FR15FR45 was changed to FR25, and the animals were reinforced on mixed FR25FR45.

For subject K-5 reinforcement was scheduled on mixed FR25FR45 for 29 sessions, over a period of 30 experimental sessions, while 6 cc. pre-feeding was maintained.

K-6 was run on FR25FR45 contingencies for 11, ½ hour experimental sessions, over a period of 12 days and the mean pauses after the short and long runs were computed separately. On the 11th session the schedule was changed to mixed FR35FR45 and maintained for 18 experimental sessions.

For animals K-7 and K-8 the reinforcement density was increased. The values of the schedule were reduced to mixed FR5FR15, while 6 cc. pre-feeding was maintained. In the following 29 sessions, animal K-7 was run under this procedure, while K-8 was run for 28 experimental sessions under this procedure over a period of 30 days. This ended the subsidiary experiment.

Animals K-5, K-6, K-7 were run for the subsidiary experiment for 29 sessions, and K-8 for 28 experimental sessions, over a period of 30 days.

Mean pauses after short and long runs were calculated separately for the various ratios.

In Table III are summarized changes in schedule, drive level, reinforcement agent and number of sessions for animals in Group I and II in the subsidiary experiment.

MOTIVATIONAL EFFECTS ON PAUSE LENGTHS DURING MIXED SCHEDULES OF REINFORCEMENT

By

VASSILIA D. PATRIKIOU

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Vassilia D. Patrikiou

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CHAPTER I

Introducing the Problem

Reinforcers are the best known variables controlling behavior. A reinforcer in general is defined as a stimulus event of one sort or another which increases the strength of the response it follows.(1)

One of the important parameters of a reinforcement is frequency of reinforcement. For the strength of a response to be maintained, however, it is not necessary to reinforce every response regularly. A response may be reinforced only occasionally, under a schedule of reinforcement. Some schedules generate a high stable rate of responding which show a great resistance to extinction. It has been reported that under some schedules of intermittent reinforcement as many as 10,000 responses were emitted by a pigeon before the response was completely extinguished.(2)

Schedules of intermittent reinforcement are many. The fundamental types are fixed and variable ratio (FR and VR) and fixed and variable interval (FI and VI).(3)

Two or more schedules may be combined randomly or alternately to form a "multiple" or a "mixed" schedule, or in other ways.

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(1) Skinner, B.F. The behavior of organisms. New York: Appleton-Century-Crofts, 1938, pp. 67, 116.

(2) Skinner, B.F. Science and human behavior. New York: MacMillan Co., 1953, p. 70.

(3) Ferster, C.B., and Skinner, B.F. Schedules of reinforcement. New York: Appleton-Century-Crofts, 1957, p. 5.

a) Fixed Ratio (FR). In this type of schedule reinforcement is contingent upon the emission of a certain fixed number of responses. Originally, the ratio was said to be that of the number of unreinforced responses to each reinforced response. Thus, if the reinforcement is delivered after fifth response, the fixed ratio is 4:1. Now it is more usual to say that in a fixed ratio schedule the response which occurs after a fixed number of responses is reinforced. Thus in the fixed ratio 10 (FR10) the tenth response to occur after the previous reinforcement is reinforced and the tenth response occuring after this one is also reinforced etc. but none of the intervening responses between these are reinforced.

The typical performance generated by this schedule is a high rate of responding, and pauses after each reinforcement. With short fixed ratios responding begins almost immediately after reinforcement, and is maintained at a constant rate until the next reinforcement. As the size of the ratio is increased, a pause appears after each reinforcement. The length of the pause is, in general, directly proportional to the length of the ratio. That is, as the length of the ratio is increased, the length of the post-reinforcement pause increases.

b) Fixed Interval (FI). Under fixed interval schedules, the frequency of reinforcement is independent of the rate of responding. In this schedule reinforcement is programmed by a clock. For example, in a fixed interval 20 sec. (FI20") reinforcement is set up 20 sec. following the previous reinforcement. The first response to occur after 20 sec. is reinforced. The performance that a fixed interval schedule generates is characterized by a pause after each reinforcement, followed by a gradually increasing rate of responding to a terminal rate which is relatively constant and is maintained until the next reinforcement. The

performance produces a scalloped appearance in the cumulative curve. The FI schedule generates a moderate rate of responding, depending upon the size of the interval.

Ferster and Skinner, report the daily performance of a bird trained on FI4' after thirty eight hours of continuous reinforcement. After each reinforcement a pause from 1-2 minutes was typical, followed by a smooth acceleration in the rate of responding, to a terminal rate of about 2.5 responses per sec.(4)

c) Variable Ratio (VR). In the variable ratio type of schedule, reinforcement is determined by the number of responses emitted since the previous reinforcement. The particular number of responses, however, varies in a random fashion from reinforcement to reinforcement.

When the mean number of responses required per reinforcement is low, this schedule generates high sustained rates of response with no pause after reinforcement. Under high mean ratios, pauses may occur, but typically, pauses do not follow reinforcement, and consequently a high constant rate of responding is generated.(5)

d) Variable Interval (VI). Under variable interval schedule, the intervals occur randomly. The intervals between reinforcements are chosen at random and vary within a specified range around a specified mean value. The effect of this schedule is to eliminate the pause after reinforcement, since it is not possible to predict from one interval what the next interval length will be. The typical performance under this schedule is a sustained constant low rate of responding in which the scallops after

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(4) Ibid., p. 157.

(5) Skinner, B.F. Science and human behavior, p. 104.

each reinforcement disappear.[6]

e) Multiple Schedules. In multiple schedules any of the above schedules may be programmed randomly or alternately either within a single session or in different sessions with a particular stimulus correlated with each schedule. Thus a multiple FI5'FR10 means that when say a red light is on responding is reinforced on a 5 minute fixed interval schedule. When a green light is on responding is reinforced on a 10 response fixed ratio schedule.

f) Mixed Schedules. This schedule is identical to the multiple schedule except that no stimuli are correlated with the different components of the schedule.

g) Chaining. In chaining the completion of the requirements of one schedule in the presence of one stimulus produces a second stimulus, the completion of the requirements of the schedule in the second stimulus produces a third stimulus and so on. The completion of the requirements of the schedule in the last stimulus produces reinforcement. Chains may have two or more links, but usually they have only two or three links i.e., in the chain FI1FI1FI1, the fixed interval value in each component is one minute. In this chain the first response after a fixed interval 1 minute in the presence of a white light, say, starts the second component, the first response after an interval of 1 minute in the presence of a green light, say, starts the third component, and the first response after an interval of 1 minute in the presence of a red light, say, produces reinforcement and resets the sequence as before.

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(6) Ferster, C.B., and Skinner, B.F. Schedules of reinforcement, pp. 326-397.

General Considerations.

The typical behavior of pausing after a reinforcement on a fixed ratio or a fixed interval schedule, has been shown in several experiments. Ferster and Skinner, in their book Schedules of reinforcement, present the most extensive data.(7) Moreover, it has been shown that there is a correlation between pause length and size of ratio, and that in general the larger the fixed ratio the longer the post-reinforcement pause. Many experiments illustrate this fact. In small fixed ratios the pauses generated are very slight, under larger fixed ratios, however, pauses increase, lasting sometimes to a few minutes.(8)

In one experiment six rats with previous experience on FR were used. Starting with FR3 the rats were advanced progressively to higher ratios of FR8, FR15, FR26 and FR36.

Each animal was allowed to stabilize on each one of these ratios. Measurements of the pauses after all ratios were taken for every rat and the results averaged. It was found that increases in the length of the pause after reinforcement followed increases in the size of the fixed ratio. The average pause at FR3 was 6:36, at FR8 it was 6:11, at FR15 8:08, at FR26 it was 11:06, and at FR36 17:69.(9)

The relationship between pause length and ratio size, is further demonstrated by the following experiment.

In this experiment, a single stimulus was in control for a full session. Three birds were reinforced for key pecking on multiple FR60

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(7) Ibid., pp. 39-132, 133-325.

(8) Ibid., pp. 48-52, 54-55.

(9) Boren, J.J. Response rate and resistance to extinction as function of the fixed ratio. Unpublished doctoral dissertation, Columbia Univ., 1953, p. 12.

FR200, each one of the components of the schedule remaining in effect for a whole day's session (i.e. at the beginning of a given session the key was blue, and the reinforcement was on FR60, on the following session the key was orange and the schedule was FR200 etc.). In this way separate records of the bird's performance on each ratio were obtained. Discrimination was established, and results showed that the birds were making short pauses after reinforcement under the FR60 component of the multiple schedule and long post-reinforcement pauses under the FR200 component.(10)

Post-reinforcement breaks, as such, have been explained in terms of the S^{Δ} properties of the stimulus consequences of reinforcement and S^{D} properties of responding. Part of the break, of course, is due to the fact that the animal must move towards the magazine, find the pellet and eat it. That is, reinforcement itself generates a sequence of responses involved in consummation. The duration of the pause, however, should not be attributed solely to eating time. That this is the case is supported empirically. Boren(11) found that the average pause was different at various ratios (FR3, FR8, FR15, FR26 and FR36) and concluded that the break is prolonged due to factors others than eating, otherwise the break would have been the same at all ratios.

The break is prolonged, first because responses emitted immediatelly after reinforcement are never reinforced (in FR a certain number of responses must be emitted before reinforcement, and in FI an interval of time must elapse before reinforcement). Thus this stimulus pattern becomes an S^{Δ} condition and responding, therefore, does not occur,

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(10) Ferster and Skinner, op.cit. p. 531.

(11) Boren, op.cit. p. 25.

immediately after reinforcement. Performance of animals on variable schedules of reinforcement (where first responses following reinforcement are occasionally reinforced) have supported this notion. It was found that under such schedules, pauses after reinforcement disappear.(12)

The second explanation, in the analysis of post-reinforcement pauses, refers to the S^D properties of responding. The emission of a given number of responses at a given rate may serve as an effective S^D in controlling subsequent behavior. As the animal begins to respond, the stimulus situation, by the principle of generalization, comes to acquire S^D properties, since the stimulus situation becomes more like that which prevails when reinforcement occurs.

As Guttman and Kalish(13) showed in their generalization study the rate of an operant response can be increased by changing the stimulus situation, so that it becomes more similar to those conditions which prevail at the moment of reinforcement.

In the FI schedules of reinforcement, the gradual acceleration of rate following the pause, may be explained as being under the control of a changing stimulus class which is becoming more and more similar to those conditions that prevail at the time of reinforcement. This stimulus may be the gradual loss of effectiveness of the S^Δ present following reinforcement or it may be some other event that the animal perceives, and which changes with time during the interval between reinforcements. So as the stimulus consequences of reinforcement wear off and the S^D conditions of the coming reinforcement appear the animal begins to respond.

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(12) Ferster and Skinner, op.cit. pp. 326-339, 391-413.

(13) Guttman, N., and Kalish, H.I. Discriminability and stimulus generalization, J. exp. Psychol., 1956, 51, pp. 87-88.

A temporal discrimination is established.[14]

Under FR schedules the animal is reinforced when he is responding at a high rate, and because of this fact reinforcement quite frequently follows bursts of rapidly occuring responses. Since this pattern of responding is more frequently reinforced than spaced responding, it will be expected to occur more frequently thus increasing still more the probability that a burst of rapid responding will be reinforced. So as reinforcement is contingent upon a burst of responding this constitutes an S^D condition leading to higher and higher rates of responding. Thus the animal tends to maintain a high constant rate up to the time of next reinforcement.

The fact that some such variable as this is operating is demonstrated by experiments in which some external stimulus under the control of the experimenter (such as a counter or a clock) is made to vary during the interval between reinforcements. Ferster and Skinner describe several experiments (in which such external stimuli as a counter or a clock are used) illustrating the fact that the emission of certain number of responses at certain rate may serve as stimuli in controlling behavior.[15] Ferster also demonstrated that post-reinforcement pauses are a function of tne temporal properties of the reinforcing stimulus, as well as of the response sequence preceding reinforcement.[16] He conducted two

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(14) Keller, F.S., and Schoenfeld, W.W. Principles of psychology. New York: Appleton-Century-Crofts, 1950, pp. 83-88.

(15) Ferster and Skinner, op.cit. pp. 89-116, 266-319, 605-613.

