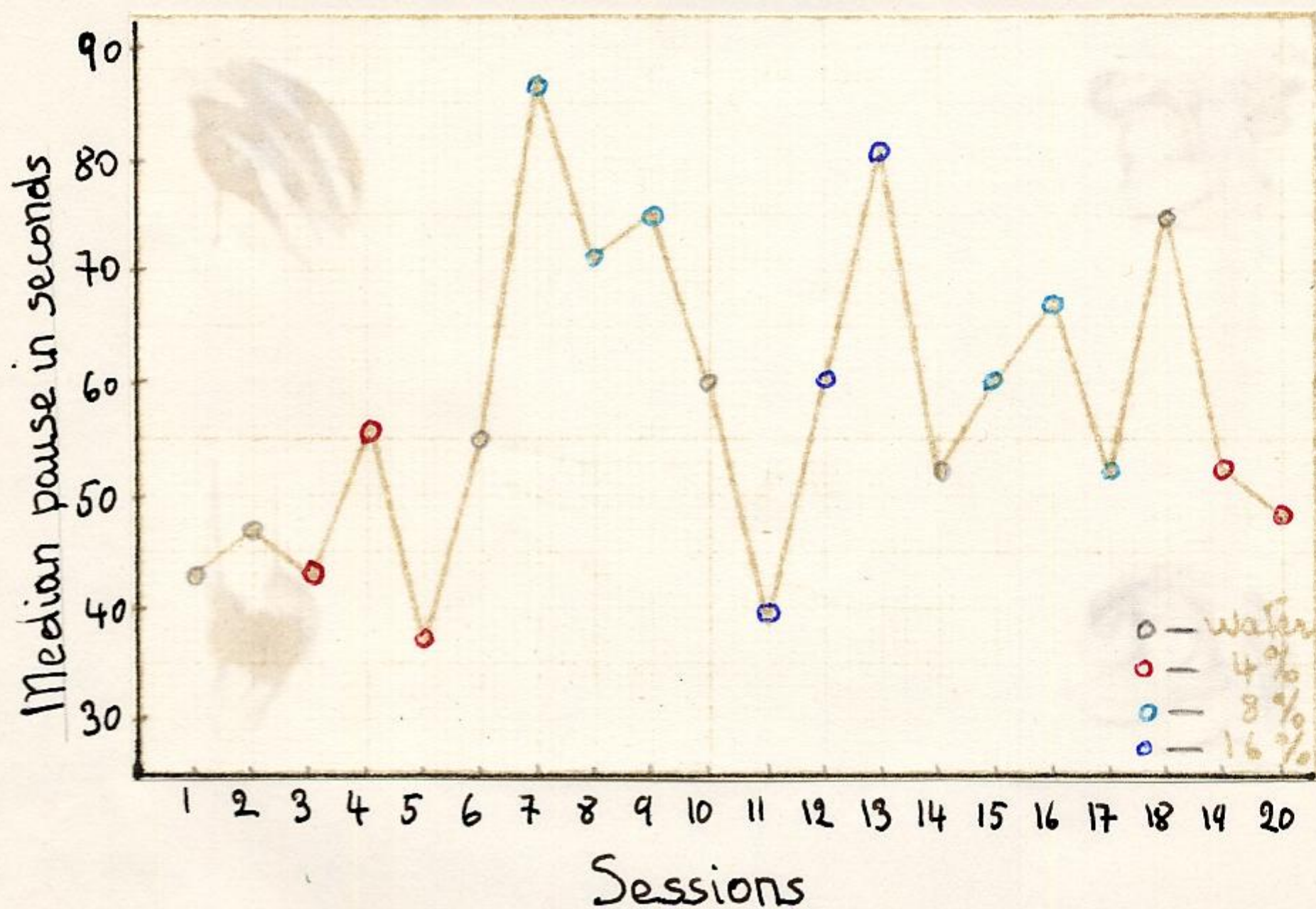


Fig. 9: The daily median ^{pause} paused by subject I under the different reinforcement amounts

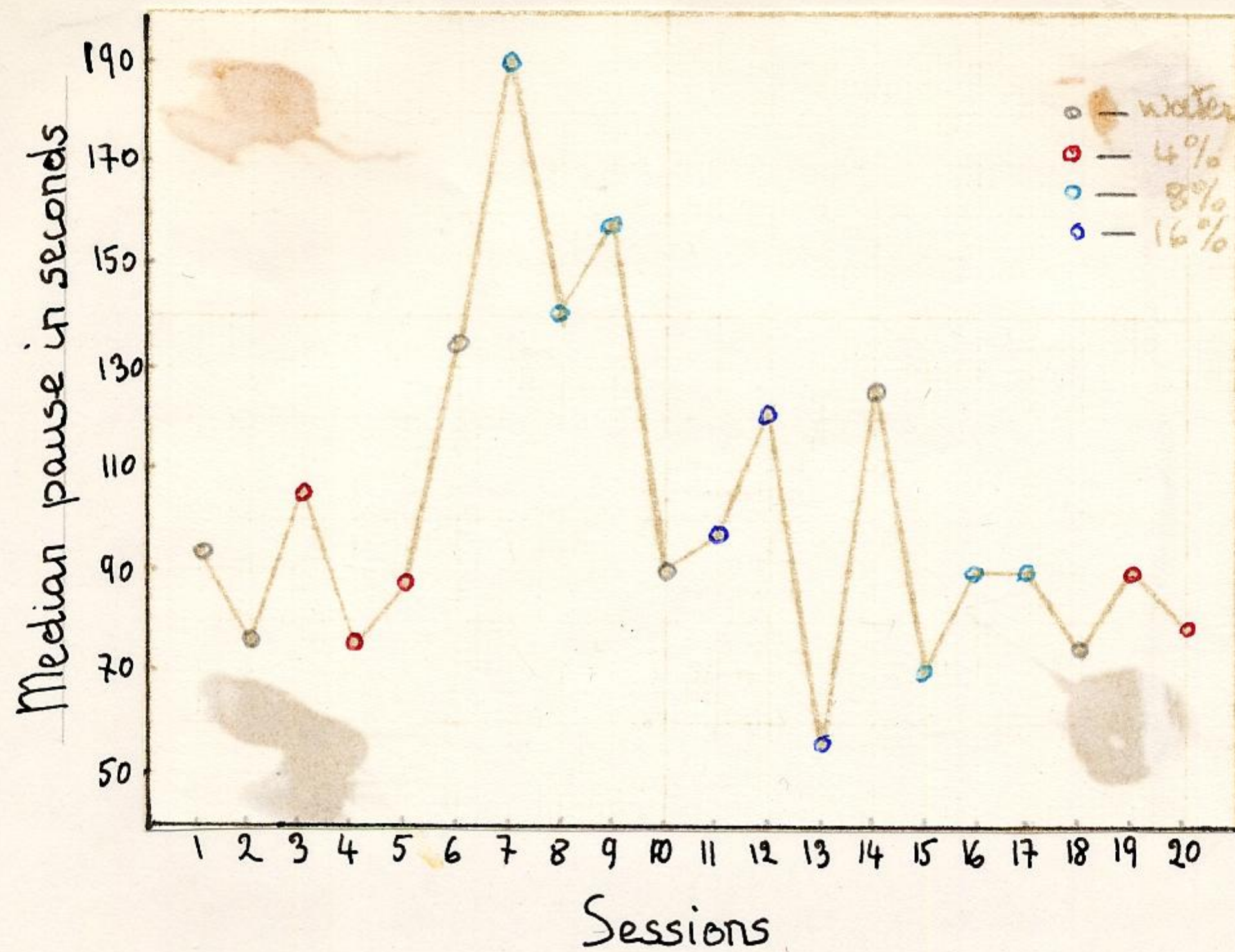
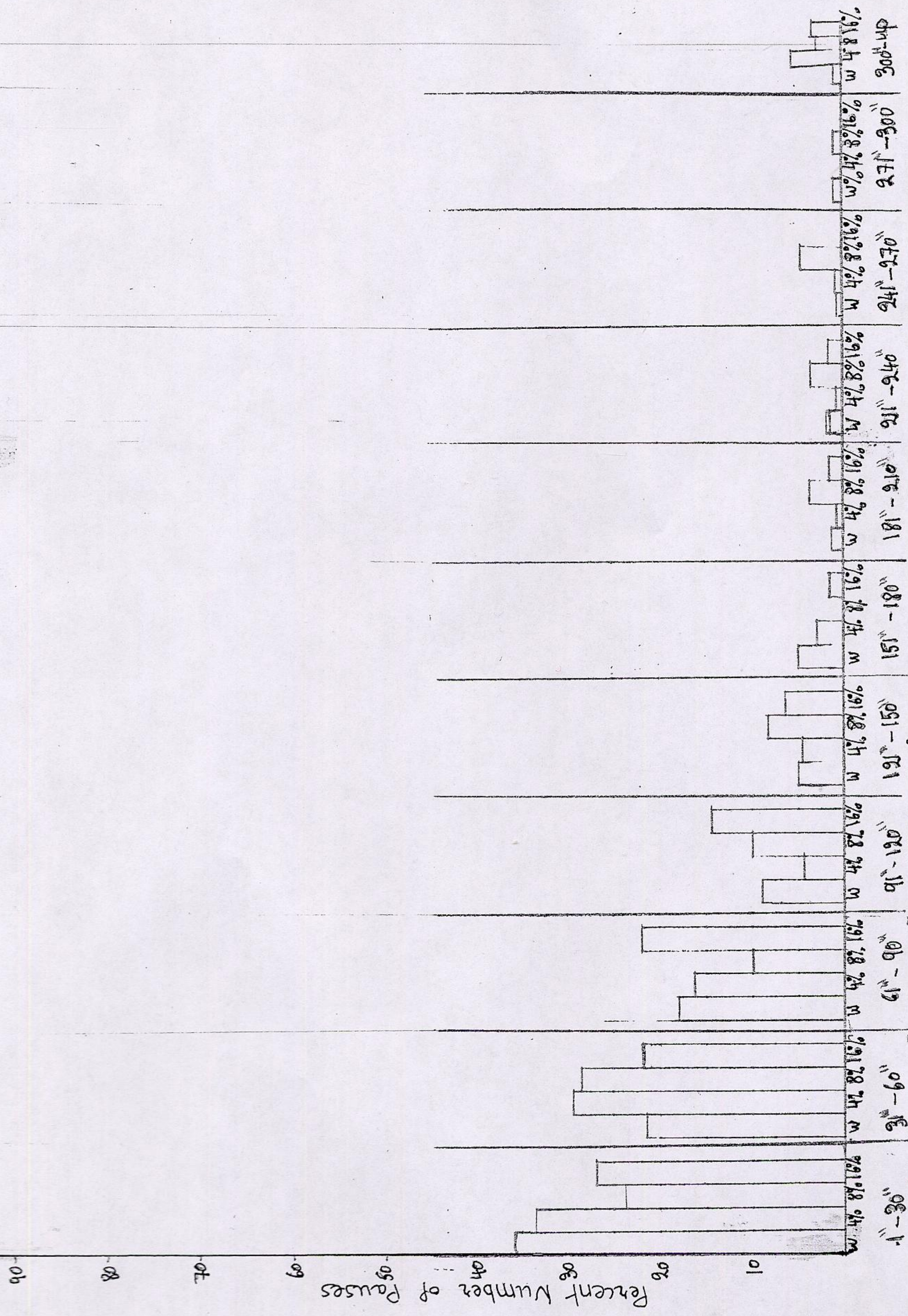


Fig. 10: The daily median pause paused by rat II following each reinforcement under each reinforcement magnitude

The average median pause under the different reinforcement magnitudes of water, 4, 8 and 16% sucrose solutions for rats I and II are 55.48, 47.6, 68.75 and 60 seconds and 98.7, 65.73, 135.37 and 91.88 seconds respectively. Though rat II paused longer after each reinforcement both rat I and II have the longest average median pause under the 8% sucrose concentration.