(16) Ferster, C.B. Use of the blackout in the investigation of temporal discrimination in fixed-interval reinforcement. J. exp. Psychol., 1954, 47, p. 69.

experiments, using pigeons as subjects and a "time out[1] of the experiment" technique known as blackout. Ferster in his study argues that on fixed interval schedules the early part of the interval is characterized by a change in the rate of responding (or low responding) and says that this change in rate of responding during a given interval may be attributed to the temporal properties of the reinforcing stimulus, if it is decreased or eliminated when reinforcement is followed by a "time out" period. Of course, the length of the time out period should be equal or greater than the time during which reinforcement is effective in controlling the rate of responding.

In the first experiment, Ferster, used two pigeons with a long history on interval schedules and time out. (He used pigeons, because these birds do not peck in the dark unless they are trained.) The birds were stabilized on a 90 sec. fixed interval, after the administration of 1200 reinforcements. When their performance became uniform and pauses became consistent, a 30 sec. blackout period was introduced, following every tenth reinforcement. He conducted this experiment for a period of six days, and compared the length of the intervals with and without blackouts. Results demonstrated that the pause at the beginning of the interval following the blackout consistently decreased, whenever a blackout period was introduced. The experiment showed that the reinforcing

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[1] "Time out" is defined as "any period of time during which the organism is prevented from emitting the response under observation."(17) Time out can be achieved by many ways, for example, by taking the animal away from the experimental box, or by turning off the lights in the experimental chamber if the subject is a bird.

(17) Ferster and Skinner, op.cit. p. 34.

stimuli have temporal properties that may be considered responsible for the low probability of response, at the start of the interval. In those cases that the blackout was introduced, it eliminated the temporal discrimination at the start of the interval and the animal began responding as soon as the blackout period was terminated.

Ferster, also, demonstrated in a second experiment that the post-reinforcement pause is a function of the response sequence that leads to it. In this experiment he investigated the S^D properties of the pre-reinforcement run.

The subjects used were 2 pigeons with a long history of fixed interval. For a period of 6 days the birds were reinforced on a FI45 minute schedule and were allowed to stabilize till pauses following reinforcement became consistent. Then a 20 min. blackout period was introduced following each reinforcement. Measures were (a) the period of time after the delivery of reinforcement to the first response in the interval (after the blackout period was terminated), (b) the number of responses emitted in the first 5 minutes of the interval. The data obtained during the 6 days preceding and the 6 days following the introduction of the blackout was compared. Results demonstrated that the blackout period had two effects on the birds' performance, (a) the first response in the interval (after the termination of blackout) was considerably postponed, therefore the post-reinforcement pauses were lengthened; (b) the total number of responses emitted during the first 5 minutes of the interval were significantly reduced.

Usually the S^D properties of the response sequence preceding reinforcement have the effect of generating a relatively constant rate of

responding which is maintained until the reinforcement occurs at the end of the interval. Since the rate of responding is correlated with reinforcement, it becomes an S^D stimulus with temporal properties responsible for controlling behavior in the following interval, but this normal pattern did not happen when the blackout period was introduced, because the blackout had the effect in eliminating the temporal properties of the response sequence prior to reinforcement.

Thus Ferster concluded that "following reinforcement" two stimuli are present, (a) the reinforcing stimulus (food in the mouth, biting, swallowing) which is responsible for the low rate of responding and (b) the number of responses (the carry-over as Ferster calls them) which control the constant rate. The post-reinforcement pause is under the control of recent eating, and the rate of responding (when the animal starts responding) is under the control of the number of responses emitted in the preceding interval.(18)

Another explanation of the pause following reinforcement on FR is that the emission of a number of responses at a high rate tends to weaken the response temporarily, an effect sometimes called fatigue. Boren(19) argues that since under a shorter ratio the animal makes fewer responses at lower rate the fatigue effect should be less than in the case of animals maintained at a larger ratio. Implicit in this explanation is that since more responses are required for a larger ratio than for a smaller one, longer pauses follow long runs for the fatigue effect to dissipate.

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(18) Ibid., p. 72.

(19) Boren, op.cit. p. 26.

In Hull's theory of learning is also implied another explanation of the pause following reinforcement. Hull maintains that each time a response occurs, it produces in the organism an increment of a state which can be considered analogous but not identical with the fatigue that typically develops with repeated occurrence of behavior. This state generates a need for rest, which has the innate capacity of stop the activity which produced the state of fatigue. Hull calls this condition reactive inhibition (Ir) and argues that it is directly proportional in amount, to the number of responses emitted. As the number of responses is increased, and since each response produces an increment to the amount of inhibition which has already accumulated, a gradual decline on the strength or rate of response is developed until a time is reached when the organism is no longer able to respond, and the activity which has generated this need for rest is stopped. Hull maintains that the accumulated inhibition effects have a chance to dissipate and the strength of the response returns gradually, merely by the passage of time following the cessation of the response.(20) Implicit, therefore, in Hull's theory is that in ratio schedules more reactive inhibition is generated after longer runs and therefore longer pauses would be expected to occur after the longer ratio for reactive inhibition to dissipate, and that the post-reinforcement pause is actually determined by the response sequence that precedes reinforcement.

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(20) Hull, C.L. Principles of behavior. New York: Appleton-Century-Crofts, 1943, pp. 278-291.

But recent findings are inconsistent with both of the above mentioned explanations for it was found that under certain conditions, longer pauses follow small ratio runs and shorter pauses follow larger ratio runs.(21)

It is clear from all that was said that post-reinforcement pauses are mainly explained in terms of the behavior that precedes them. In fact results of some recent studies are consistent with this general point of view.(22) But the bulk of the recent experimental evidence supports the fact that the pause length is not determined solely by the stimulus conditions that prevail at the beginning of the pause, and that under certain conditions, a given pause may be controlled by both the pre and post-reinforcement runs.(23)

In one experiment a rat with a previous history on FR, demonstrated on a multiple FR10FR24 and FR10FR10FR57, distinct and systematic differences between the pauses after each of the components of the fixed ratio; longer median pauses after small ratios and shorter median pauses after larger ratios.(24)

It was concluded that in cases when the shorter of the FR components on a multiple schedule falls below a certain threshold level the pause is controlled by both the pre and post-reinforcement runs.(25)

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(21) Salman, M.A. Determinants of post-reinforcement pauses on fixed-ratio schedules. Unpublished M.A. thesis, Amer. Univ. Beirut, 1962, p. 29.

(22) Ibid., p. 39.

(23) Ibid.

(24) Ibid., p. 28-30.

(25) Ibid., p. 30.

Another experiment which documents the fact that length of pauses are jointly determined by the ratio size to come as well as by the ratio just completed was conducted by Findley.(26)

In this experiment, three different animals with a long fixed ratio history were used, a rat, a pigeon, and a monkey. The following procedure was followed. Under a single green light, three progressively increasing fixed ratios were programmed. Then the same 3 fixed ratios were programmed under a red light, but the ratios in the red light were in a decreasing order. The completion of each ratio produced reinforcement and the next requirement. Thus the third ratio in each sequence produced reinforcement, but at the same time changed the color and the sequence of ratios was reversed. The animals were allowed to stabilise. It was shown that the pauses prior to longer ratios were longer than the pauses prior to shorter ratios.

A final important experiment which documented the fact that the length of the ratio pause is not solely a function of the size of the previous ratio is also reported by Findley.(27)

In this experiment a monkey and a bird were used. The procedure was as follows. Three progressively increasing fixed ratios were programmed under a red light, the ratios were FR33, FR132, FR528, and three equal ratios FR132, FR132, FR132 were programmed under a green light. Each ratio, as in the previous experiment, produced reinforcement and requirements for the next ratio. The completion of the fixed ratio in

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(26) Findley, J.D. An experimental outline for building and exploring multi-operant behavior repertoires, J. exp. anal. Behav., 1962, 5, p. 132.

(27) Ibid.

each sequence, produced reinforcement, changed the color and sequence of the ratios. It was shown that the pauses after the equal ratios (FR132, FR132, FR132) were relatively uniform, whereas the pauses following FR132 in the red sequence were significantly longer.(28)

The explanation given to the above results is that post-reinforcement pauses are in fact determined by the preceding pattern of ratio runs, but after considerable training the animal has come to discriminate the schedule as a whole and that performance eventually is controlled by stimuli arising from the animal's own behavior.(29)

This conclusion is further supported by one of the findings of the following experiment. A pigeon was trained in a chain operant, whereby if no response was made for 5 seconds, the color of a key was changed from green to red, after which pecking the key in the red on a FR125 was reinforced and the FR condition was re-established for four successive FR125. With the completion of the fifth ratio, reinforcement was produced and the green light and conditions for the first operant were re-established. The bird was trained in this procedure until its behavior stabilized. Following this procedure the first part of the experiment was ended. In the second part of the experiment longer temporal contingencies under the green light were required, that is 16 minutes plus the 5 sec. of no responding were required. Results showed (1) that the pauses prior to a ratio run are shorter when longer temporal contingencies are required in the first operant, (2) under both conditions (that is whether the temporal requirements for the first operant were longer or shorter) the length of the

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(28) Ibid., p. 132.

(29) Ibid.

pauses increased with successive ratios of equal size. Since the ratios did not differ in size and since there was a gradual increase in pause length with successive ratios of the same size, such an effect was said to be due to the fact that the last ratio produced conditions for a temporal delay.(30) So a given pause is a function of both the ratio size that precedes it, and that one that follows it.

It seems that the length of the pause is a question of methodology, since it is possible, for example, to decrease the length of a long pause that normally follows a long ratio run by alternating the long fixed ratio with a very short ratio run. It was found, on a multiple operant FR3FR31, short pauses followed the FR31 component, thus indicating that the pause was less under the control of the FR31 that preceded than the FR3 that followed the pause.(31)

Post-reinforcement pauses, however, may also be a function of other variables such as motivation, delay of reinforcement etc. In an experiment conducted by Findley, a bird was accidentally run almost to satiation. The bird was run on the schedule previously described; FR33, 132, and 528 under a red light and FR132, 132, 132 under a green light. The third ratio in each sequence produced reinforcement, changed the light and the sequence as before. Under this condition the pauses prior to long run FR528 were extremely long.(32)

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(30) Findley, op.cit. pp. 131-134.

(31) Salman, M.A. Determinants of post-reinforcement pauses on fixed ratio schedules. Unpublished M.A. thesis, Amer. Univ. Beirut, 1962, p. 37.

(32) Findley, op.cit. p. 132.

In another experiment, under a three chain operant, when a bird was run to satiation, the performance could not be reliably described because of the infrequency of the behavior.(33)

In the following experiment, the effects of the degree of satiation was also studied. In this experiment a bird was put on FI2' and received 500 reinforcements during an 18 hour session. (60 reinforcements were enough to maintain the bird at its normal body weight.) Results showed that as satiation proceeds, the effect is a lengthening in the post-reinforcement pause.(34)

Sidman and Stebbins(35) investigated also the effect of partial liquid-satiation upon bar-pressing using fixed ratio schedules, with 4 rats, 2 cats and a monkey. The fixed ratio for the cats was 25:1 and for rats and monkey 20:1. Partial satiation was accomplished in one part of the experiment by simply continuing the ratio schedule on a given day until each subject had received all the liquid (water for rats, milk or sugar water for cats and monkey) he could drink.

Results showed that the principle change during the entire period of satiation was an increase in the length of post-reinforcement breaks, as the period progressed.

In the second part of the experiment 1 monkey and 2 rats were used, the ratios were the same and the satiation effect was studied by

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(33) Ibid., p. 136.

(34) Ferster, C.B., and Skinner, B.F. Schedules of reinforcement. New York: Appleton-Century-Crofts, 1957, p. 320.

(35) Sidman, M., and Stebbins, W.C. Satiation effects under fixed-ratio schedules of reinforcement, J. comp. physiol. Psychol., 1954, 47, pp. 114-116.

pre-feeding the animals. The rats had access to water bottles for ½ hour, and the monkey was pre-fed approximately 500 cc. of the sugar solution.

Results demonstrated that partial satiation showed its effect, solely as an earlier and more frequent appearance of post-reinforcement pauses.

It has also been reported that zero drive, when animals were fed and watered for ½ hour immediately before their daily experimental sessions, resulted in a decrease in overall, but not in local rates of responding.(36)

All these studies suggest that there is a relationship between degree of drive (motivation) and pause length.