Charts 3 and 4, show the distribution of the pauses after the reinforcements. The optimal pause lengths would be 30 seconds, because reinforcements were not obtainable sooner according to the specific



Intervals in Seconds

Chart 3: Percent of pauses paused by rat I within each interval (seconds) under the different reinforcement magnitudes

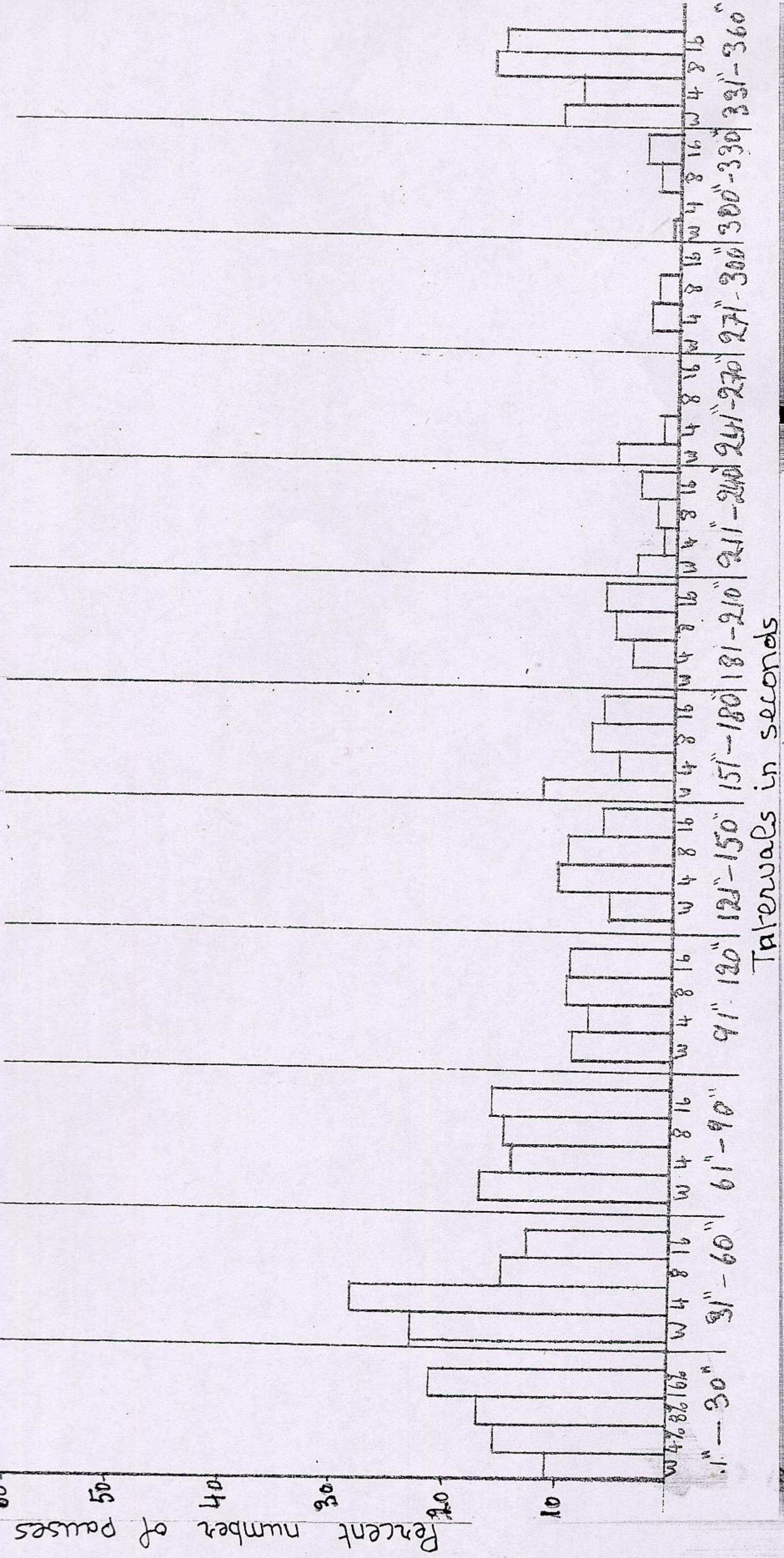


Chart 4: Percent of pauses paused by rat II within each interval (seconds) under the different reinforcement magnitudes

As in the overall rate of responding, animal I differs in the percent of total number of pauses that fall within the 30 seconds interval than rat II. Under the water, 4, 8 and 16% concentrations the percents of such pauses ^{are} 35.88, 33.54, 24.84 and 27.4% for rat I and 10.92, 15.6, 17 and 22.4% for rat II. Though the length of the pauses are not affected by the reward magnitude they are, however, related to the overall rate of responding of the particular rat.

In general neither subject showed a relationship between the overall rate of responding and the sucrose concentrations. Since the local rates are constant, and are the same for both animals under all the reinforcement magnitudes, the marked differences in the overall rates of responding between the two subjects are mainly due to the length of the pauses after reinforcements, which in turn influence the number of reinforcements received in a session. As the average median pauses after reinforcements of both subjects I and II are longer than the specified 30 seconds interval during which no response is reinforced, the animals frequently obtained the reinforcements with the minimum number of responses. However, the average median pauses of rat II after reinforcement under all concentrations are almost twice as long as the average median pauses of rat I, which in turn has a higher percent of total number of pauses falling within the 30 seconds interval. This means that following such short pauses the subject is required to emit more than the minimum number of responses in order to be reinforced.

CHAPTER IV

SUBJECT IV

Conjunctive FR 12 FI 15"

This animal was given 15 daily training sessions to build up gradually to the schedule conjunctive FR 12 FI 15" under 23 hours water deprivation, with water reinforcement. The schedule denotes that reinforcement is given after 15 seconds and after 12 responses have been emitted concurrently.

The training sessions included:

1. 4 sessions of 30 minutes each to build up the schedule from FI 15" to FI 30".
2. 5 sessions of 60 minutes each to build up the schedule to FI 60".⁴⁶
3. 2 sessions of 30 minutes each to build the schedule up to conjunctive FI 15" FR 12.
4. 4 sessions of 30 minutes each to stabilize the rate of the rat's responding under this schedule with water as the reinforcing agent before the introduction of the different sucrose solutions. The presentation of the 4% sucrose solution marked the beginning of the experimental

⁴⁶On the next 17 sessions the rat was run under a FR 5 schedule and then extinguished for a different experiment. These sessions are not included in the present account.

sessions. Under the same schedule the subject was run for 3, 30 minutes sessions under 4, 8 and 16% of the sucrose concentration with one 30 minutes session under the water as the reinforcing agent in between each of the concentration.

Results

The results summarized in Table III, indicate that the magnitude of reinforcement does not materially affect the local response rate of this rat trained under the schedule conjunctive FI 15" FR 12, although the overall rate of responding is appreciably higher under the water reinforcement than under the sucrose concentrations.

TABLE III

Reinf.	Total No. Sessions	Mean Reinf.	Mean Overall rate Resp./min.	Mean Local Rate Resp./sec.	Av. Med. Pause Seconds
Water	4	14	6.6	2.4	24.37
4%	3	9.7	3.94	2.2	19
8%	3	7.3	3.3	2.6	33.25
16%	3	7.3	4.2	2.8	45.91

Table III: Results of the effects of the reinforcement magnitudes on the bar pressing response of rat IV trained under the schedule conjunctive FI 15" FR 12.

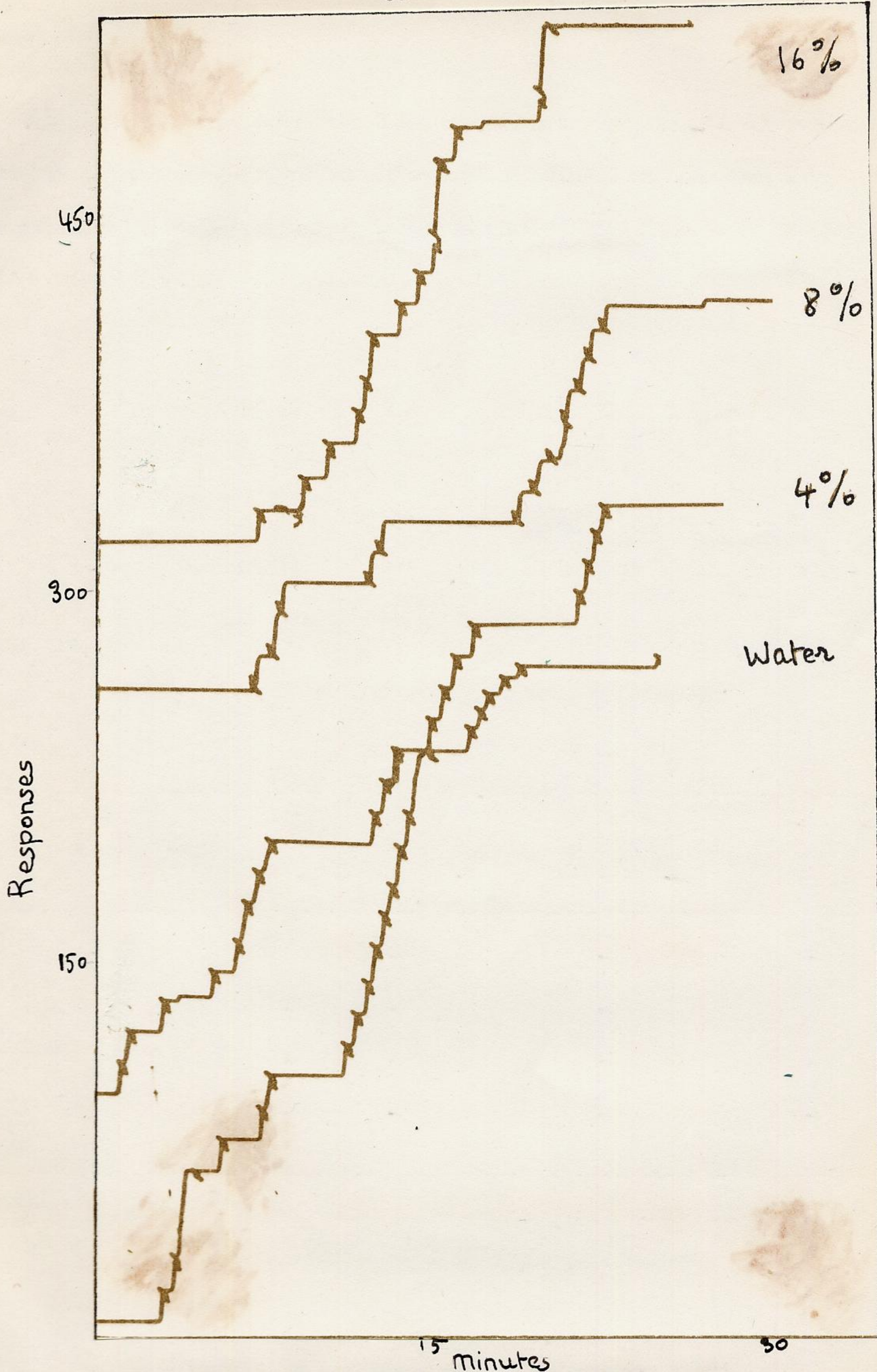


Fig. 11: Typical cumulative bar pressing response curves of a rat IV ran under the schedule conjunctive FI 15" FR 12 with different sucrose concentrations as reinforcers

The daily total number of responses emitted and the total daily number of reinforcements received under the different reinforcement magnitudes are presented in Figures 12 and 13.

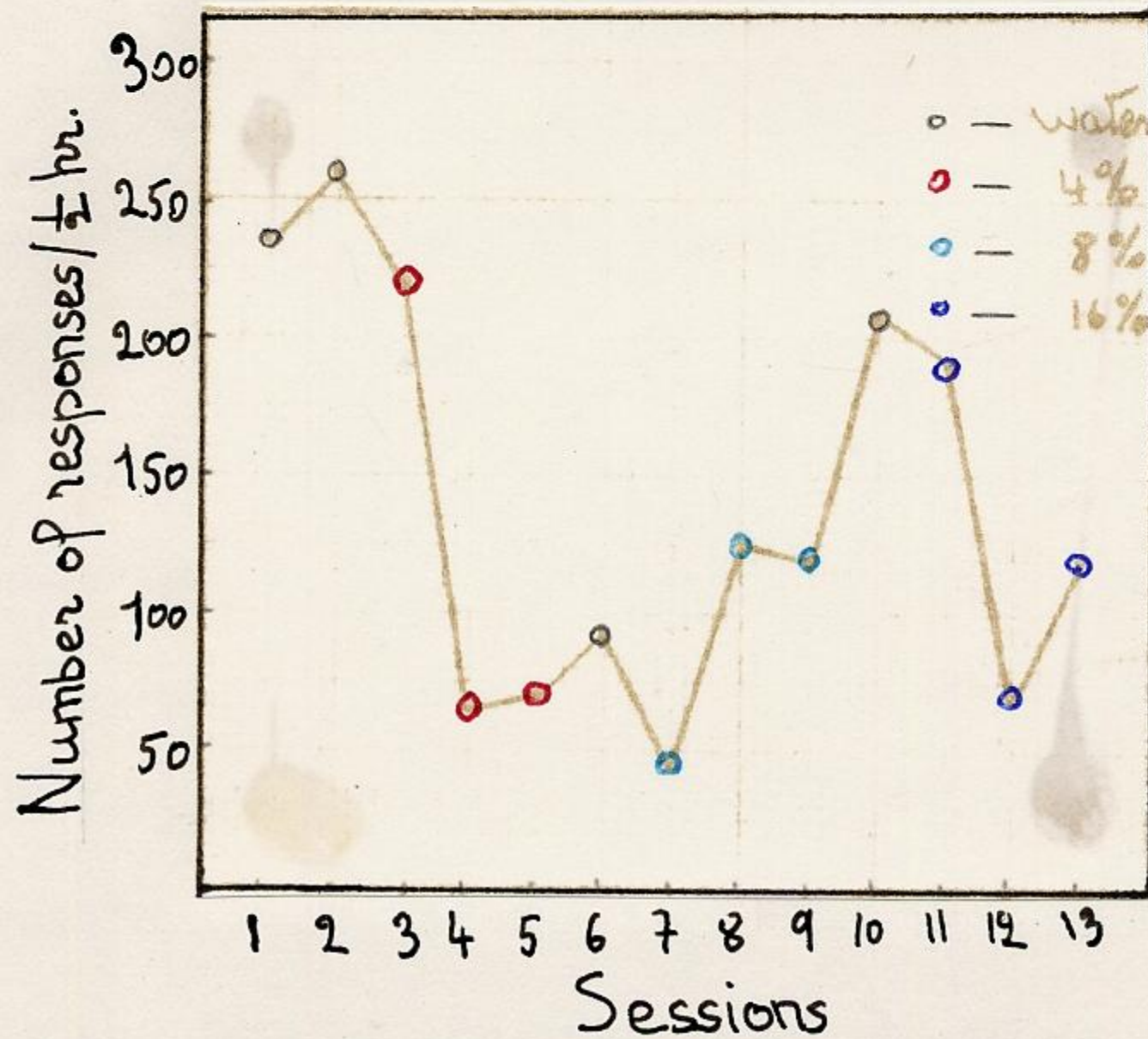


Fig. 12: The daily total number of responses of rat IV emitted under each reinforcement magnitude.