The present study is an attempt to investigate the effects of motivation on pause length during mixed schedules of reinforcement.

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(36) Haroz, M.M. Some effects of drive changes on local and overall responding reinforced by different sucrose solutions. Unpublished M.A. thesis, Amer. Univ. Beirut, 1962, p. 114.

CHAPTER II

Method

Subjects.

The subjects used in the present experiment were eight rats of local stock. Six of them, numbered K-1, K-2, K-3, K-4, K-5 and K-6 were males. The animals, numbered K-7 and K-8 were females. The animals, numbered K-1, K-2, K-3 and K-4 had been on a mixed FRFR schedule in a previous experiment for at least 58 experimental sessions. A period of 33 days elapsed between the cessation of the previous experiment and the use of these rats in the present experiment.

Four animals numbered K-5, K-6, K-7 and K-8 were naive (not used in experimental work prior to this experiment). The four naive rats were 221 days old at the beginning of the experiment and the other four rats were 193 days old when they were brought for use in this experiment.

Apparatus.

The experimental apparatus consisted of a Grason-Stadler 2-bar "Skinner-box". The animal chamber was 9.25 in. wide, 11.5 in. long and 7.5 in. high. The front wall of the box, which served also as a door, was made of clear plastic, the floor consisted of rods that ran parallel to the long end of the chamber and were placed $\frac{1}{2}$ in. apart measured from center to center.

The experimental box was equipped with 2 bars, a dipper mechanism for the delivery of reinforcement, and 3 lights. Each one of the bars was 2 in. in length and was activated by a force of about 22

grams. The bars protruded from one wall of the animal chamber 3 in. above floor level of the compartment, separated from each other by 1 3/8 in. end to end. In the present experiment reinforcement was produced by responses on the left bar and was provided through an opening to the reinforcement magazine, located below the two bars and centered between them. The second bar had no function. Bar pressing responses were recorded on a cumulative recorder, placed outside the experimental room. The number of reinforcements each subject received in each experimental session was also counted. Post-reinforcement pause measures after FR15 and FR45 were taken independently on 2 electronic timers, measuring in 1/100 minutes.

The dipper lay in a magazine, outside the Skinner-box and when activated was automatically raised to deliver .1 cc. of the reinforcing substance for a period of 3 sec. The reinforcing substance consisted of either water, or sucrose solution, 12% by weight sugar in tap water.

The box was dimly illuminated by a 6 watt light, situated in the upper right corner, on the outer part of the front wall of the chamber. A black screen placed between the glass wall and the light served to reduce the intensity of the light.

The Skinner box was enclosed in a large ventilated, sound reducing chamber with a single round one way observation window on its frontwall, situated about 4 in. from floor level, so that the animal could be observed during experimentation.

Habituation, feeding schedule and daily routine.

Prior to their use in the present experiment, rats K-1, K-2, K-3 and K-4 were placed on food and water rhythm for a period of eight

days, that is they were deprived of food and water for 23½ hours and were fed and watered for ½ hour of a 24 hour period.

The four naive subjects were handled and kept on hunger and thirst 23½ deprivation schedule, designated H.T. 23½. That is they were deprived of food and water for 23½ hours and were fed and watered ½ hour of a 24 hour period, for a period of 16 days before the beginning of the present experiment.

All subjects in this experiment were run on a hunger-thirst deprivation schedule designated H.T. 23, that is they were deprived of food and water for 23 hours of a 24 hour period and were given access to water bottles and were fed 6 or 8 grams of food depending on their body weight for ½ hour after the daily experimental sessions. All animals were maintained at 80-90% of their free-feeding weight.

The daily routine was as follows: Each animal, before it was due into the experimental box, was weighed. The experimental sessions, except for very few occasions, lasted for a period of 30 minutes. At the end of each session every subject was taken to the waiting cage where it was fed and watered for ½ hour before being shifted to its home cage.

Procedure.

In this study two experiments were performed. The nature of the experiments was exploratory, in the sense that whenever results raised formal questions and suggested changes in methodology to bring more of the animals behavior under experimental control, it was this activity which was mainly followed.

1. Experiment I (Main experiment).

The 8 animals were divided into 2 equal groups. In the first

group the animals with previous experience on mixed FRFR were included; the second group consisted of the four naive rats. The experiment was designed to answer the main question posed in this thesis, and the general procedure adopted consisted of the following:

a) Reinforcing the animals of Group I on mixed alternating FR15 FR45, under the deprivation schedule H.T. 23 and changing the reinforcing agent.

b) With 12 per cent sucrose solution as reinforcer, the motivational level of the subjects was decreased. The animals were provided with varying amounts of pre-feeding with the reinforcing substance employed. (Each animal was individually placed, just before the start of the sessions, in the experimental box, where it was pre-fed a given amount of the reinforcing agent.)

The experiment was repeated with the second group to confirm the results of the first experiment.

2. Experiment II.

This experiment was programmed to investigate more complex aspects of the organisms behavior. The special procedure adopted was to change for both groups the components of the mixed alternating FR15FR45 under the drive level adopted and with the reinforcing agent employed, and observe whether the organisms paused consistently before the different ratios.

Following is in detail the general procedure adopted, in the main experiment I, as described separately for each one of the groups, and the special procedures followed in the subsequent experiment II, for both groups, with supplementary tables.

1. General procedure (Main experiment I).

All animals in group I had been exposed to mixed FRFR schedule for a period of 58 experimental sessions, prior to this experiment. The general procedure consisted of 4 phases.

Phase 1. Animals K-1, K-2 and K-4 were reinforced on mixed alternating FR15FR45, for 15 daily, ½ hour experimental sessions with 12% sucrose concentration. Animal K-3, had great difficulty in holding the schedule. Records demonstrated that its performance was not likely to be maintained with further exposure to this schedule, so the animal was given reinforcement on a short FR, which was slowly increased in size. Following 7 sessions of gradual increase in the ratio, the animal on the 8th session was placed immediately on FR15FR45. The subject adjusted to this change quickly and in the following 7 sessions demonstrated that the mixed schedule was held well. For all 4 animals, pause measures were taken after the 9th session and the median pauses after the short and long runs were computed separately. The median pauses did not reveal any marked and consistent differences, so it was decided to change the reinforcing substance from 12% sucrose concentration to water.

Phase II. In Phase II, all four subjects were maintained on the same schedule mixed alternating FR15FR45, while tap water was used as the reinforcing agent. The animals were reinforced under these conditions for 15, ½ hour sessions, except animal K-1, which was reinforced only for 14 experimental sessions in this phase. The overall performance of all 4 animals was very poor and as records demonstrated that their performance was not likely to change with further exposure to water as reinforcing agent, it was decided to change the reinforcing substance. An inspection of the records showed that during the previous sessions, in Phase I,

some long pauses followed reinforcement particularly late in each session. Such pauses indicate that pauses may be developed earlier in the session by decreasing the motivational level of the animal.

Phase III. The animals were reinforced, for 8 experimental sessions, on 12% sucrose concentration as reinforcing agent, while 2 cc. pre-feeding was introduced, as explained above. The values of the schedule remained the same.

Phase IV. In the present phase the animals were run for 7, ½ hour sessions, under the same ratio contingencies, but were pre-fed 4 cc. of 12% sucrose solution in the experimental chamber at the beginning of each session.

In all four Phases post-reinforcement measures were taken after short and long ratios and means were computed separately.

A summary is given in Table I of all these changes in drive level, reinforcement agent, schedule and number of sessions for animals in Group I.

Table I

Changes in schedule, drive level and reinforcement agent

Changes in schedule	Drive level	Subjects	Reinforcement agent	Number of sessions
FR15FR45	H.T. 23	1,2,4	12% Sucrose	15
Shaping	"	3	"	7
FR15FR45	"	3	"	8
"	"	2,3,4	Water	15
"	"	1	"	14
"	2 cc. Pre-feeding	1,2,3,4	12% Sucrose	8
"	4 cc. Pre-feeding	1,2,3,4	"	7

Animals K-2, K-3, and K-4 were used in the present experiment for a total of 45 experimental sessions. Animal K-1 was used in this experiment for a total of 44 experimental sessions.

The animals in the second group (group II) had no previous training on operant conditioning, so as a preliminary to this experiment, they were shaped to bar press for 12% sucrose concentration in the Skinner box. After continuous reinforcement, the subjects were given reinforcement on a short fixed ratio schedule which was gradually increased in size, until in five sessions, schedule FR15 was reached.

Phase I. The animals were reinforced for 7 daily, ½ hour sessions on FR15. Post-reinforcement pause measures were taken for all seven sessions and the mean pauses after odd and even reinforcements were computed separately.

Phase II. The schedule for all animals was changed to mixed alternating FR15FR45. The animals were run under these intermittent reinforcement contingencies for 10 daily sessions.

Phase III. Throughout, this phase, the schedule remained mixed, FR15FR45, but the animals were pre-fed with 4 cc. 12% sucrose concentration. The animals were reinforced, in Phase III, for 7, ½ hour experimental sessions, except animal K-8 who was run on this phase for 6 sessions.

Phase IV. Reinforcement was scheduled on FR15FR45 with 6 cc. pre-feeding of the reinforcement substance for all four animals of Group II. The animals were run on this phase for 3 experimental sessions.

In all four phases post-reinforcement pause measures were taken and means after short and long runs were calculated separately.

Animals K-5, K-6 and K-7 were used in this experiment for a total of 27 sessions. Animal K-8 was used for a total of 26 sessions.

Table II demonstrates changes in schedule, drive level, reinforcement agent, and number of sessions for animals in Group II.

Table II

Changes in schedule, drive level with 12% sucrose

Changes in schedule	Drive level	Subjects	Reinforcement agent	Number of sessions
FR15	H.T. 23	5,6,7,8	12% sucrose	7
FR15FR45	"	"	"	10
"	4 cc. pre-feeding	5,6,7	"	7
"	"	8	"	6
"	6 cc. pre-feeding	5,6,7,8	"	3

2. Special procedures (subsidiary experiment II).

In this experiment, the subjects of both groups were run on various mixed ratio schedules.

a) Complex mixed ratio. Subjects K-1 and K-2 were reinforced in the complex mixed ratio FR15FR45FR15FR5, with 12% sucrose as reinforcing substance with 4 cc. pre-feeding for 27 experimental sessions over a period of 31 days.

Subjects K-3 and K-4 were run under the mixed schedule FR15 FR45FR15FR135. Animal K-4 was maintained in this schedule for a period of 27, ½ hour experimental sessions, while K-3 was run under these conditions for a period of 25 sessions, over a period of 31 days.

Throughout this period the animals remained under the drive level adopted, that is 23 hours food and water deprivation and 4 cc. pre-feeding of 12% sucrose solution.

b) Simple mixed ratios. For subjects K-5 and K-6, the reinforcement density was decreased. The first component of the mixed ratio

FR15FR45 was changed to FR25, and the animals were reinforced on mixed FR25FR45.

For subject K-5 reinforcement was scheduled on mixed FR25FR45 for 29 sessions, over a period of 30 experimental sessions, while 6 cc. pre-feeding was maintained.

K-6 was run on FR25FR45 contingencies for 11, ½ hour experimental sessions, over a period of 12 days and the mean pauses after the short and long runs were computed separately. On the 11th session the schedule was changed to mixed FR35FR45 and maintained for 18 experimental sessions.

For animals K-7 and K-8 the reinforcement density was increased. The values of the schedule were reduced to mixed FR5FR15, while 6 cc. pre-feeding was maintained. In the following 29 sessions, animal K-7 was run under this procedure, while K-8 was run for 28 experimental sessions under this procedure over a period of 30 days. This ended the subsidiary experiment.

Animals K-5, K-6, K-7 were run for the subsidiary experiment for 29 sessions, and K-8 for 28 experimental sessions, over a period of 30 days.

Mean pauses after short and long runs were calculated separately for the various ratios.

In Table III are summarized changes in schedule, drive level, reinforcement agent and number of sessions for animals in Group I and II in the subsidiary experiment.

Table III

Changes in schedule and drive level with 12% sucrose reinforcement

Changes in schedule	Drive level	Subjects	Reinforcement agent	Number of sessions
FR15FR45FR15FR5	4 cc. pre-feeding	1,2	12% sucrose	27
FR15FR45FR15FR135	"	3	"	25
"	"	4	"	27
FR25FR45	6 cc. pre-feeding	5	"	29
"	"	6	"	11
FR35FR45	"	6	"	18
FR5FR15	"	7	"	29
"	"	8	"	28

In the next chapter III, results will be reported for experiment I. In chapter IV, the results of experiment II will be reported.

CHAPTER III

Results

Experiment I

Results of this experiment will be presented from findings in the final session before each procedural change. In addition the daily means of the pauses after the respective ratios used in the mixed schedules, and the cumulative records of these pauses on certain daily sessions are reported.

Figures 1-4 show in four phases the daily mean post-reinforcement pauses after FR15 and FR45 produced by subjects K1-4 respectively. In these figures the 58 experimental sessions the subjects received prior to the present experiment, and the 9 sessions of retraining to mixed alternating FR15FR45 are excluded.

The four phases show the procedural changes during the experiment. Phase I "no pre-feeding" shows the average post-reinforcement pauses under the reinforcement conditions with which the subjects were retrained to alternating mix FR15FR45. Phase II, "water" presents the mean post-reinforcement pauses under the reinforcement change from 12% sucrose to water, and in the case of all subjects, pauses after reinforcements became longer and more variable on the average, from day to day. Finally Phases III and IV present the mean post-reinforcement pauses under the drive level change from H.T. 23 "no pre-feeding" to 2 cc. and 4 cc. pre-feeding respectively. During both these phases average pauses after FR15 are almost invariably longer and less stable than those after FR45.

It is clear from these figures that as the amount of pre-feeding increases pauses following short runs (FR15) come to exceed those after

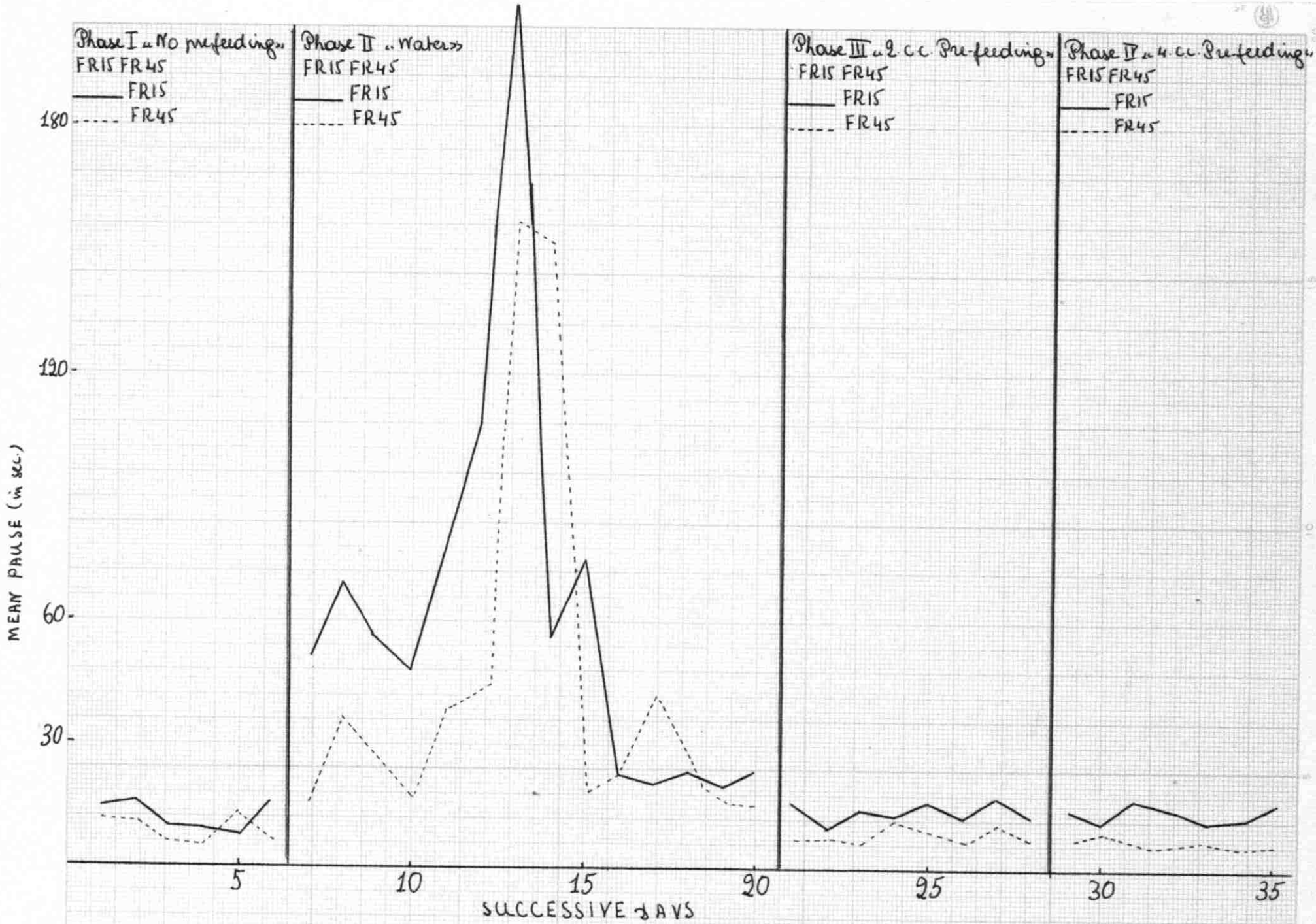

FIG. 1. Daily mean post reinforcement pauses produced by S. K-1

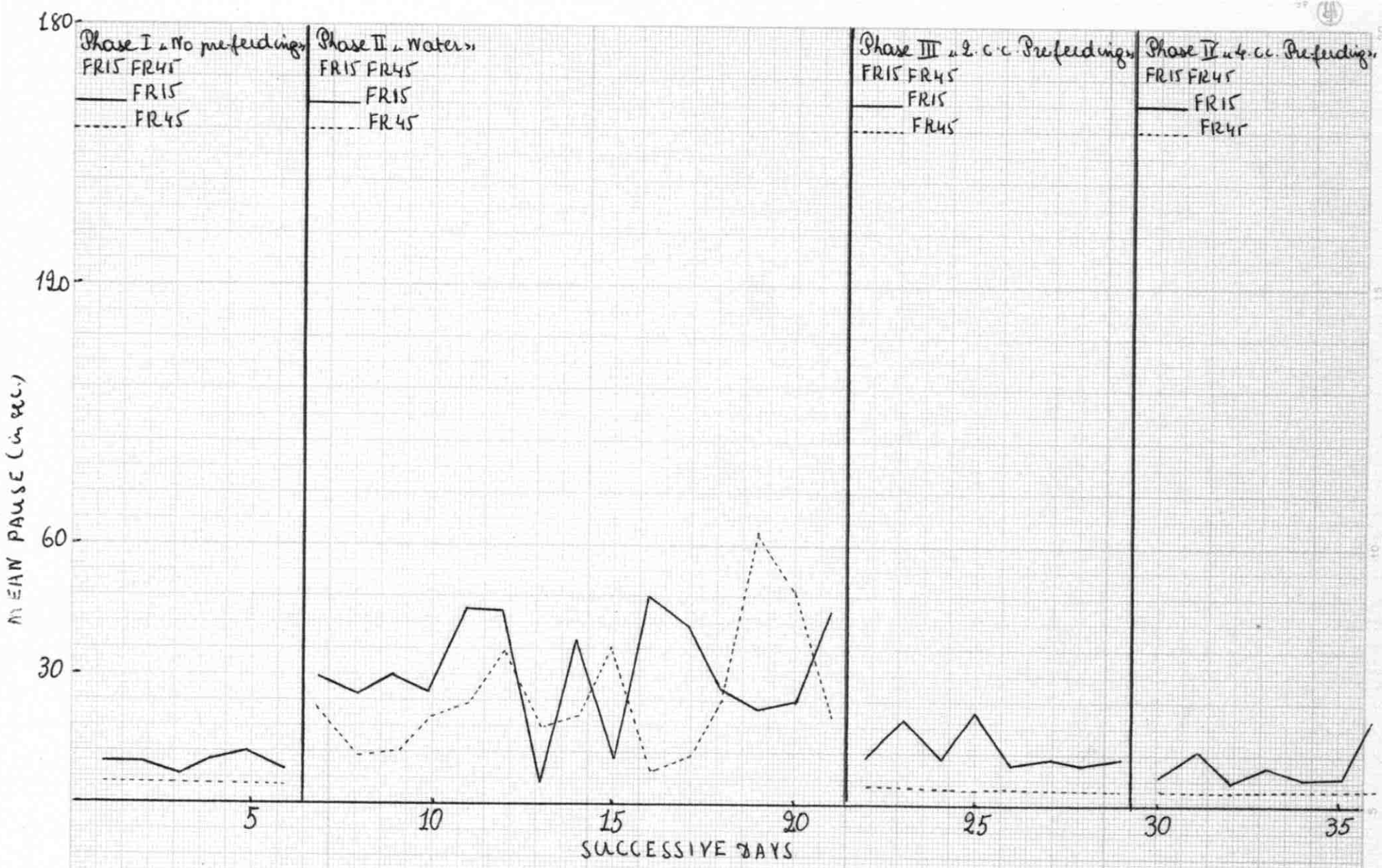

FIG. 2. Daily mean post-reinforcement pauses produced by S. K-2.

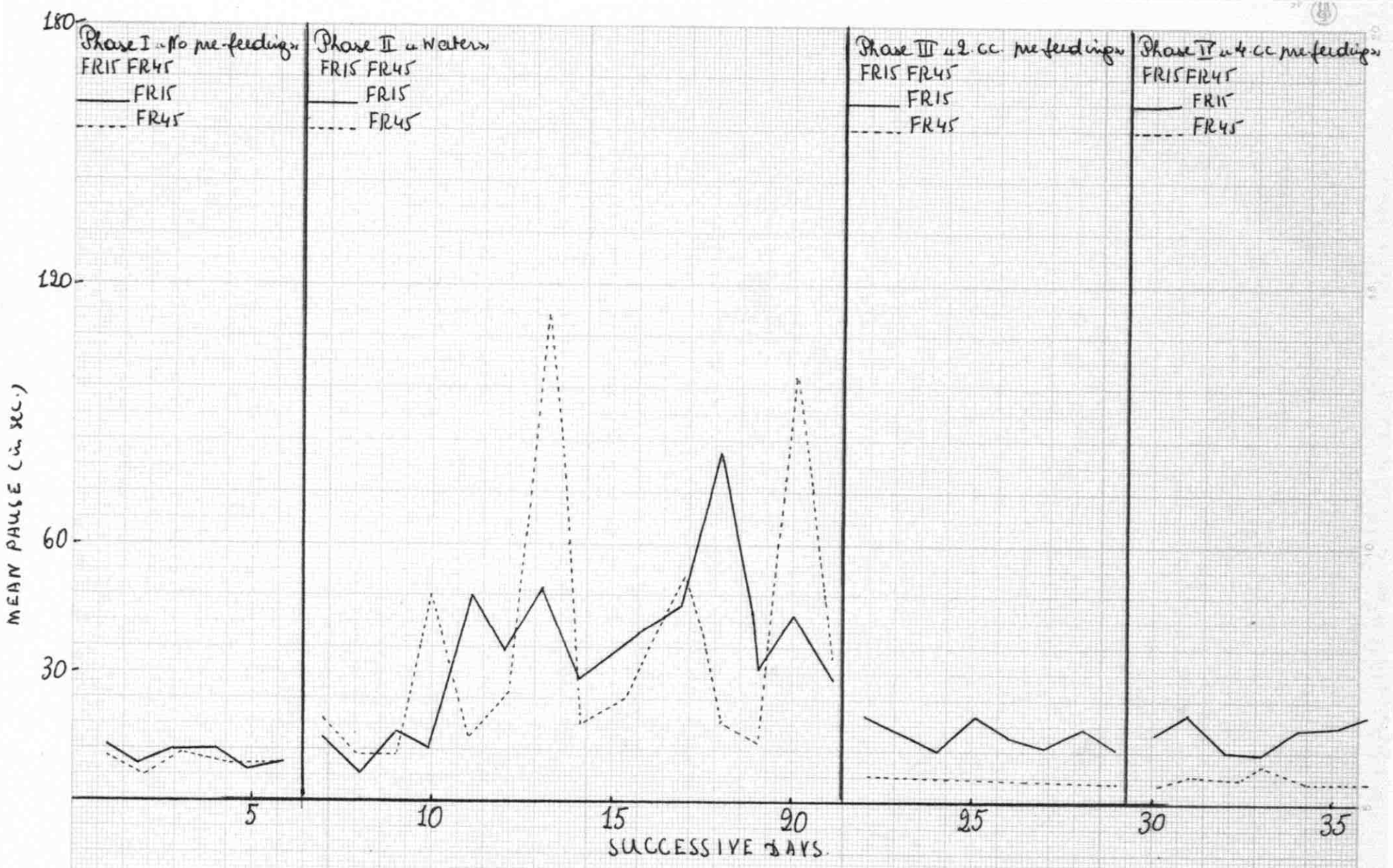

FIG. 3. Daily mean post-reinforcement pauses produced by S. K-3.