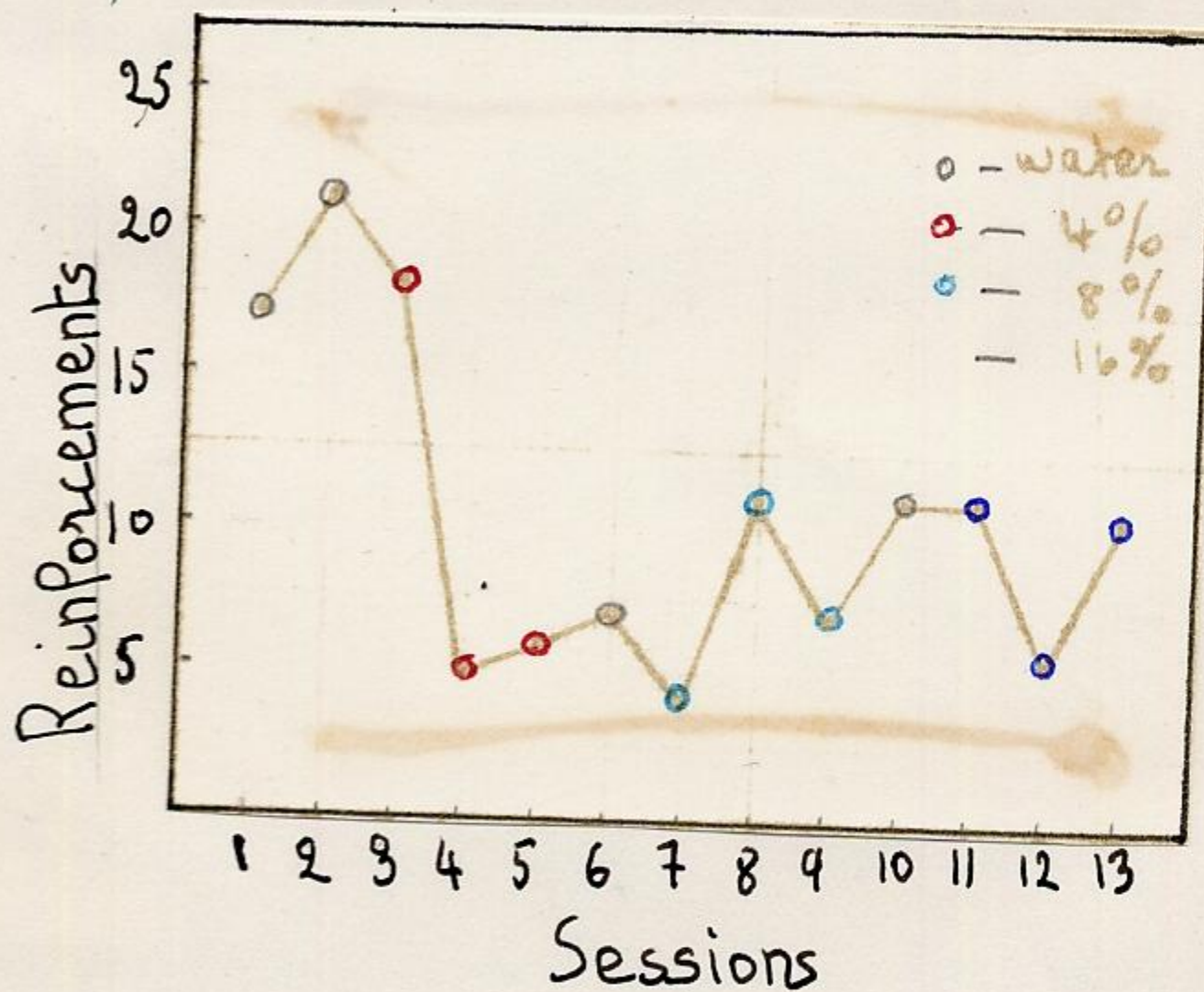


Fig. 13: The daily number of reinforcements received by rat IV under the different sucrose magnitudes

Though the sucrose concentrations do not seem to affect materially the overall rates of responding there is some indication that the overall amount of responding falls as the reinforcement differs from the original training solution. The mean overall rates and the mean reinforcements under the reinforcement magnitudes from water to 16% concentration show the superiority of the water as a reinforcer over the sucrose concentrations. The mean overall rates are 6.64, 3.94, 3.3 and 4.2 responses per minute and the mean reinforcements are 14, 9.7, 7.3 and 7.3 reinforcements. The higher effectiveness of water as a reinforcer is puzzling. It may be that the taste of water in the mouth had become an SD for bar pressing during the extended training sessions with water reinforcement and the fact that the animal was only water deprived. While the data of the present animal shows a higher overall rate of responding under the water reinforcement only, animals I, II and V tended towards higher overall rates of responding under both the water and 4% concentrations. The difference may be due to the fact that this animal was not run on the down series concentrations.

Local rates

Though the mean overall rate of responding is higher under the water reinforcement than under the sucrose concentration the daily mean local rates as presented in Figure 14, do now show such a difference.

The mean local rates under each of the concentrations from the water till the 16% sucrose solution hardly vary. The rates are 2.4, 2.2, 2.6 and 2.8 responses per second. The slight increase in speed under the 16% concentration may be a function of time. The animal may not have

reached its asymptotic rate of responding and since he was not run under the concentrations in the down series, the effect of training differentially favors the higher concentrations.

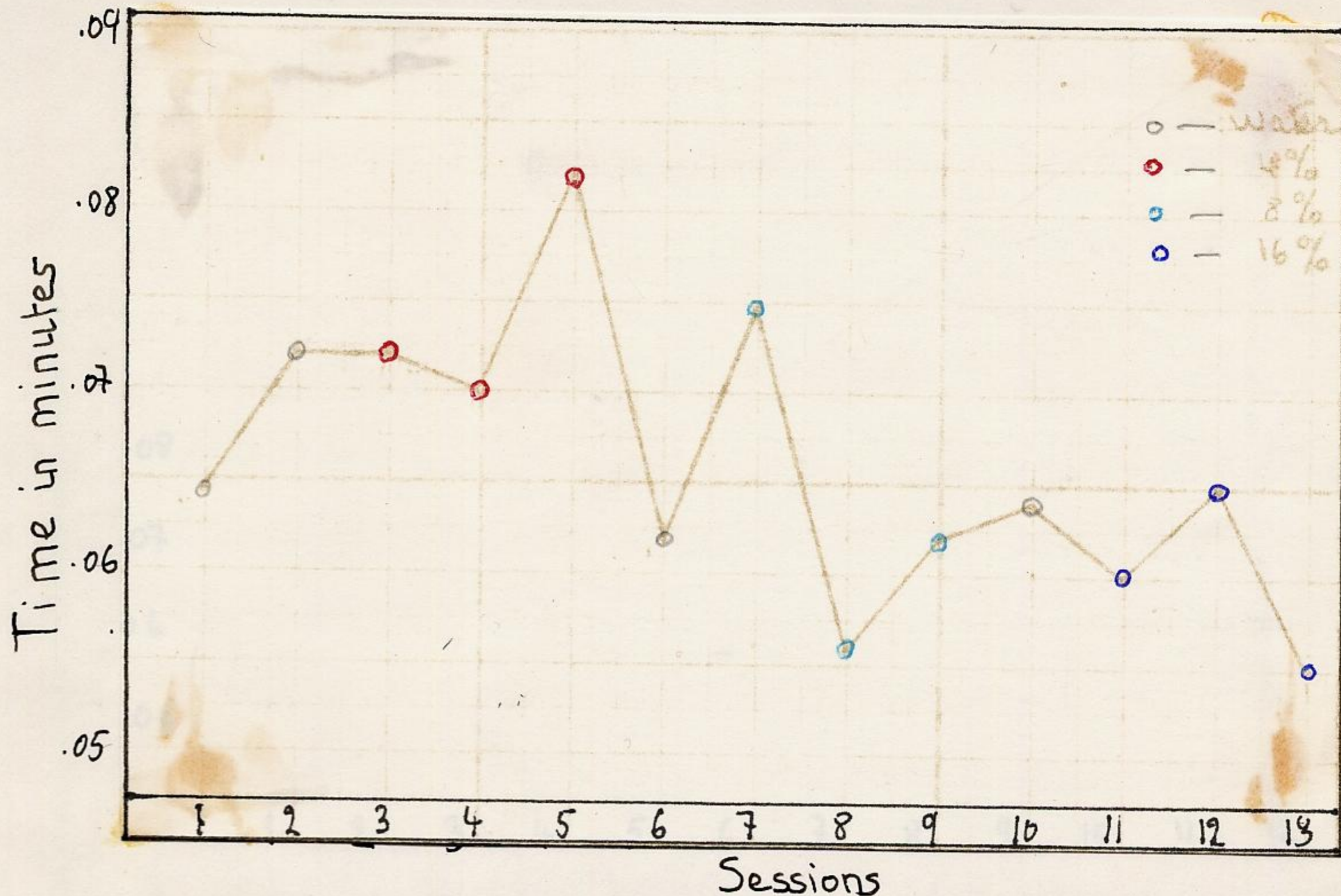


Fig. 14: The daily mean time in minutes required by subject IV to emit a burst of 10 responses under the different reinforcement magnitudes

Chart V, presents the percent of the total number of the bursts of 10 responses that are emitted within specified intervals of time. Within the .04-.07 minute, 61.92%, 50%, 86.7% and 83.3% of these bursts are recorded under the water, 4, 8 and 16% sucrose concentration respectively. The two higher solutions have more skewed distributions in the direction of higher rates of responding, which could be attributed to the fact that only the up series was recorded, as mentioned above.

39

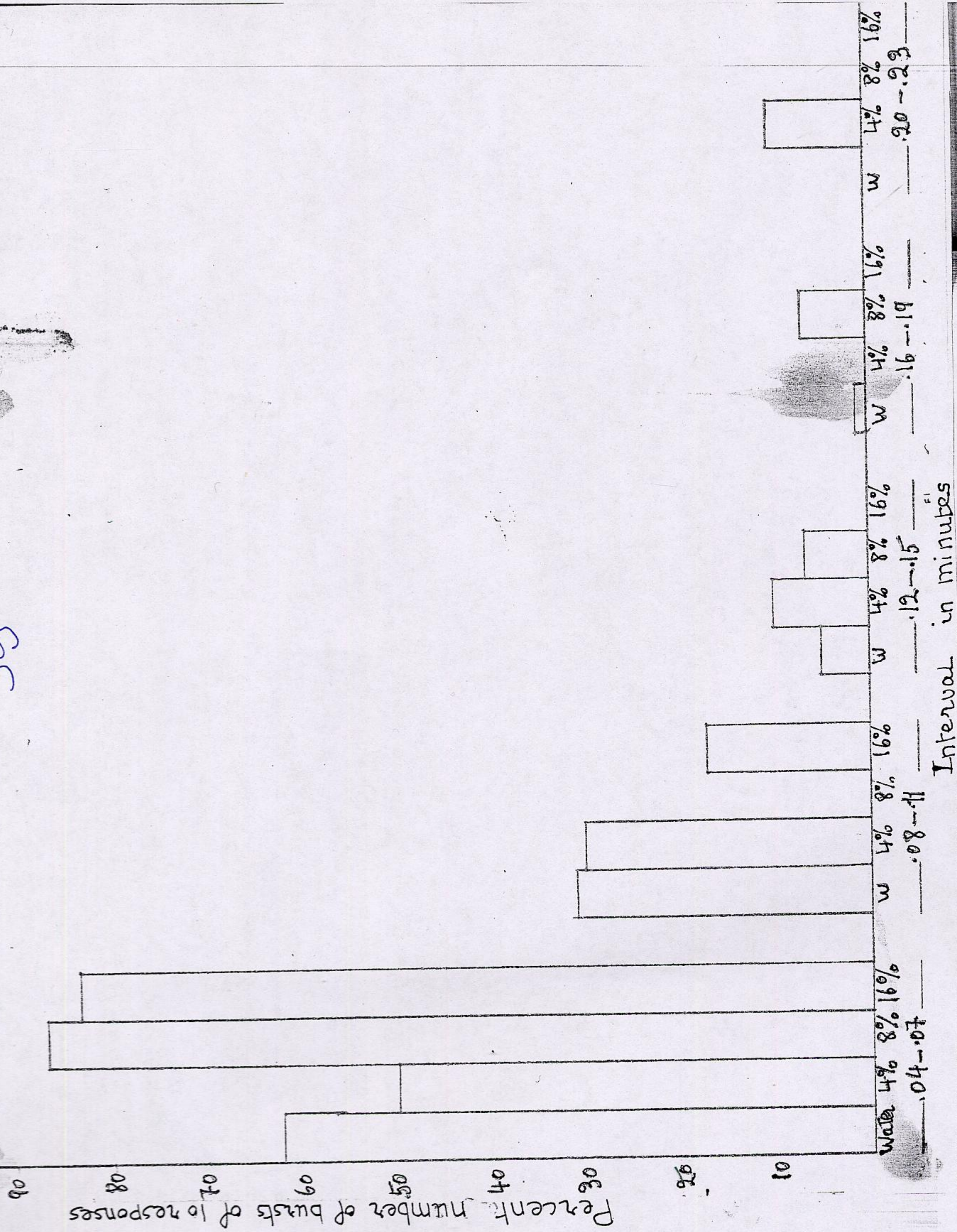


Chart V: Percent of total number of bursts of 10 responses emitted by subject IV under the conjunctive schedule FI 15" FR 12 with different sucrose concentrations as reinforcers

Pauses after reinforcement

Generally the daily median pause, as Figure 15 indicates, ranges from 7.5" to 30" with the exception of 2 long pauses. The mean median pause under each of the four concentrations are 20.6, 19, 33.25 and 25 seconds. This indicates that the length of the pause is not systematically affected by the magnitude of reinforcement.