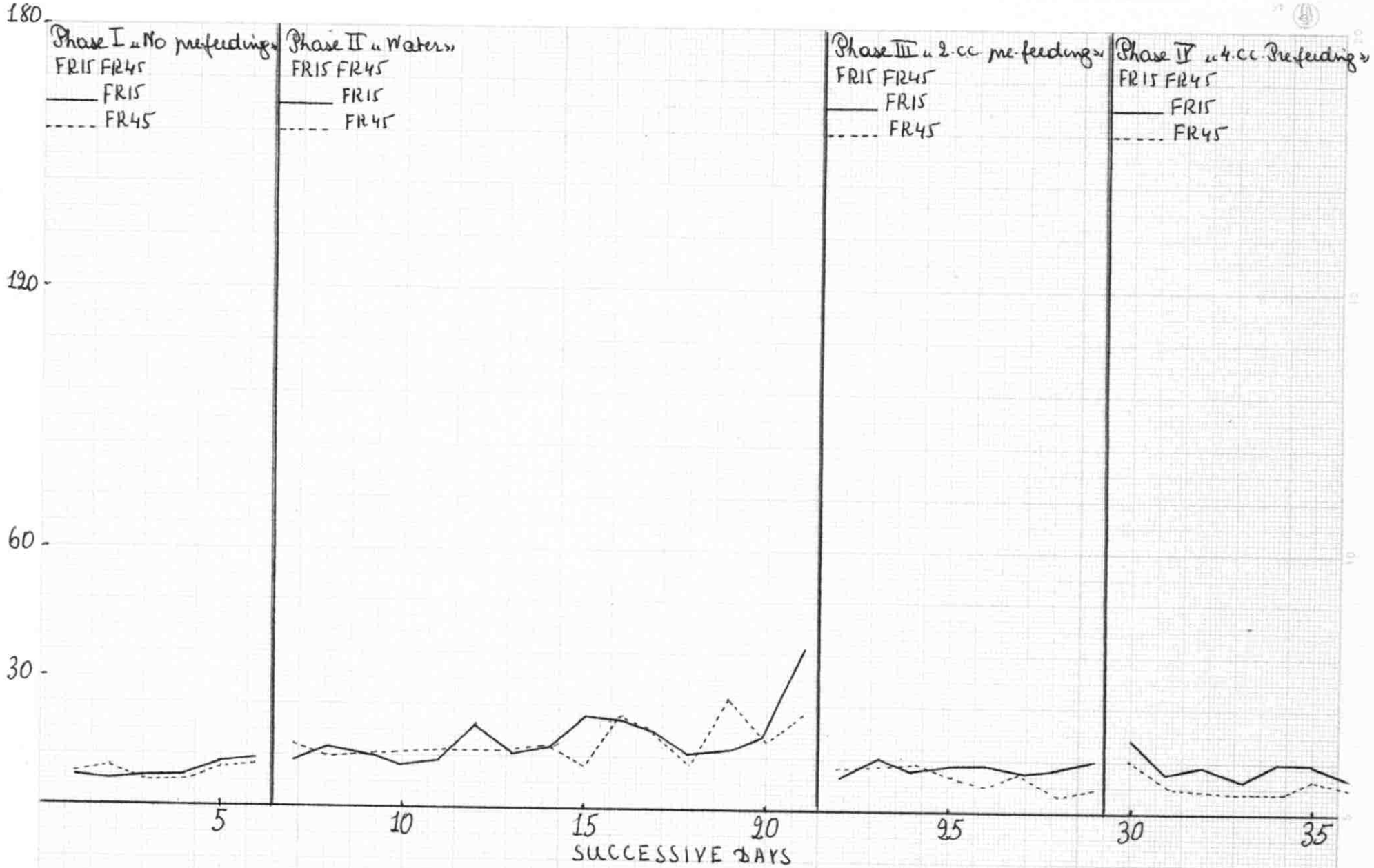

FIG. 4. Daily mean post-reinforcement pauses of S. K-4.

long runs (FR45), although mean differences are not large. The within session development of the pauses however, differ depending on the motivational level of the subjects.

Phase I "no pre-feeding".

Figure 5 shows the last session on mixed alternating FR15FR45 with 12% sucrose concentration as the reinforcing agent, under H.T. 23 for animal K-1. After 15 sessions of no pre-feeding separation between the respective cumulative curves of pauses after FR15 and FR45 occured after 36 reinforcements. The mean number of reinforcements received by this animal was 85.6.

The final session, under this regime, for animal K-2 is presented in Figure 6. As can be seen curve separation occured after 88 reinforcements. The mean number of reinforcements produced by K-2 was 91.1.

Results for K-3 and K-4 are similar. As can be seen from Figures 7 and 8 respectively for these animals, there is no separation of the two post-reinforcement pause curves. Subject K-3 produced mean reinforcements 83.6 and subject K-4 received 80.0 reinforcements on the average throughout this period.

Phase II "water reinforcement".

Under water reinforcement the performance of all 4 animals deteriorated and is characterized by few runs and irregular pausing.

Figure 1 (phase II) shows the average post-reinforcement pauses after short runs (FR15) and long runs (FR45) produced by K-1 under the water reinforcement on successive experimental sessions. The subject did not respond uniformly throughout the intervals between reinforcements, but paused after reinforcements for a long period of time. There

FIG. 5 Cumulative records of post-reinforcement pauses of the last session on alternating mix FR15 FR45 with «no pre-feedings» of S. K-1.

The solid line shows pause length after FR15
The dotted line shows pause length after FR45

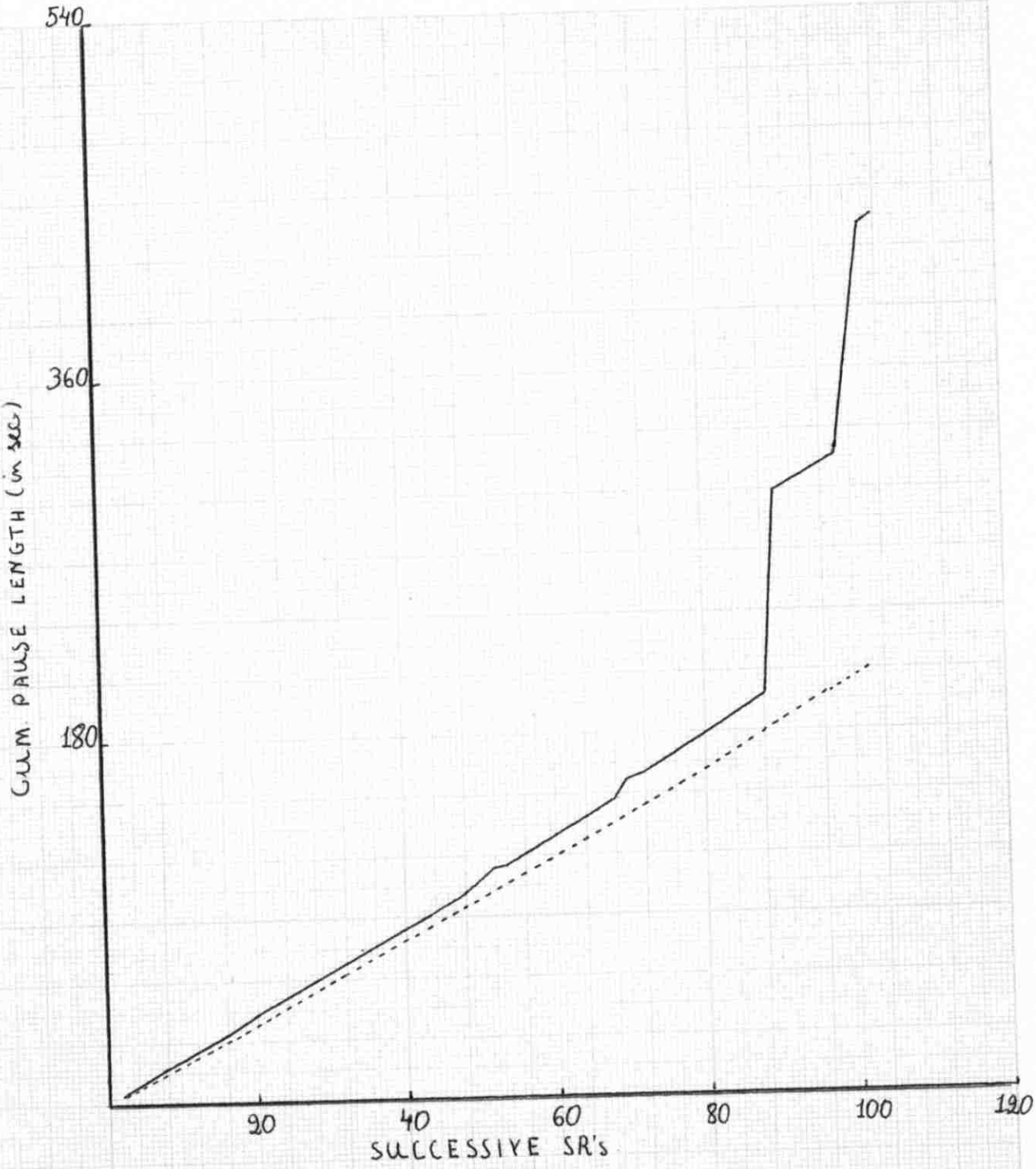

FIG. 6. Cumulative record of post-reinforcement pause length of the last session on alternating mix FR15 FR45 with a no pre-feeding of S. K-2.

The solid line shows pause length after FR15

The dotted line shows pause length after FR45

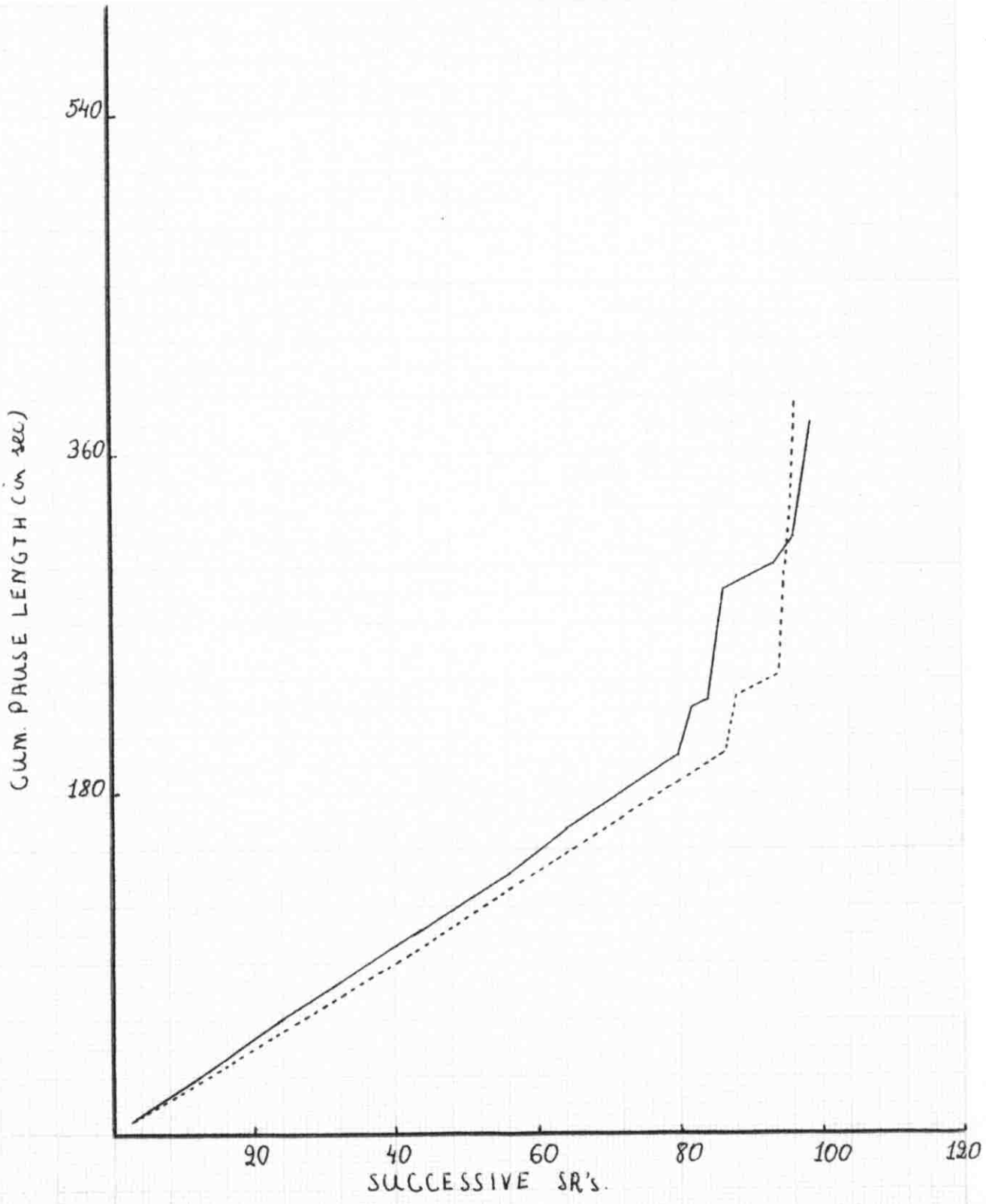

FIG. 7. Cumulative record of post-reinforcement pause length of the last session on alternating mix FR15 FR45 with «no pre-feeding» of S. K-3.

The solid line shows pause length after FR15
The dotted line shows pause length after FR45

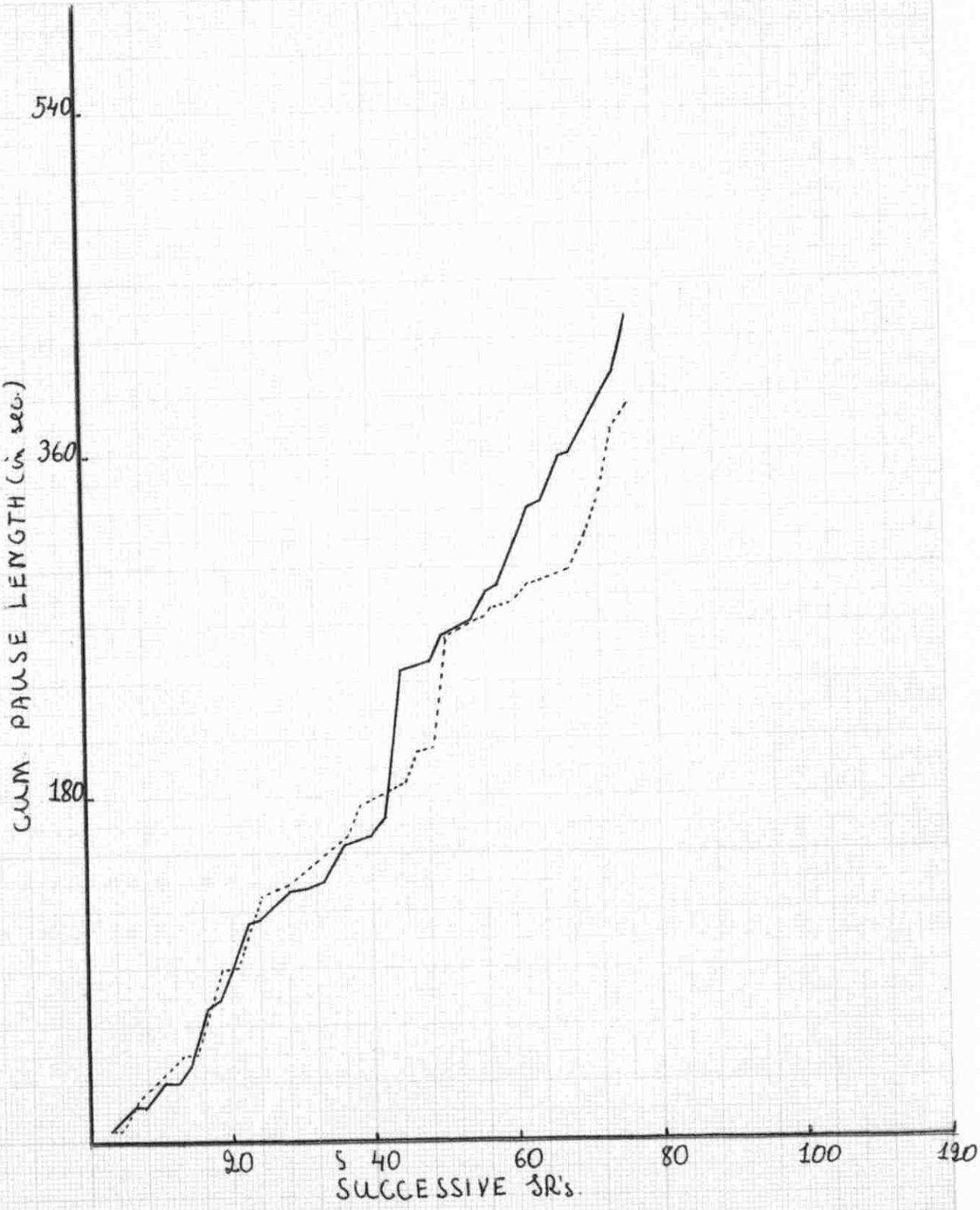

FIG. 8. Cumulative record of post-reinforcement pause length of the last session on alternating mix FR15 FR45 with no pre-feeding of S. K-4.
The solid line shows pause length after FR15
The dotted line shows pause length after FR45

is separation of the two mean pause curves for the first 6 sessions but during the latter sessions the two curves overlap a great deal. The mean number of reinforcements per sessions received by this subject decreased from 85.6 with sucrose reinforcement to 11.2 reinforcements with water as reinforcer.

The records for subjects K-2, K-3, and K-4 are similar to those of subject K-1 although the pause length periods of subjects K-2, and K-4 are typically shorter than those of subject K-3. This can be seen in Figures 2, 3 and 4 respectively in phase II marked "water", for all three animals.

Cumulative pause records of the last sessions under this regime, for subjects K-1-4 are shown in Figures 9, 10, 11, and 12 respectively. For all four subjects there is no separation of the curves with little responding produced.

The reinforcement change from 12% sucrose to water, therefore, for subjects K-1-4, did not lead to consistent differential pausing after the respective ratio runs. Since in the previous phase I all subjects produced considerable pausing particularly towards the end of the session (subjects K-1 and K-2), it was hypothesized that if separation of the two curves is due to motivation, the less motivated the subject the sooner the separation.

In the following 2 phases, the drive level of the subjects was changed from one of no pre-feeding to 2 cc. and 4 cc. pre-feeding of 12% sucrose solution superimposed upon a 23 hours food and water deprivation.

Phase III "2 cc. pre-feeding".

Figure 13 shows cumulative records of post-reinforcement pauses after FR15FR45 during the last session under this regime. Separation of

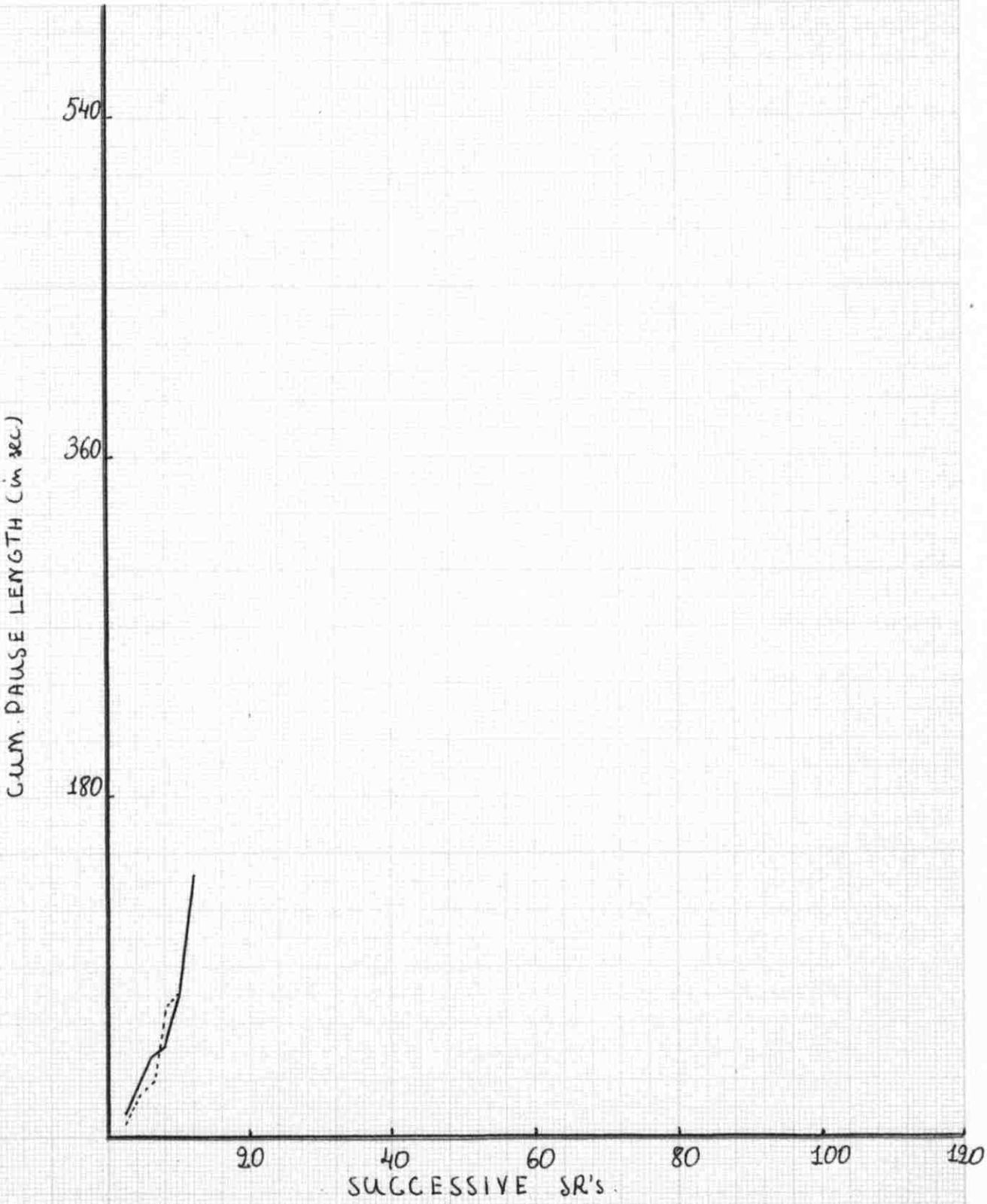

FIG. 9. Cumulative record of post-reinforcement pause length of the last session on alternating mix FR15FR45 under «water» reinforcement of S. K-1.