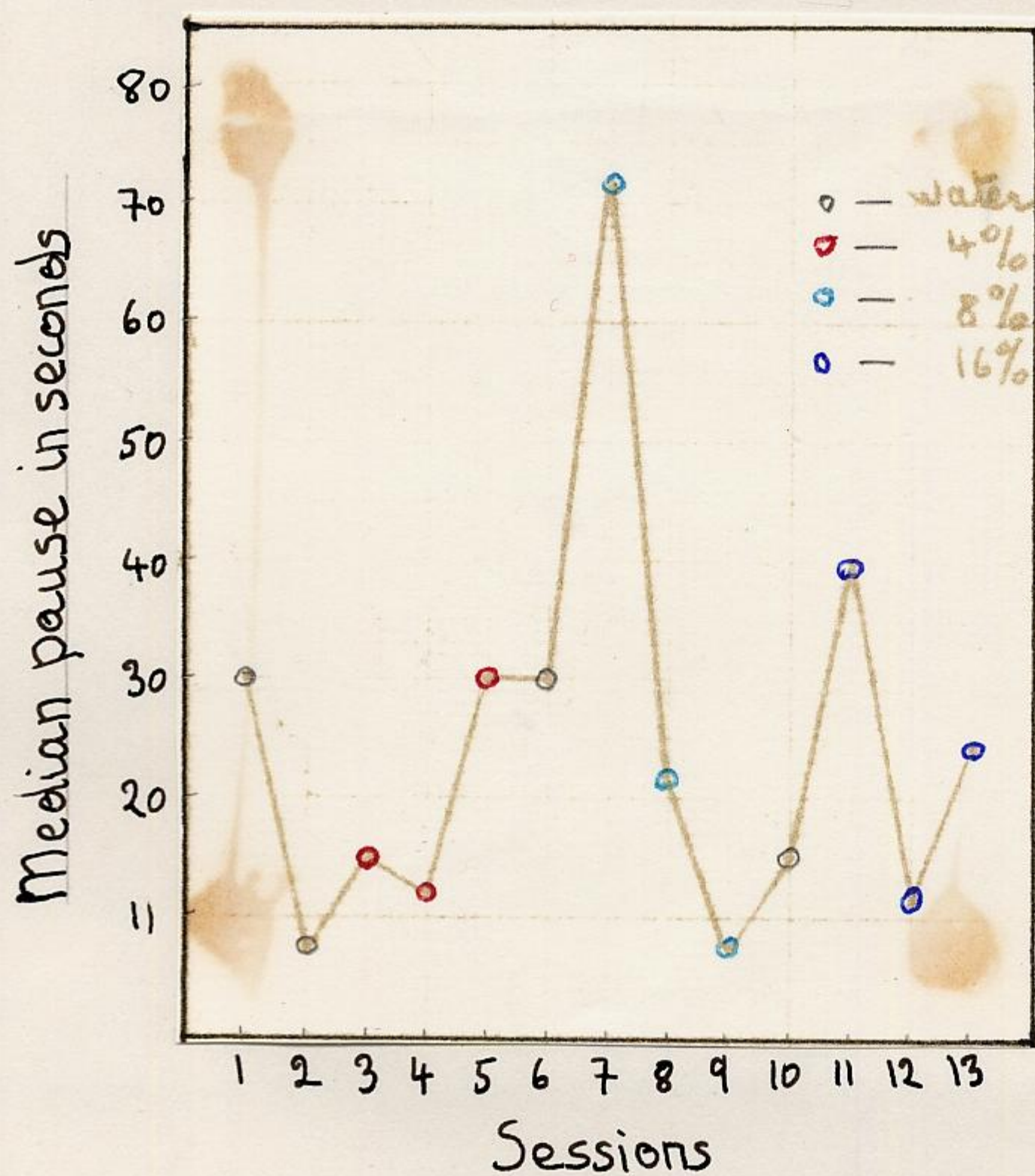


Fig. 15: The daily median pause after reinforcement of subject IV following different reinforcement magnitudes.

CHAPTER V

SUBJECT V

Conjunctive FI 30" FR 12

One animal, deprived of water for 23 hours before each session was trained to bar press under the schedule conjunctive FI 30" FR 12" with water as the reinforcing agent. Before the introduction of the different sucrose concentrations, the animal received 20 successive daily sessions to build up to conjunctive schedule FI 30" FR 12. The training sessions included:

1. Three sessions of 30 minutes each under continuous reinforcement.
2. Four sessions of 60 minutes each under an interval schedule gradually built up to FI 60".
3. Eight sessions of 60 minutes each and 2 sessions of 30 minutes each under schedules gradually building up to FI 30" FR 12.
4. Three sessions of 30 minutes each under the schedule conjunctive FI 30" FR 12 to stabilize the rate of responding with water as the reinforcing agent.

Following the training sessions the experimental sessions were introduced with the presentation of the different sucrose concentrations. These sessions comprised 3 sessions of 30 minutes each under each of 4,

8 and 16% sucrose concentration successively (up series) followed by 8 and 4% concentration in succession (down series). One 30 minutes session with water as the reinforcing agent was included in between each of the different reinforcing magnitudes.⁴⁷

⁴⁷This rat was not run under the water reinforcement between the 16 and 8% sucrose concentration in the down series. The third session under the 4% concentration was omitted because the rat was not deprived of water.

Results

Just as in the case of the animals run on tandem schedules so under a conjunctive schedule of FI 30" FR 12 the magnitude of reinforcement does not affect the local or overall response rates in any significant way as indicated by the results set in summary form in Table IV.

TABLE IV

Sucrose concentration	Total No. of Sessions	Mean reinf.	Mean overall rate in Resp./min.	Mean local rate Resp./sec.	Av. med. pause sec.	% of pauses within a 30" interval
Water	5	7.2	2.9	2.6	108.93	12
4%	5	7.2	3.1	2.4	102.73	22.4
8%	6	4.7	2.05	2.3	91.55	18.5
16%	3	4.3	1.92	2.4	126.25	23

Table IV: The results of the bar pressing response of subject V run under the schedule conjunctive FI 30" FR 12 with different sucrose concentrations as the reinforcing agents.

Fig. 15, shows typical curves of the bar pressing response under the different reinforcement magnitudes.

The daily total number of responses and daily total number of reinforcements as presented in Figures 16 and 17, are not systematically affected by the different reinforcement magnitudes although there is a general tendency towards reduced responding with the passage of time.

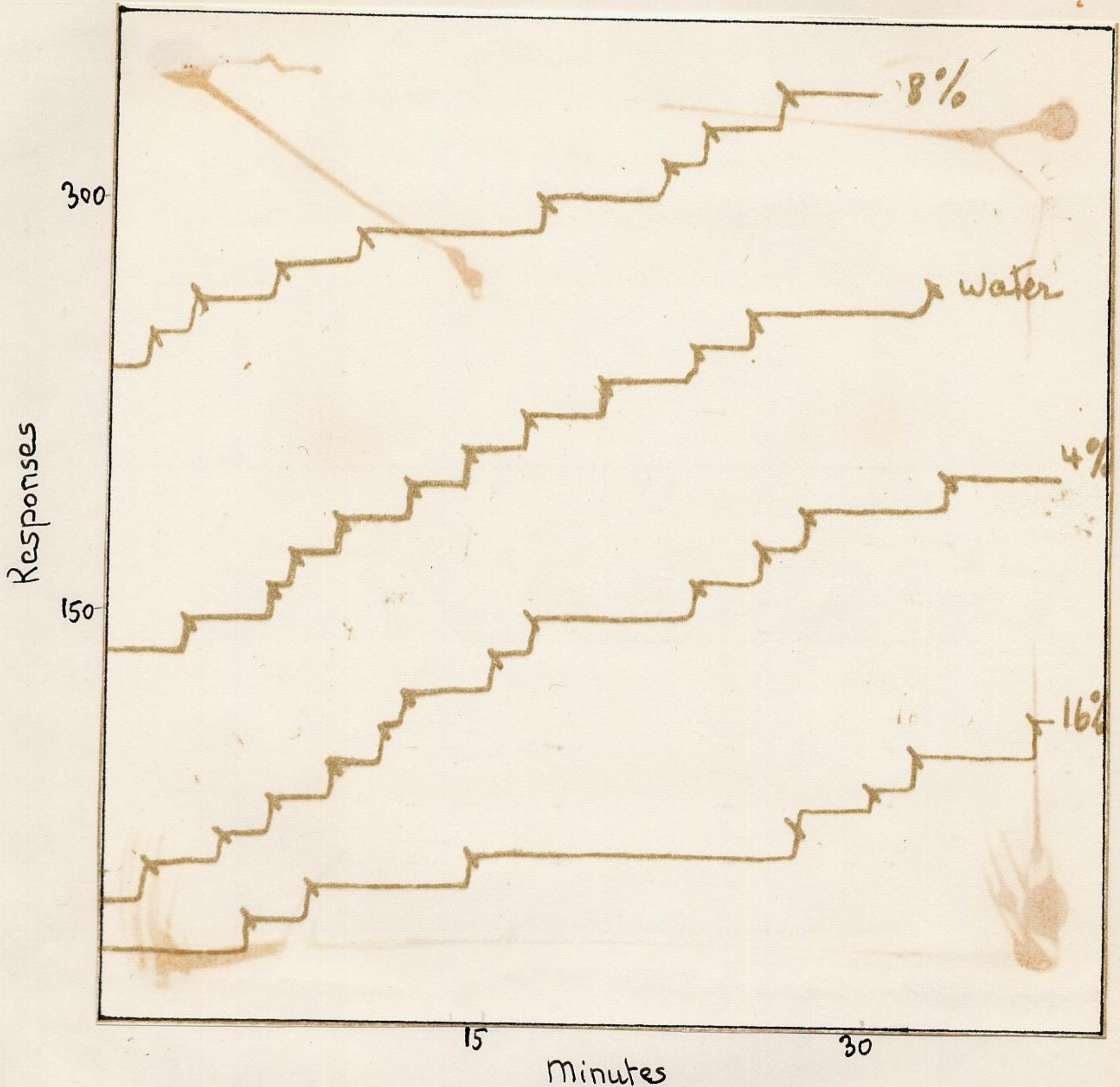


Fig. 15 a: Typical cumulative bar pressing response curve of subject V run under conjunctive FI 30" FR 12 with the different reinforcements of water, 4, 8 and 16% sucrose concentration

With the exception of the sessions under the 8% sucrose concentration in the up series all the sessions tend to show a decrease in the daily total number of responses after the presentation of each

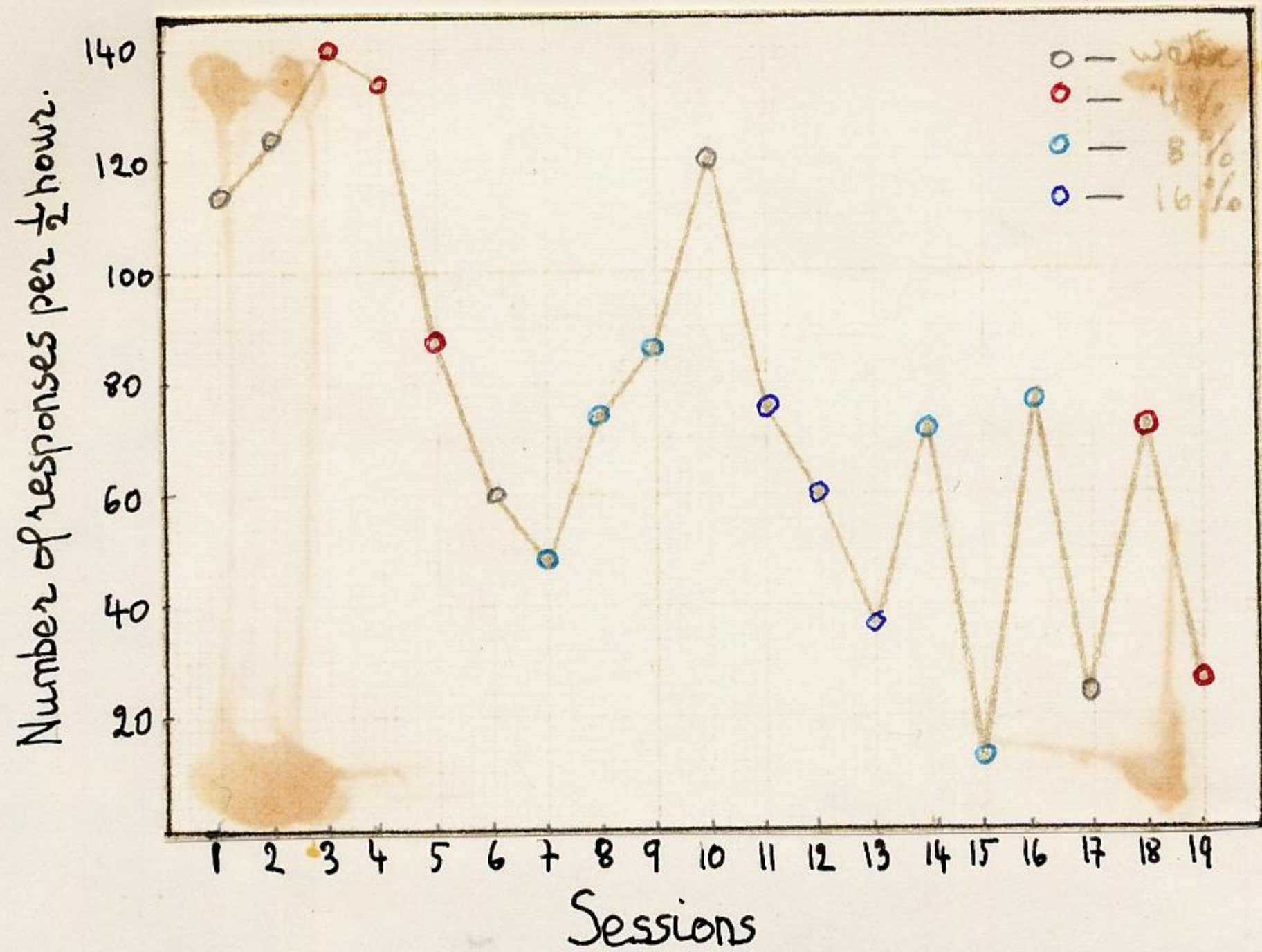


Fig. 16: The daily total number of bar pressing responses of rat V under the different reinforcement magnitudes during 30 minutes sessions.

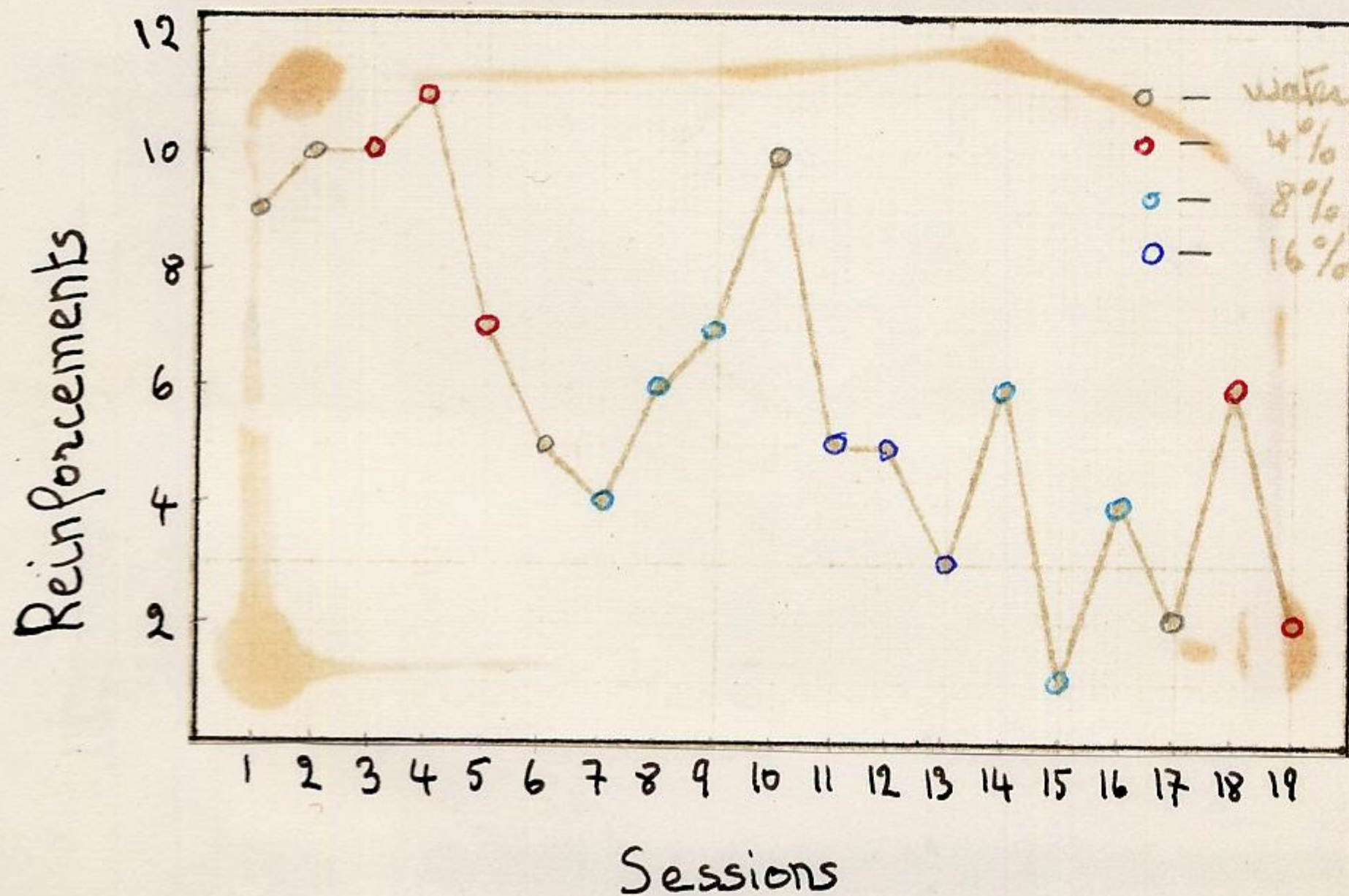


Fig. 17: The daily total number of reinforcements received by rat V under the different reinforcement magnitudes.

sucrose concentration. The mean overall rate of responding is unaffected in any systematic way by the different reinforcement magnitudes. The mean overall rates under the water, 4, 8, and 16% concentrations are 2.9, 3.1, 2.05 and 1.92 responses per minute respectively and the mean reinforcements are 7.2, 7.2, 4.7 and 4.3 reinforcements. Though there is not a great difference in the rate of responding the subject tends to respond faster under the two lower concentrations than under the two higher concentrations.

Local Rates

The daily mean rates of emitting the 10 responses in the ratio are presented in Fig. 18. Although the daily rate is neither consistent nor steady the mean local rates under each of the four concentrations are not affected by the magnitude of reinforcements. These rates are 2.6, 2.4, 2.3 and 2.4 respectively.

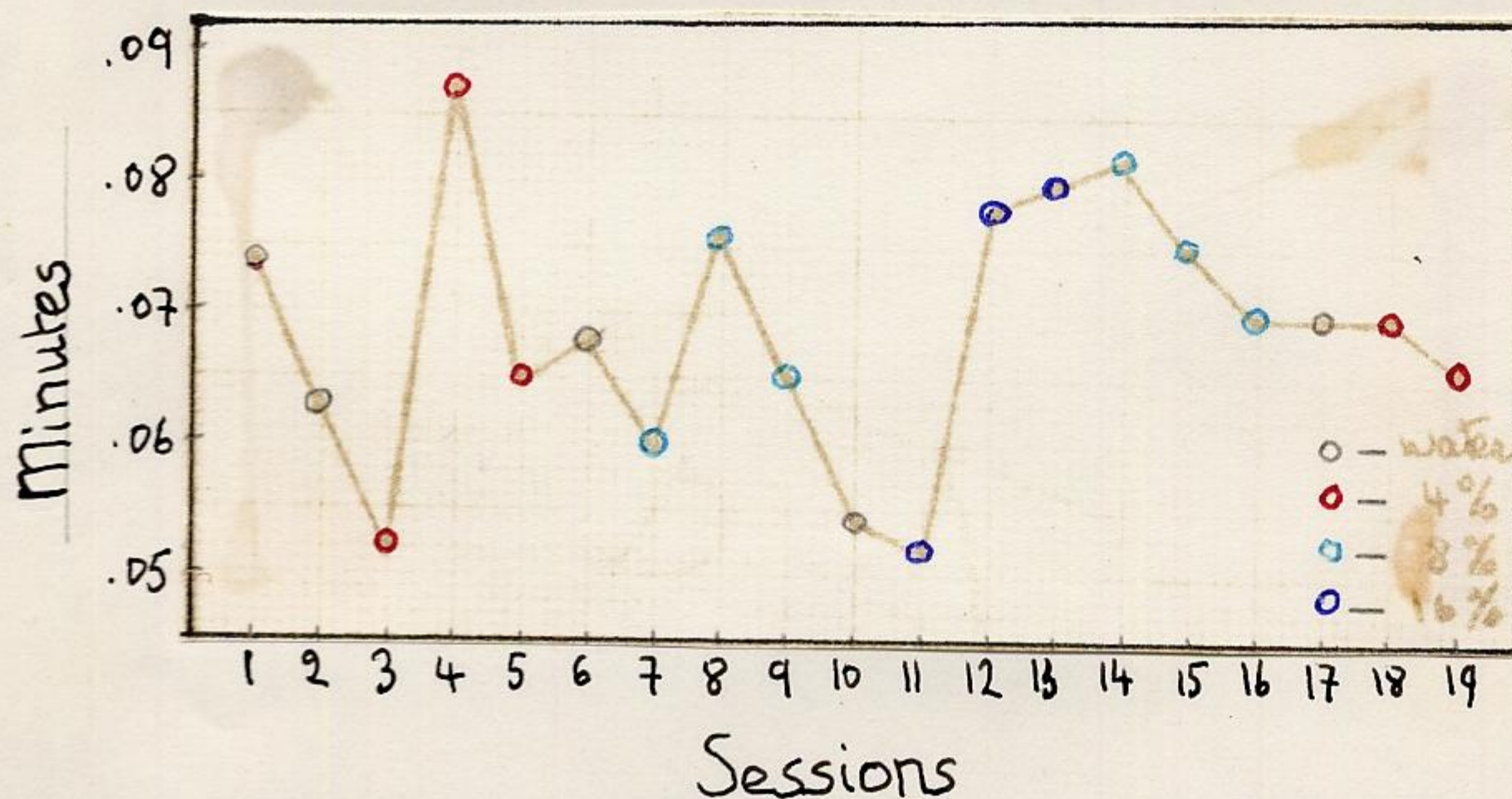


Fig. 18: The mean local time in minutes to emit a burst of 10 responses under different reinforcement magnitudes by subject V

Chart VI, represents the percent of total number of readings occurring in each time interval. The percent of total number of bursts emitted under each of the water, 4, 8 and 16% sucrose solutions are 74.88, 80.0, 57.9 and 37.56% within the interval .04-.07 minute.

The .08 minute interval included 21.84, 6.6, 31.58 and 50% of the total number of bursts under each of the water, 4, 8 and 16% concentrations.

Pauses after reinforcement:

The daily median pauses over all the experimental sessions are presented in Figure 19.⁴⁸

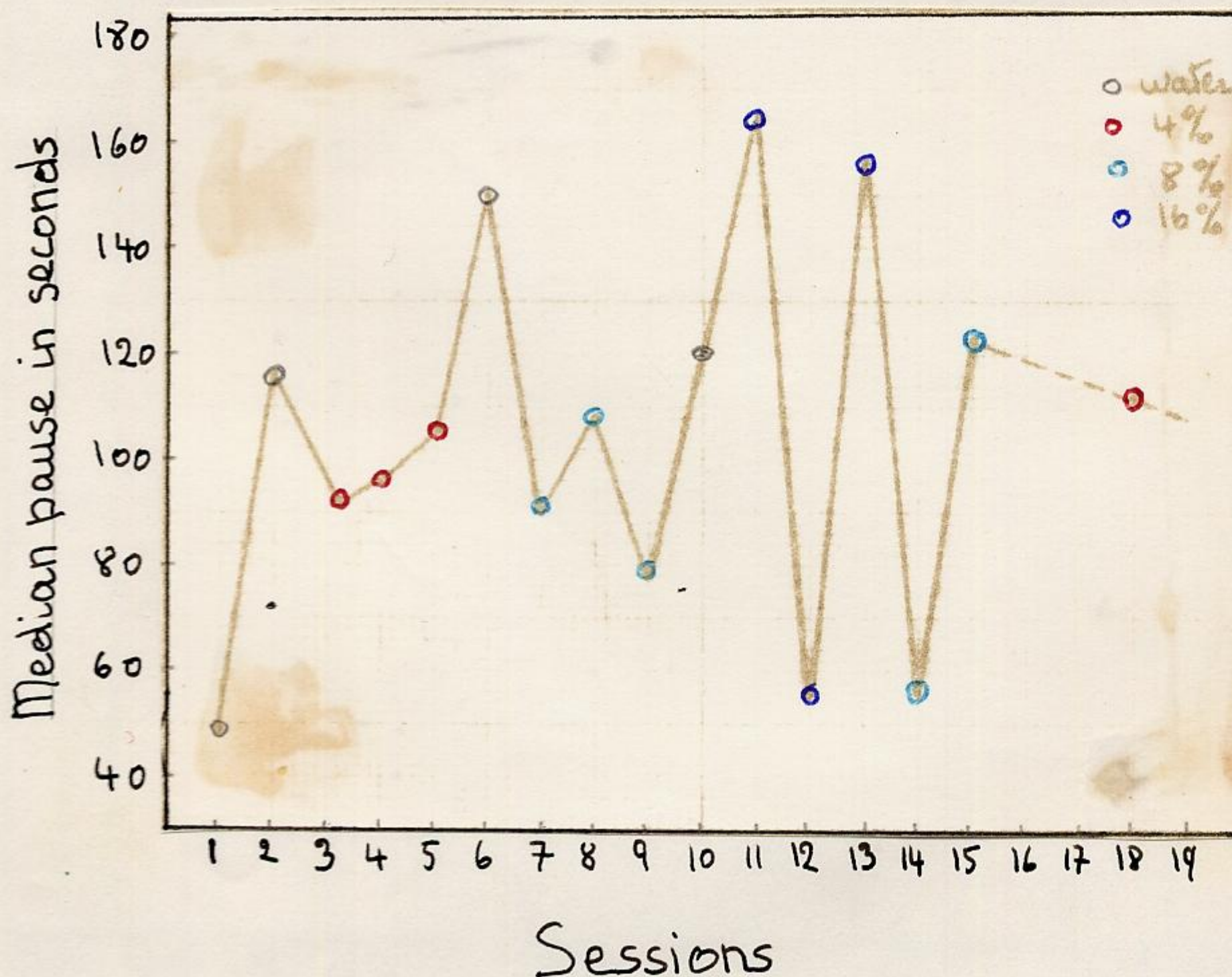


Fig. 19: The daily median pauses of rat V under each reinforcement magnitude

⁴⁸The last session under the 8% sucrose concentration and the first session under the 4% sucrose solution in the down series do not have a median pause due to the small number of pauses in these sessions.