The solid line shows pause length after FR15
The dotted line shows pause length after FR45

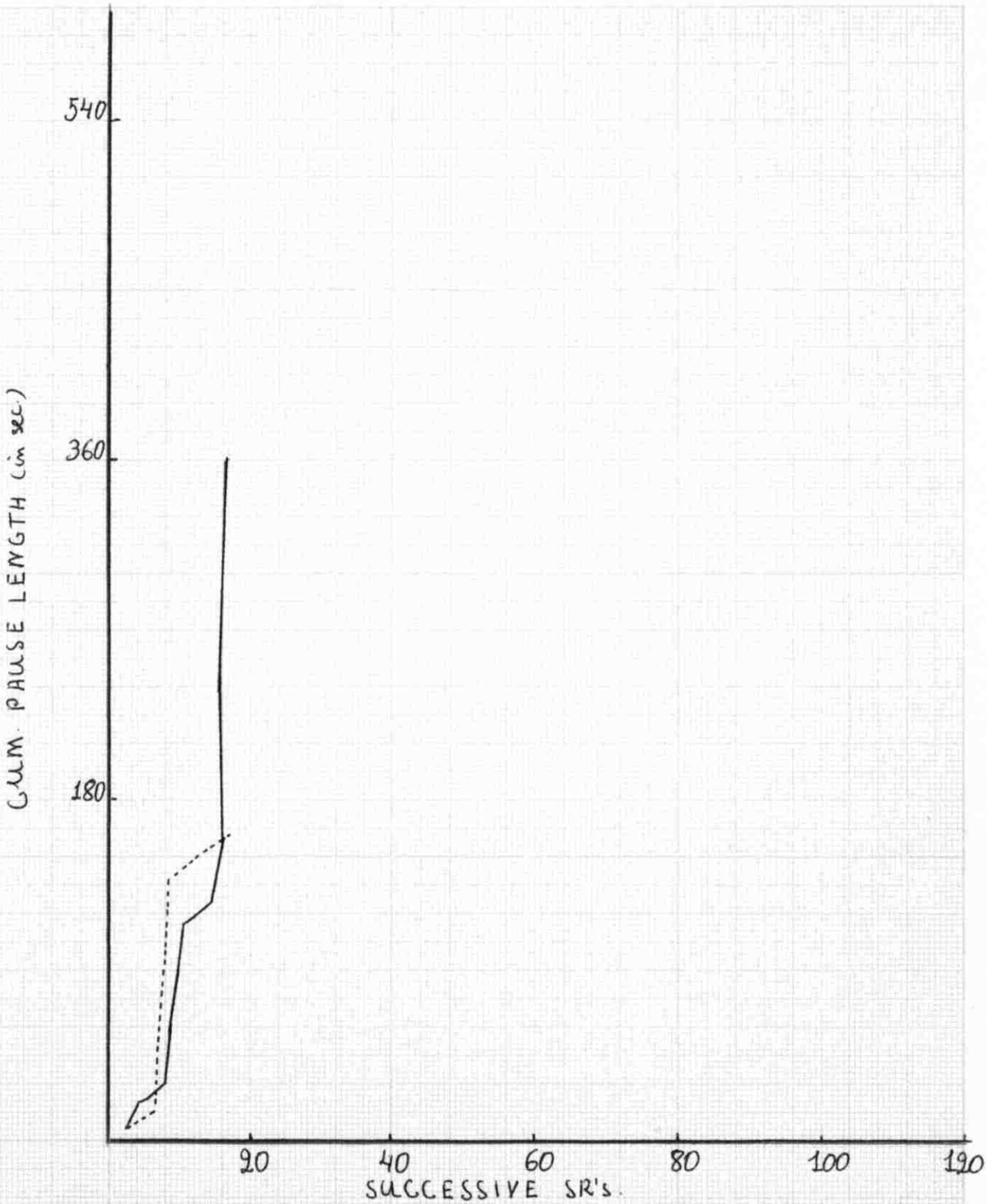

FIG. 10 Cumulative record of post-reinforcement pause length of the last session on alternating mix FR15 FR45 under «water» reinforcement of S. K-20.
The solid line shows pause length after FR15
The dotted line shows pause length after FR45.

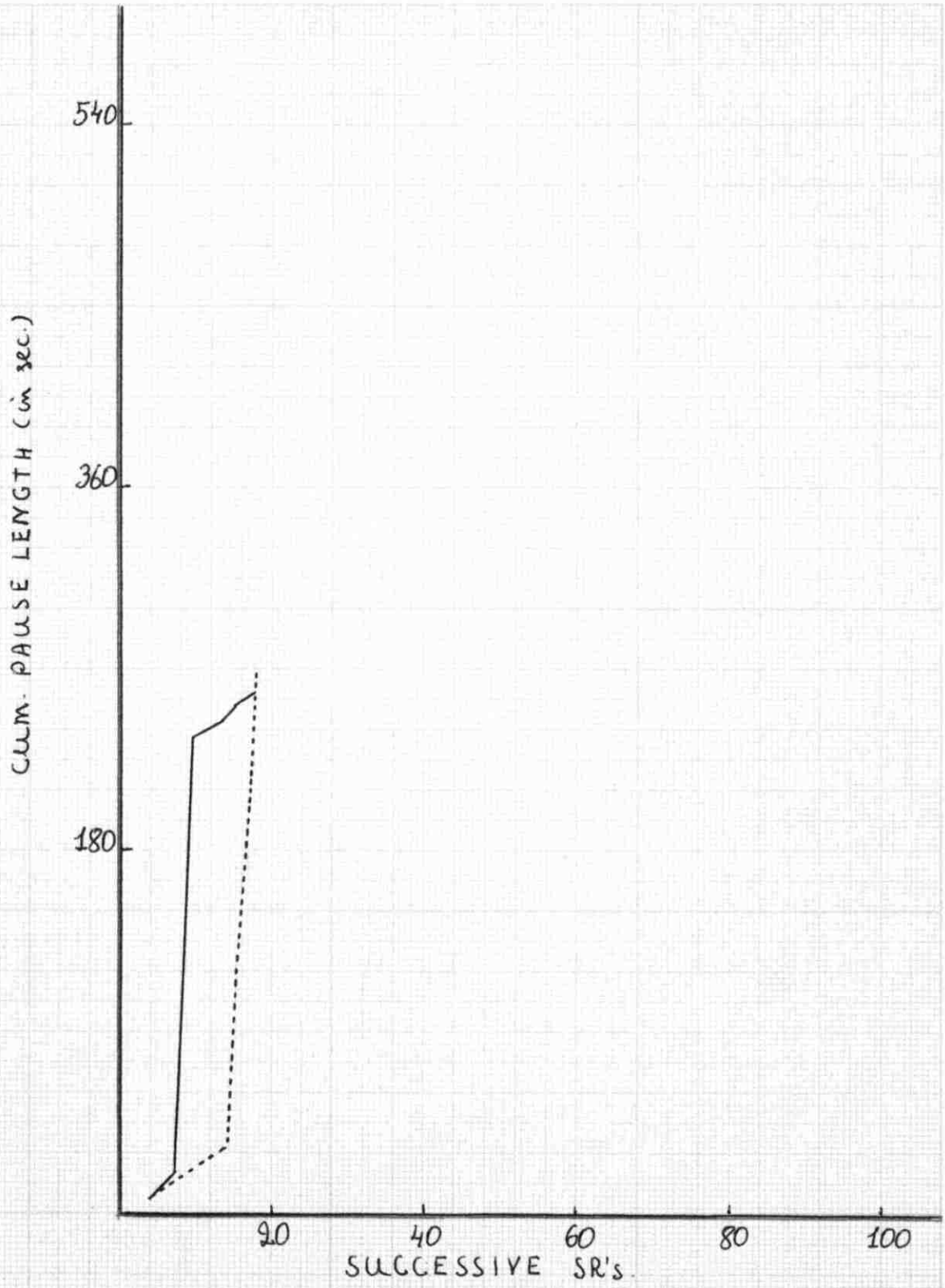

FIG. 11. Cumulative record of post-reinforcement pause length of the last session on alternating mix FR15 FR45 under a "water" reinforcement of S. K-3.
The solid line shows pause length after FR15
The dotted line shows pause length after FR45.

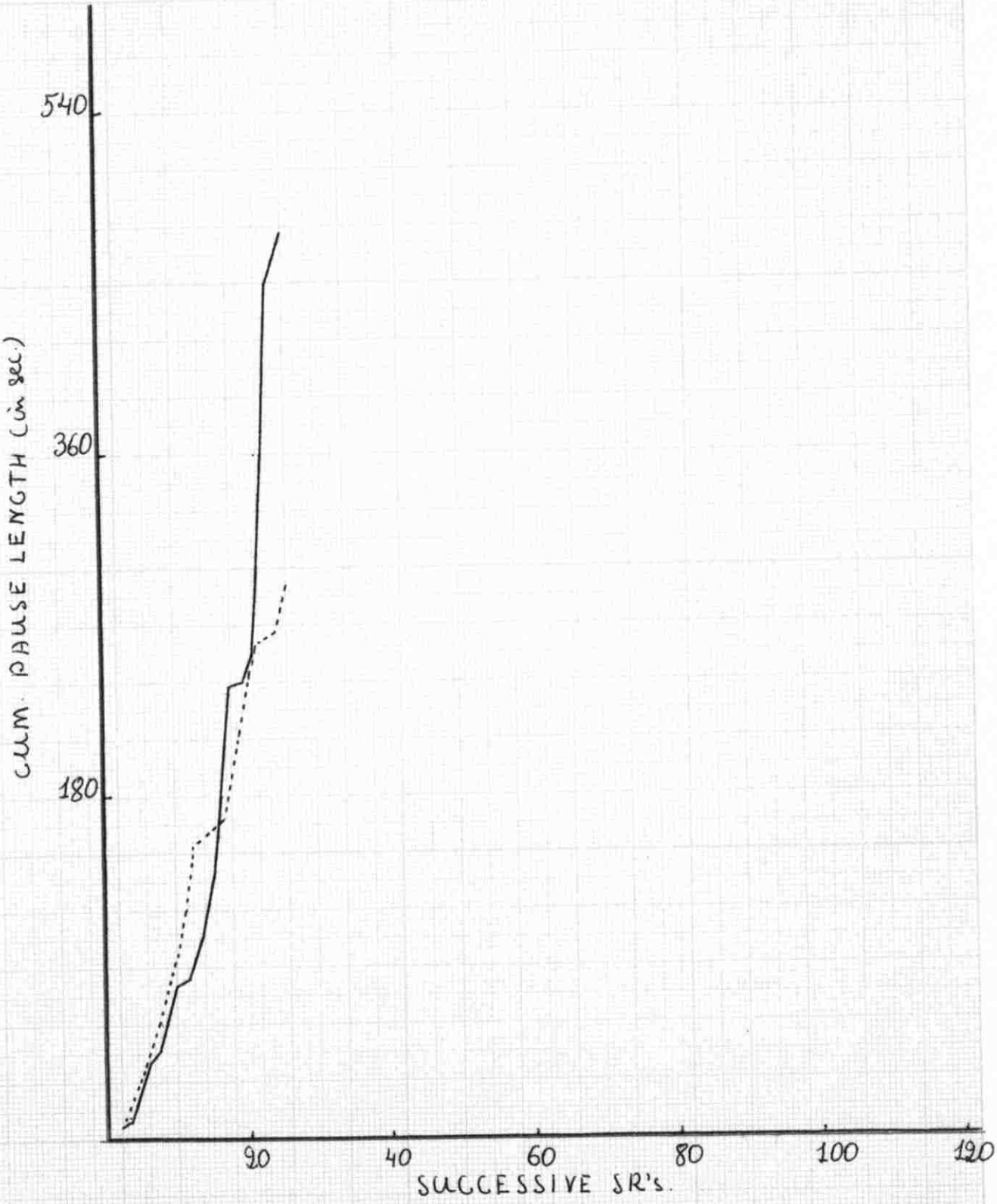

FIG. 12. Cumulative record of post-reinforcement pause length of the last session on alternating mix FR15FR45 under waterss reinforcement of S. K-4.

The solid line shows pause length after FR15
The dotted line shows pause length after FR45.