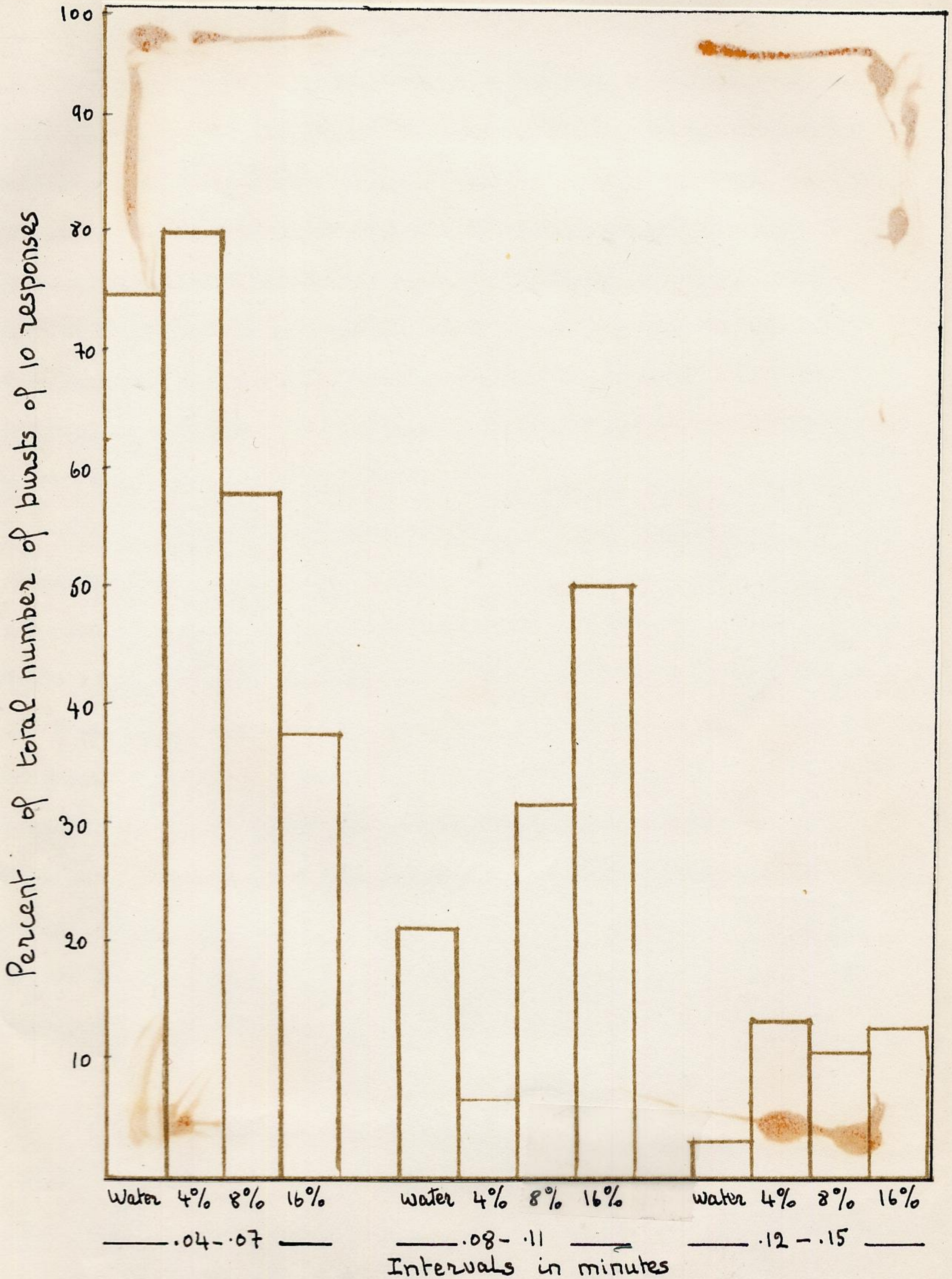


Chart VI: The percent of total number of response bursts emitted by subject V under the different reinforcement magnitudes

Neither the daily median pause nor the average median pause under each concentration seem to be related or affected by the reinforcement magnitudes. The mean median pause under each of the water 4, 8 and 16% sucrose concentration are 108.93, 102.73, 91.55 and 126.25 seconds respectively, while only 17, 22.4, 18.5 and 23% of the total number of pauses fall within the 30 seconds interval. This indicates that more than three-fourth of the pauses are longer than the determined 30 seconds interval so that none of the responses in the 10 response burst is emitted within this time on these occasions.

In general the response rates of this animal is not systematically affected by the magnitudes of reinforcement. Though the local rates are almost constant under all the concentrations the overall rates tend to be slightly higher under the water and 4% concentration than under the 8 and 16% concentrations. The overall rates of responding seem to be dependent on the length of the pause after reinforcement. However under the 8% concentration the effect is non-monotonic since the pause is shorter than, and the overall rate is less than, the pauses and rates under the two lower concentrations. The reason for such an effect may be due to some long daily median pauses which affected the daily overall rates of responding.

CHAPTER VI

DISCUSSION

The results obtained from the experiment indicate that the response rates of the bar pressing response of old male albino rats which are run 22 hours thirsty under the schedules FI 30" FR 11, conjunctive FR 12 FI 30" and conjunctive FR 12 FI 15" ~~were~~ not affected by the different sucrose concentrations used as reinforcers. The results do not confirm Guttman's results which show that both the asymptotic rate and the time to reach it are clearly affected by the percentage of sucrose concentrations. Though Guttman's⁴⁹ study and the present study are designed to test the effects of the same concentrations of sucrose on the bar pressing situation in rats, there are different procedural aspects which may account for the obtained different results.

The first variable which may be of importance is the drive under study. Guttman's experiment involved the effect of the sucrose concentrations on response rates using the hunger drive, while the present study is concerned with the thirst drive only.

Apparently under the thirst drive the response rate of the animals is not influenced by the different sucrose concentrations,

⁴⁹Guttman, op.cit., p. 213.

whose nutritive values increase as the concentration increases, for the overall rate of responding, the local rate of responding and the median pause after reinforcement are largely independent of the reinforcement magnitudes.

The second variable is the general procedure used by the experimenters. Guttman's experiment involves younger rats whose age ranged from 64 to 110 days at the start of the experiment. The subjects received constant training sessions whereby each had to emit 500 responses before they were introduced to the periodic reinforcement schedule of a FI 60 seconds. This schedule was used with both the absolute method and the differential method. Under the former method the subjects were divided into 4 groups where each was tested under one sucrose concentration only while the latter each subject acted as its own control. All the subjects were tested for 15 minutes on each of the 4, 8, 16 and 32% of sucrose concentration in 4 Skinner boxes in a one hour daily session for 12 days.

In contrast the present experiment involved the testing of rats which were about 200 days old at the beginning of the experiment. The training sessions did not require the animals to emit a specific number of responses under continuous reinforcement before the introduction of the different schedules of reinforcement mentioned above. Though the method used is the differential method still it is different from Guttman's method. The sucrose concentrations were each presented successively for 3 daily sessions with one daily session with water as the reinforcing agent to minimize the effects of the previous concentrations.

The local rates of responding for the individual rats are almost constant under all concentrations. This constant local rate for all rats conforms with Gilbert's finding⁴⁹ that the tempo is not affected by the sucrose concentrations but it disagrees with his report with respect to individual differences in the tempo of bar pressing. The local rate of responding under all the sucrose concentrations for all the rats run under the different schedules of reinforcements ranged from 2.2 to 2.8 responses per second.

On the other hand obvious individual differences are observed in the overall rate of responding for these were somewhat higher under the water and 4% sucrose solution than under the two higher concentrations for all the rats. This is particularly noticeable in the overall rate of responding of rat IV (ran under the schedule conjunctive FI 15" FR 12). Its overall rate under the water reinforcement was twice as much as its rate under the 8 and 16% concentrations.

Though the overall rate of responding differs from rat to rat, the local rate of responding is independent of both the overall rate and of the average median pause. However it does appear that the overall rate of responding is to a large extent dependent on the median pause because the shorter the median pause the higher the overall rate, which would be expected.

⁴⁹Gilbert, T.F. "Fundamental Dimensional Properties of the Operant," Psychol. Rev. 65, (1959) p. 276.

CONCLUSION

This study was designed to test the effects of different sucrose concentrations on the bar pressing response of thirsty rats. The subjects were 4 male albino rats trained to bar press under the following schedules of reinforcements: Tandem FI 30" FR 11, conjunctive FI 30" FR 12 and conjunctive FI 15" FR 12.

Once a stable rate of responding was obtained under the water as a reinforcing agent, the experimental sessions under the different concentrations were introduced as follows: 3 daily sessions under each of the 4, 8, 16, 8 and 4% sucrose concentration with one session with water as the reinforcing agent in between each concentration.

The results show that the overall rates of responding, the local rates of responding and the average median pauses are not affected by the reinforcement magnitudes. It is concluded that increasing sucrose concentration is not an effective way of increasing the rate of bar pressing of thirsty animals, although when run hungry white rats do respond faster (overall rates) for higher than for lower sucrose solutions as was confirmed by some of the authors mentioned in Chapter I above.

PART II

CHAPTER VII

The above conclusion that with 22 hours of water deprivation different magnitudes of sucrose concentration do not affect the response rates of rats run under different reinforcement schedules brings up the question as to whether an increased drive of both water and thirst deprivation or an increased deprivation time would have an effect on the bar pressing response reinforced by the same sucrose concentrations.

Deprivation time and magnitude of reinforcement are two variables that are known to determine instrumental response strength. However, the combination of both variables to determine the response strength has been discussed under two different hypotheses. Hull proposed a multiplicative hypothesis which implies a significant interaction whereby the reward effects increase as deprivation increases. On the other hand Spence assumes that this relation is an additive relationship where K , as the reward magnitude and deprivation time, D , has a non-significant interaction.⁵⁰ Thus the effects of different reward levels are assumed to be independent of the level of deprivation.

The different experimental studies designed to test this interaction

⁵⁰Spence, op.cit., p. 130.

give different results. Supporting Spence's hypothesis, it was found that response strength increases as the deprivation time is increased up to a maximum deprivation time beyond which the response strength declines.⁵¹ Moreover the interaction between deprivation time and reward magnitudes was not significant in another study,⁵² though running speed increased systematically as the levels of both drive and reward increased.

Such an additive interaction is not always the case for rats ran significantly faster under a greater deprivation time than under a shorter deprivation time when reward magnitudes were varied.⁵³ Moreover, the greater deprivation time increases the rate of bar pressing and tends especially to increase the rate at both the extreme high and low sucrose concentrations.⁵⁴

Theoretical considerations apart, it seems that deprivation time affects running speed just as reward magnitude affects the running speed.⁵⁵ Thus increasing deprivation time reduces the occurrence of the competing

⁵¹Reynolds, W.F. and Pavlik, W.B. "Running Speed as a Function of Deprivation Period and Reward Magnitude." J. Comp. Physiol. Psychol. 53, (1960), p. 618.

⁵²Weiss, op.cit., p. 390.

⁵³Lewis^{10.} and Cotton,¹⁴ op.cit., p. 188. Also Brush, F.R. et al. "Running Speed as a Function of Deprivation Conditions and Concentration of Sucrose Incentive," Psychol. Rep. 9, (1961), 634.

⁵⁴Conrad and Sidman, op.cit., p. 384.

⁵⁵Davis and Keehn, op.cit., p. 271. Also Pereboom and Crawford, op.cit., p. 85.

or irrelevant responses rather than increasing the speed of the instrumental response per se.⁵⁶

The second part of this study is therefore designed to examine the effects of increased drive on the response rate of the rats run under the same schedules of reinforcements and under the same reinforcement magnitudes as used in Part I. Thus the magnitude of reinforcements are held constant while the drive is varied in both kind and in deprivation time.

Procedure

Without any interruption and without adapting the subjects to food and water deprivation rhythm the drive was changed from thirst alone to hunger and thirst. After the daily $\frac{1}{2}$ hour free access to both food and water, three of the animals were set on a 22 hour food and water deprivation schedule. Following this deprivation schedule, each animal was run according to its previously determined schedule of reinforcement for 1 daily session under 8 and 16% sucrose concentration and water as the reinforcing agents. One session under the 16% solution with a 46 hours deprivation of both food and water was run between the 16% sucrose solution and the water reinforcement. Following each experimental session the animals were given free access to both water and food for a whole hour.

This part of the experiment involved 3 animals, I, II and V only.

⁵⁶Cotton, op.cit., p. 198. Also, Stellar and Hill, op.cit., p. 100.

CHAPTER VIII

ANIMALS I AND II

Tandem FI 30" FR 11

Table V summarizes the results obtained from the effects of the different reinforcing magnitudes on the response rates of rat I as a result of increasing the drive to 22 hours hunger and thirst and on then to 46 hours hunger and thirst. The 46 hours deprivation time will be referred to henceforward as (H.D.)

TABLE V

Hours of Drive Hunger and Thirst	Reinf. Sucrose concentration	Session 60 minutes	No. of reinf.	Mean Overall rate Resp./	Mean Local rate Resp./	Md. pause secs.	% of pause within the 30" interval
22	water	1	18	5.6	3	45	33
22	8%	1	21	7.1	2.6	19	56
22	16%	1	45	10.8	3.2	30	55
46	16%	1	68	18.6	3.8	15	71.10

Table V: Results of the effects of reward magnitudes on the response strength of subject I as a result of an increase in drive.

Evidently with the increased drive, the overall rate of responding is affected by the magnitude of reinforcement as is indicated in Figures 20, 21 and in Table V, Column 5.

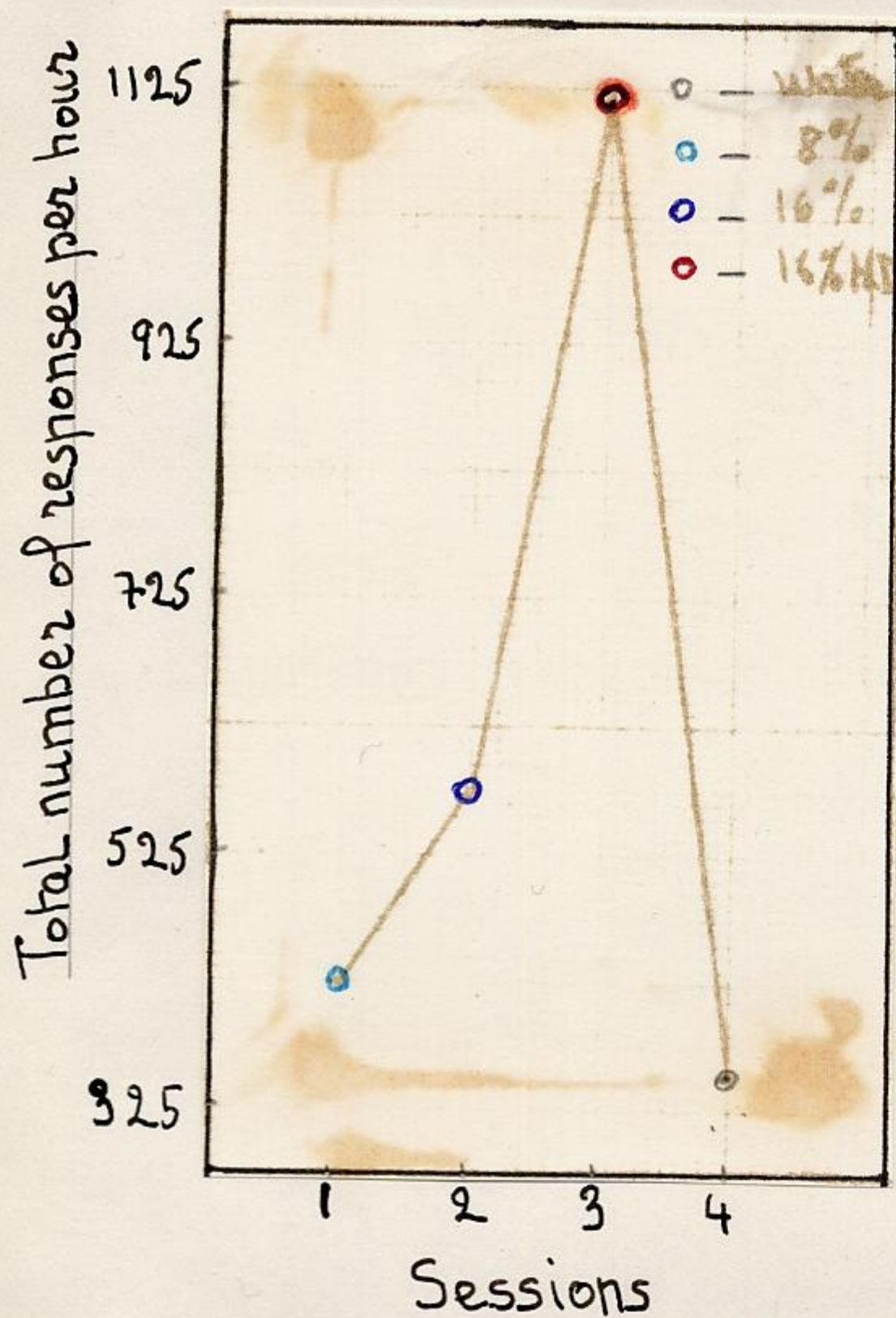


Fig. 20: Total daily number of responses emitted by subject I under each reinforcement magnitude

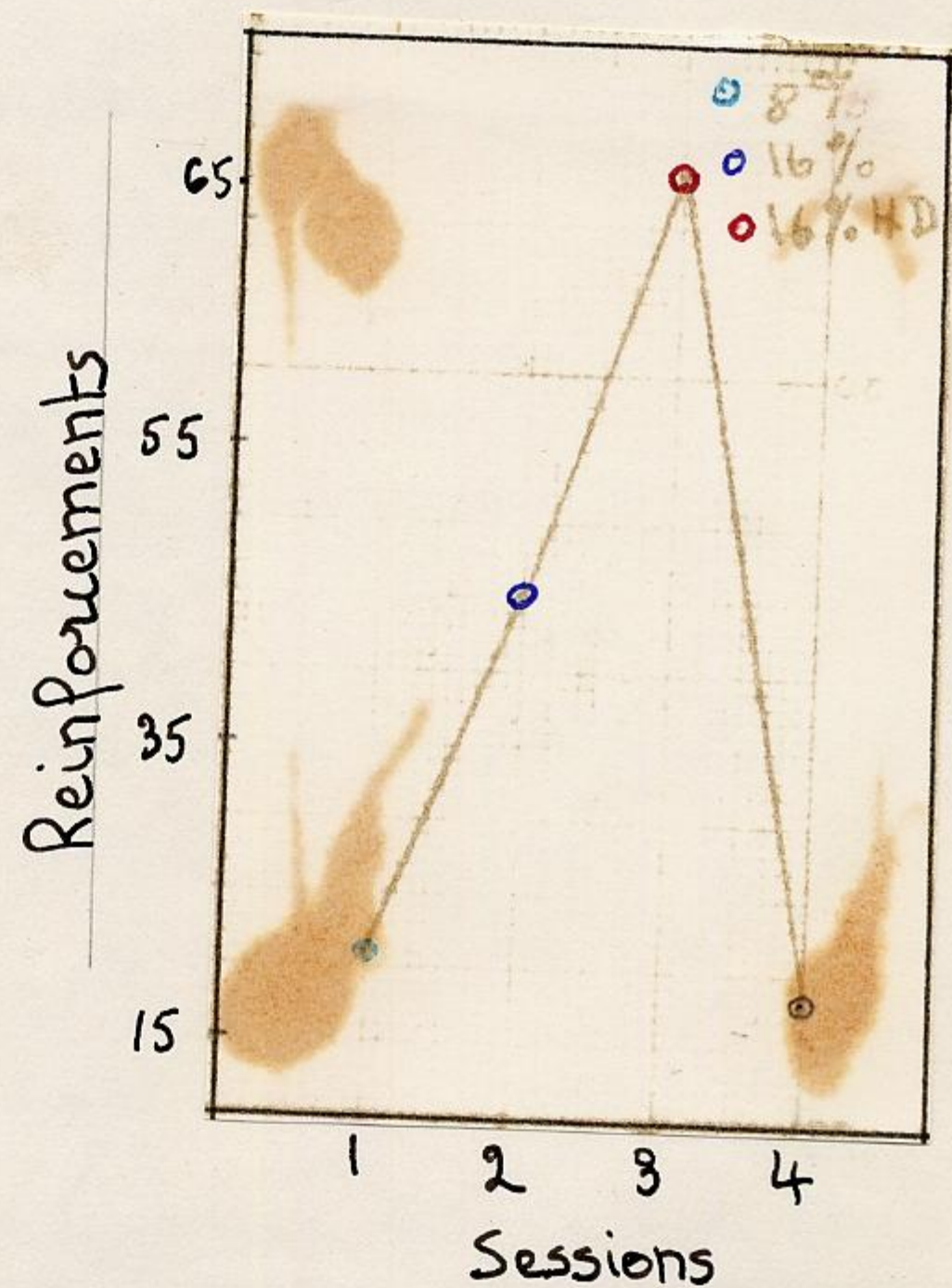


Fig. 21: Total daily number of reinforcements received by subject I under each reinforcement amount

The total number of responses emitted during the 60 minutes session under the water 8 and 16% and 16% (H.D.) sucrose concentration are 338, 426, 653 and 1120 responses. The number of reinforcements received under these respective amounts are 18, 21, 45 and 68. The mean overall rate of responding is definitely higher under the 46 hours deprivation. It is 18.6 responses per minute as compared to the 5.6,

7.1 and 10.8 responses per minute under the water, 8 and 16% concentration respectively. Therefore the response strength is affected by the drive, and also by the magnitude of reinforcement in this particular subject after the drive had been increased from 22 hours water deprivation to 22 hours deprivation of food and water.

On the other hand the results summarized below in Table VI, indicate that the rate of the bar pressing of rat II, which ran under the same schedule, tandem FI 30" FR 12, is not affected by the magnitudes of reinforcement as a result of the increased drive.

Hunger and thirst drive in hours	Sucrose concentration %	Session 60 min.	No. of reinf.	Mean overall rate Resp./min.	Mean local rate Resp./sec.	Md. Pause seconds
22	water	1	9	1.85	4	135
22	8	1	5	1.05	3.4	232.5
22	16	1	10	2.06	4	150
46	16	1	5	2	4.8	142.5

Table VI: Results of the effects of the magnitude of reinforcement on the bar pressing response of subject II run under tandem FI 30" FR 11 as a result of a change in drive.

In contrast to the 3.97, 4.2, 3.5 and 3.1 responses per minute under the water, 4, 8 and 16% concentrations respectively following the thirst drive alone, the overall rate of responding under the thirst and hunger drive and the high drive, 8, 16, 16 (H.D.) and water successively are 1.85, 1.05, 2.6 and 2 responses per minutes. Thus the overall rate of responding decreased with the change in drive. However the overall responding of this animal was poor, and it received very few reinforcements per session.

Local Rates

The daily local rates of both rats I and II as indicated in Figures 22 and 23, show the local rates tend to be slightly higher under the 16% sucrose concentration with 46 hours deprivation.

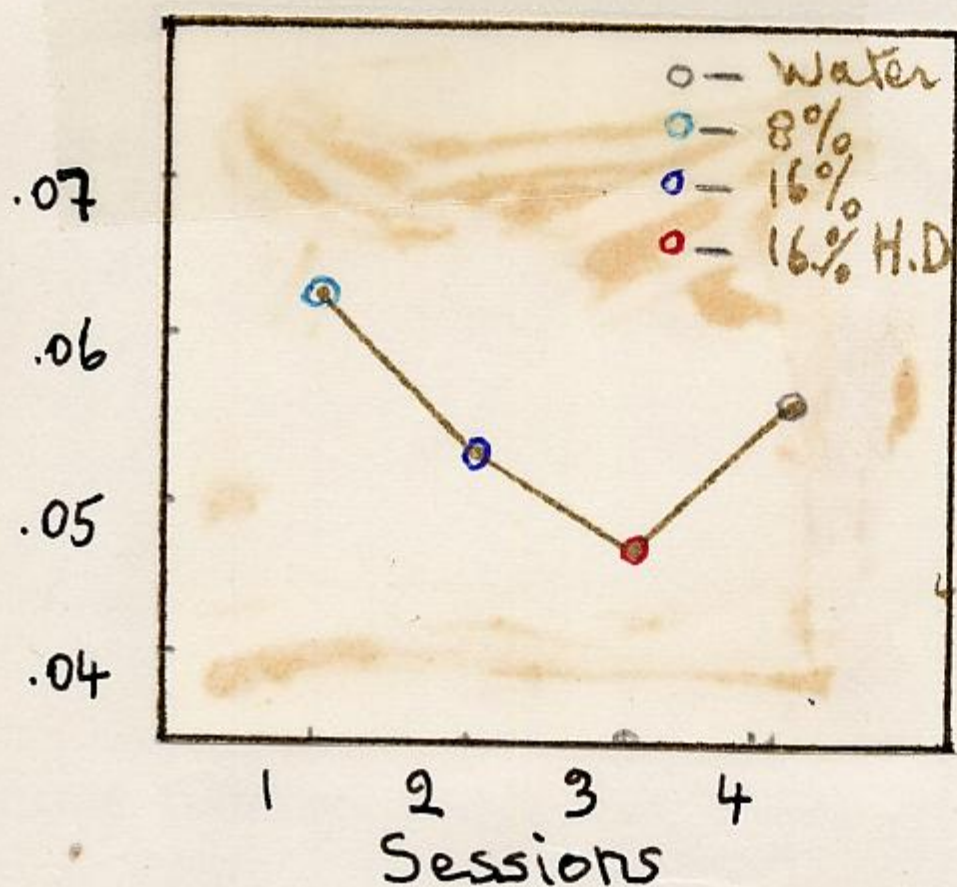


Fig. 22: Mean daily time in minutes taken by rat I to run under the different reinforcement magnitudes

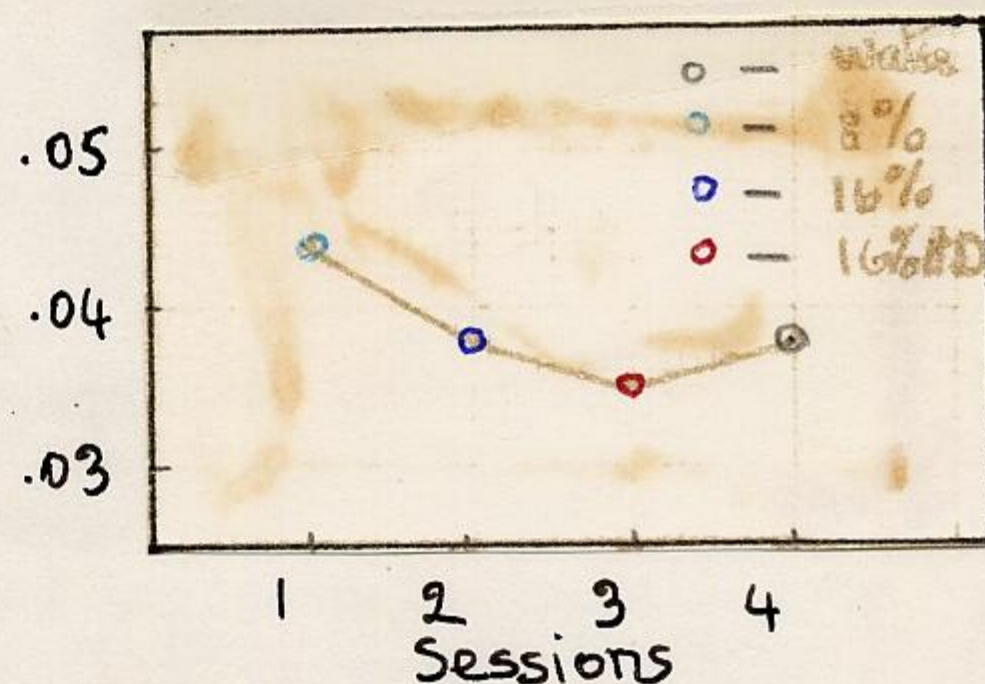


Fig. 23: Mean daily time in minutes taken by rat II under different reinforcement

Though the mean local rates of responding for both rats do not seem to be affected by the magnitudes of reinforcement, they do show an increase in rate of responding as compared to the mean local rate under the thirst drive only. The mean local rates for both rats I and II under the water, 8, 16 and 16% (H.D) sucrose concentrations were 3, 2.6, 3.2 and 3.8 responses per seconds and 4, 3.4, 4 and 4.8 responses per seconds respectively. The increased local rate is observed in the increased percent of the total number of bursts of 10 responses that were emitted within the interval .03-.06 minute. Rat I had 77, 70, 75 and 88% of the total number of the bursts fall within this interval, while a 100, 75,

100 and 100% of the total number of the bursts of rat II fell within this interval. However it can be seen from Table VI, p. 59, that the latter animal emitted only a few bursts of responses.

Pauses after Reinforcement

As the overall rate of responding of rat I increased the median pause after reinforcement decreased. The median pauses under the water, 8, 16 and 16% (H.D.) sucrose concentrations were 45, 19, 30 and 15 seconds. Moreover under the 46 hours deprivation rat I emitted several bursts of 30 to 48 responses without pausing after the reinforcements. Such short pauses were the cause of the marked increase in overall rate of responding under the 16% sucrose concentration after the 46 hours deprivation time.

On the other hand the overall rate of responding of rat II decreased because with the change in drive the median pauses increased in length. In contrast to the 98.7, 67.32, 125.37 and 91.88 second pauses under the thirst drive alone, the pauses under the thirst and hunger drive were 135, 232.5, 150 and 142.5 seconds long under the water, 8, 16 and 16% (H.D.) concentration.

CHAPTER IX

SUBJECT V

Conjunctive FI 30" FR 12

In agreement with the results obtained from rat II the response rate of rat V, run under the schedule conjunctive FI 30" FR 12, is not affected by the reward magnitude or by the increased drive to 22½ hours of water and food deprivation. Table VII, summarizes the results and indicates that the overall rate of responding of the subject tends to decline as the drive increased in comparison with the overall rate of responding obtained under the thirst drive only (Table IV, p.43). However there was a marked increase in the rate of responding as the

TABLE VII

Hunger and thirst drive in hours	% Sucrose concentration	Session 30 minutes	No. of reinforcements	Mean overall rate Resp./min.	Mean local rate Resp./sec.	Md. pause seconds
22½	water	1	3	1.2	1.9	135
22½	8	1	1	-	-	-
22½	16	1	3	1.2	2.8	111.25
46½	16	1	6	2.4	2.8	165

Table VII: The effects of the magnitude of rewards on the response strength of rat V ran under the schedule conjunctive FI 30" FR 12 as a result of the increased drive.

drive was increased from $22\frac{1}{2}$ hours deprivation to a $46\frac{1}{2}$ hours deprivation. The mean overall rates of responding under the water, 16 and 16% (H.D.) sucrose concentration were 1.2, 1.2 and 2.4 responses per minutes which is very low. The session under the 8% concentration does not have a mean overall rate because the animal received just one reinforcement and then stopped responding, while under the water 16 and 16% (H.D.) concentration the number of reinforcements received were 3.3 and 6 reinforcements respectively. Fig. 24, shows the total number of responses under the different reinforcement magnitudes.

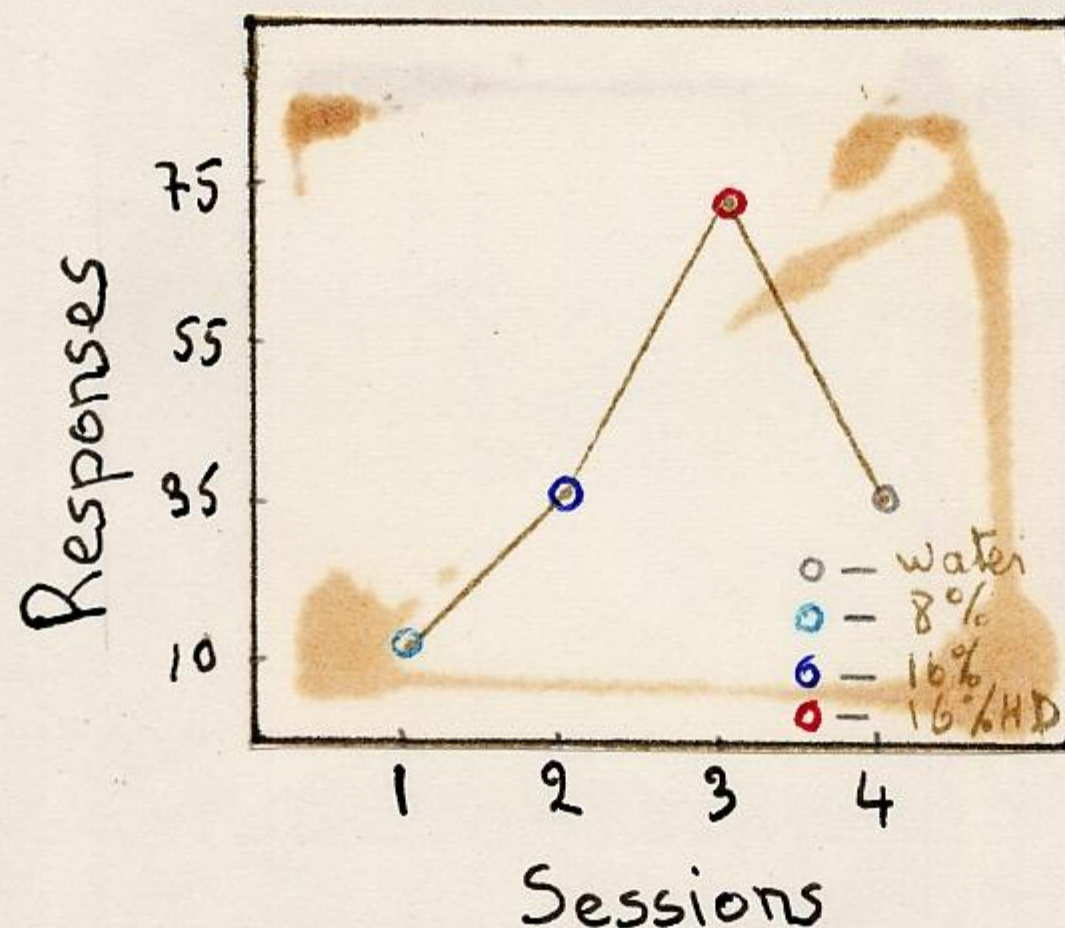


Fig. 24: The daily number of responses emitted by rat V under the different reinforcements with the increased drive.

Fig. 25, presents the daily mean time in minutes taken by the animal to emit a burst of 10 responses. Though the mean daily rate does not seem to differ greatly under the 8 and 16% concentrations it does however show a marked decrease under the water reinforcement. Such a difference is observed in the mean local rates where the animal

emitted 1.9, 2.8 and 2.8 responses per second under the water, 16 and 16% (H.D.) concentration.

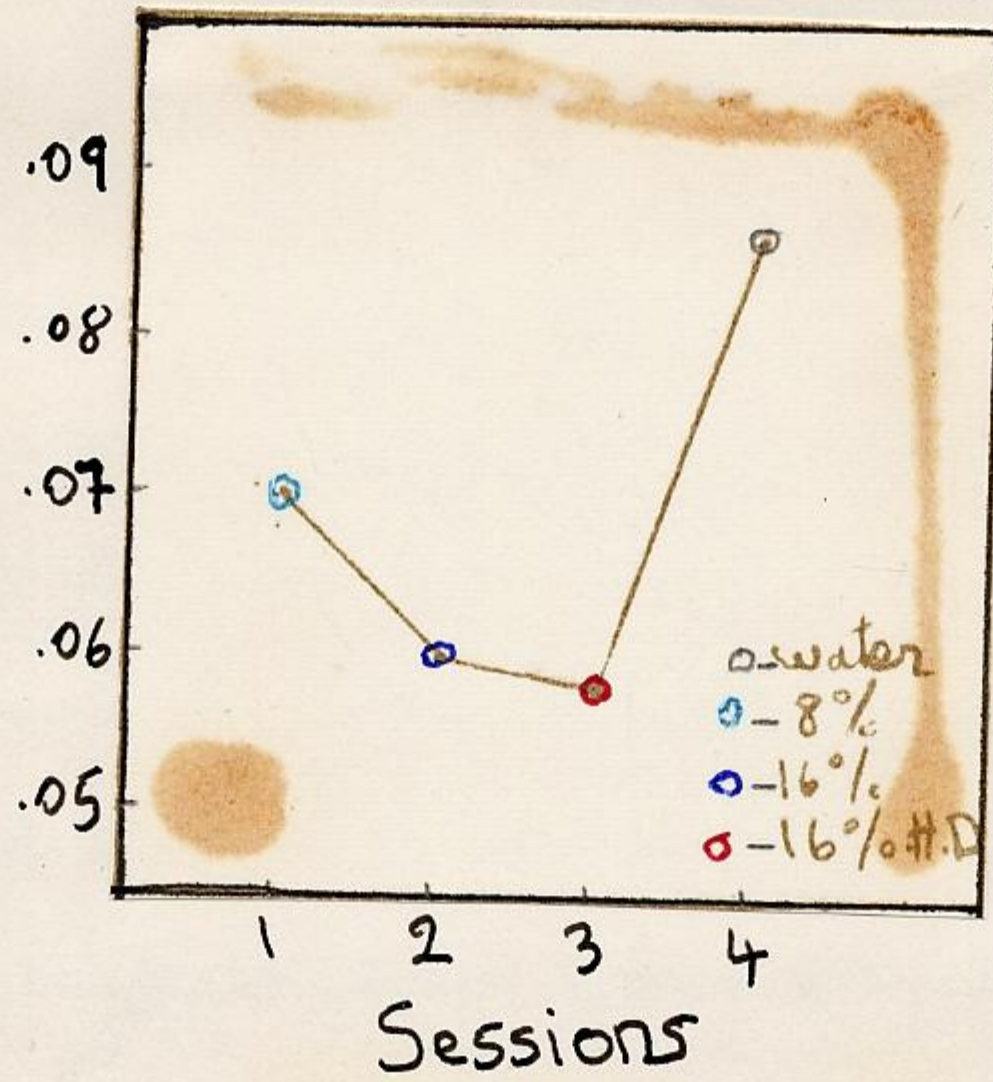


Fig. 25: The mean daily time in minutes taken by rat V to emit 10 responses under the different reinforcements

CHAPTER X

DISCUSSION- Part II

The results obtained from subject I show that under the thirst drive the animal was not responding at maximum speed since the increased drive from thirst alone to hunger and thirst and to longer deprivation time systematically increased the overall rate of responding as the reinforcement magnitudes increased. On the other hand, the overall rates of responding of subjects II and V were not affected by the increased drive until deprivation time was increased to 46 hours.

The increased overall rate of responding, particularly in the case of rat I, came about by a decrease in the length of pauses after reinforcement. The average pause under all the concentrations following the thirst drive alone was 57.92 seconds, while the average pause under the increased drive was 26.7 seconds. The reduced length of the pauses under the increased drive means that the number of competing responses interfering with bar pressing response are reduced.

Though the local rates of responding were not affected by the reinforcement magnitude under the thirst drive alone, it seems that changes in drive can affect these rates under different reinforcement magnitudes providing the overall rate of responding is high enough. While the mean local rates of all the subjects is 2.4 responses per second under the thirst drive, it shifts up to 3.3 responses per second under the thirst and hunger drives.

CONCLUSION

The overall rates and local rates of responding of subject I and II run under the tandem schedule FI 30" FR 11, and subject V ran under the conjunctive schedule FI 30" FR 12 were tested as a function of both reinforcement concentration and the drive.

The results showed that though the local and overall rates of responding are not affected by reinforcement magnitudes under the thirst drive (Part I) they could be increased by increasing the drive to both hunger and thirst and by increasing the deprivation time. The overall rates increased with the reinforcement magnitudes in the case of one animal, but not with the other 2 animals.

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