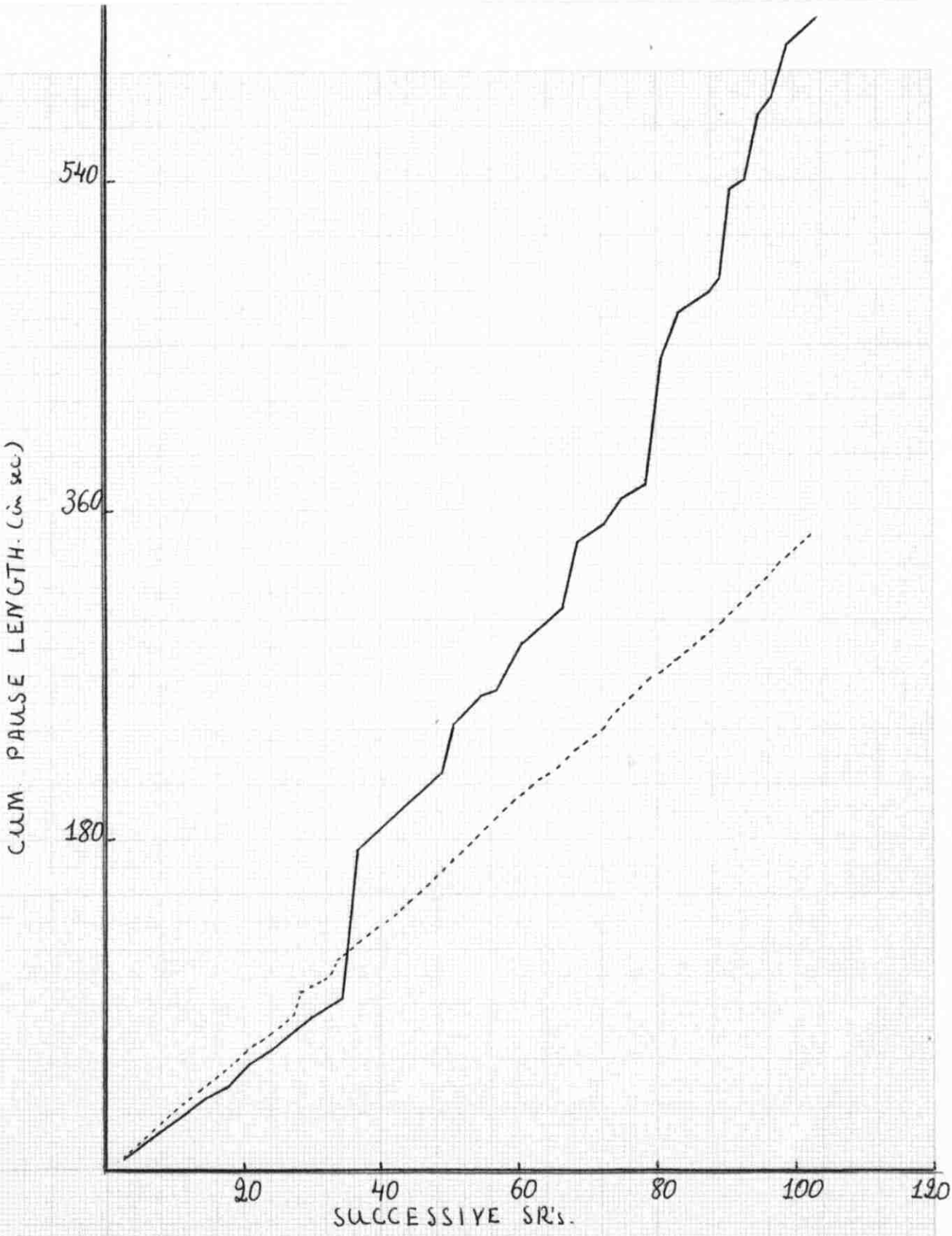

FIG. 13. Cumulative record of post-reinforcement pause length of the last session on alternating mix FR15 FR45 with «2. c.c. pre-feedings» of S. K-1

The solid line shows pause after FR15
The dotted line shows pause after FR45.

the two curves occured after 36 reinforcements. The record is characterized by constant pauses after FR45, and lengthening of pauses after FR15 (before FR45) throughout the session, for animal K-1.

Figures 14, 15, and 16 show post-reinforcement pauses in the last session under 2 cc. pre-feeding for animals K-2, 3 and 4 respectively. Note that separation of the two curves occured after 72 reinforcements for subject K-2, 60 reinforcements for animal K-3 and 58 reinforcements for subject K-4.

The records of all three animals are characterized by relatively constant pauses after FR45.

Phase IV "4 cc. pre-feeding".

With increasing pre-feeding subject K-1 did not show any earlier separation of the two cumulative pause curves. Figure 17 shows that separation occured after 40 reinforcements.

Separation of the two curves occured earlier with more pre-feeding for subjects K-2, 3 and 4.

Figure 18 shows the last session under this regime for subject K-2. As can be seen separation occured after 52 reinforcements, while for subject K-3 separation occured after 32 reinforcements and for subject K-4 after 24 reinforcements. Figures19 and 20 present the last session in 4 cc. pre-feeding for subjects 3 and 4 respectively.

The records of all four subjects are characterized by relatively constant pausing after FR45.

In general we can conclude from these findings that there is a systematic effect, in the development of post-reinforcement pauses, with changing drive from "no pre-feeding" H.T. 23, to 2 cc. and 4 cc. of 12% sucrose pre-feeding with the same deprivation schedule.

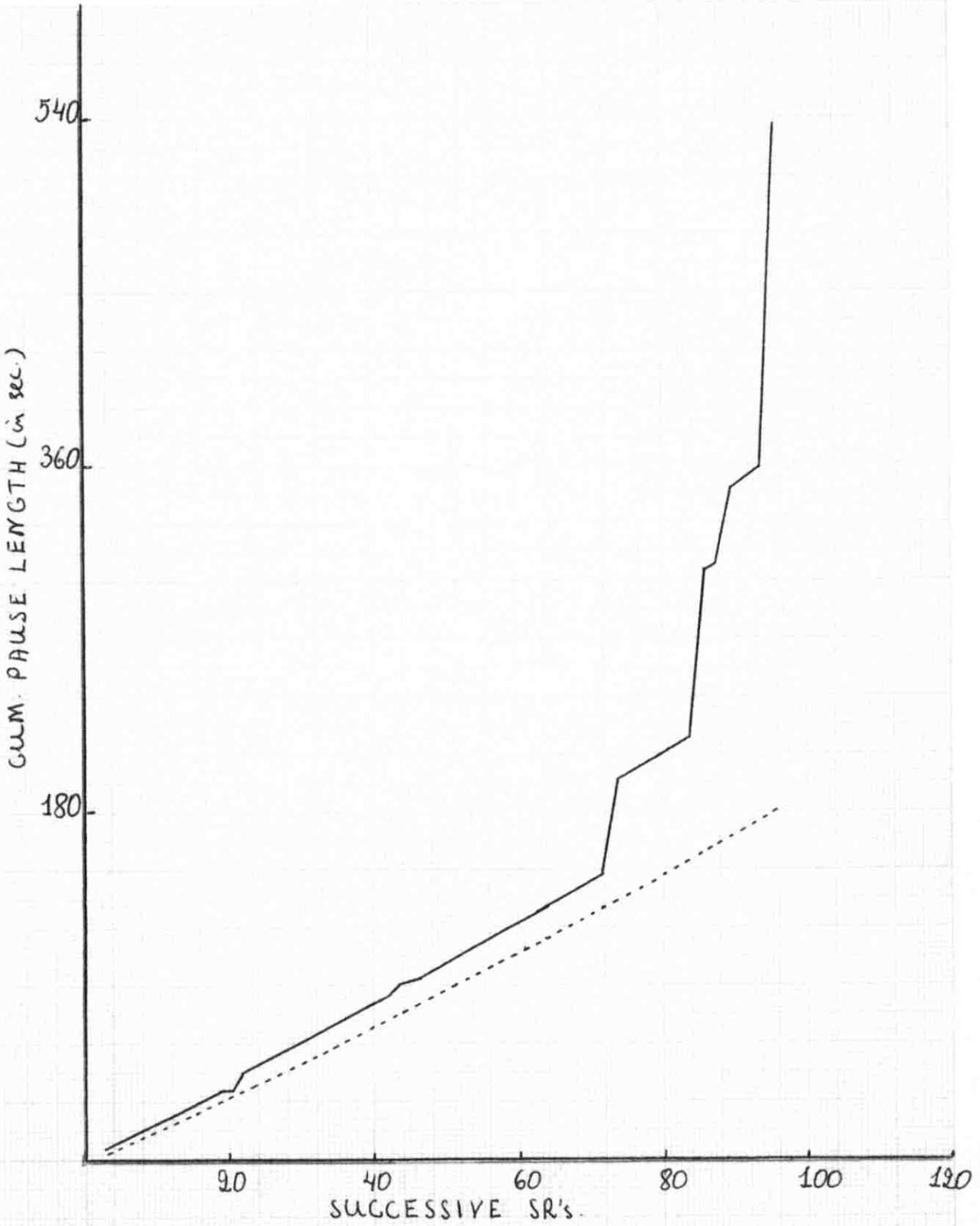

FIG. 14. Cumulative record of post-reinforcement pause length of the last session on alternating mix FR15 FR45 with "2 c.c. pre-feedings" of 3 K-2.

The solid line shows pause length after FR15
The dotted line shows pause length after FR45.

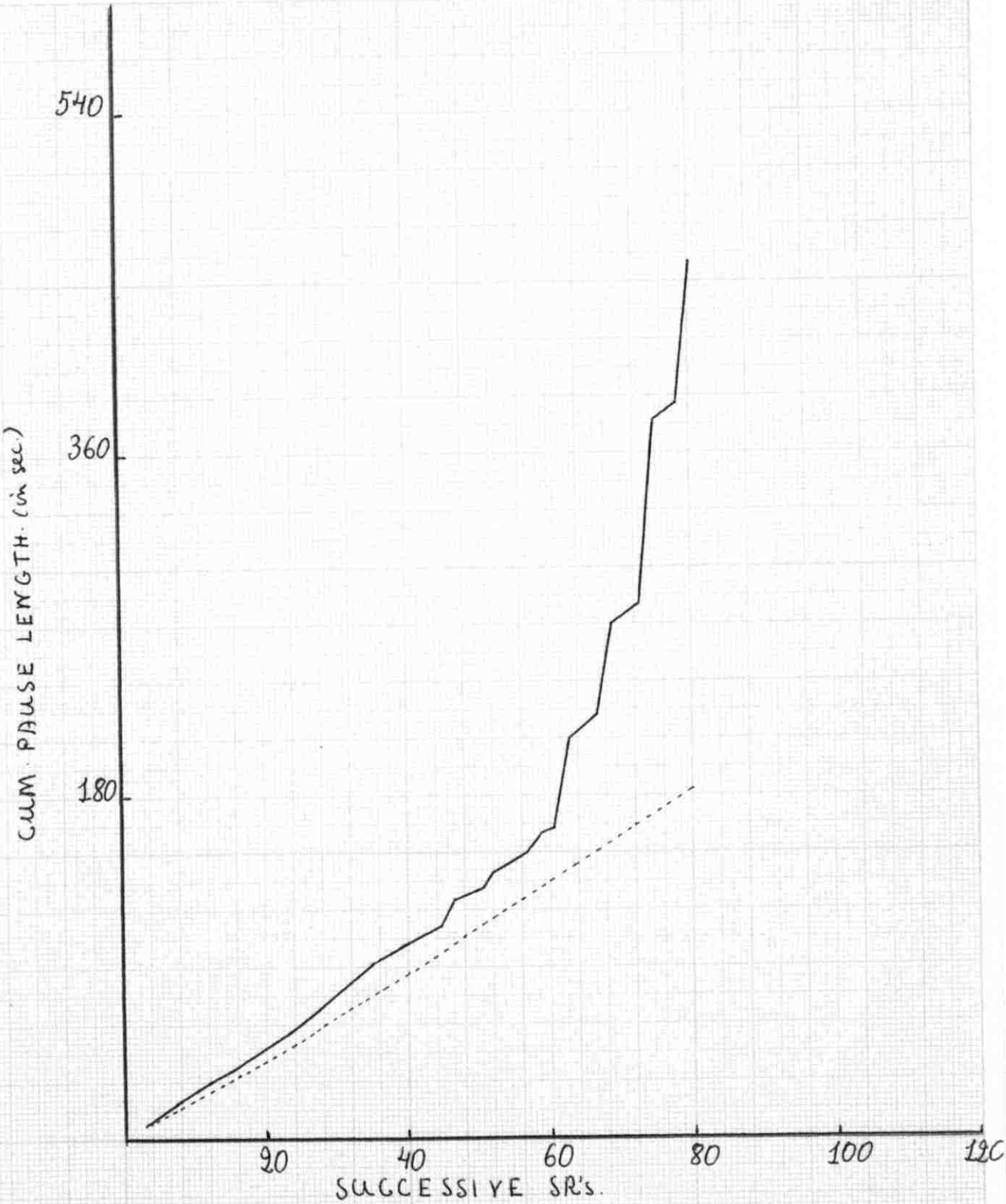

FIG. 15 Cumulative record of post-reinforcement pause length of the last session on alternating mix FR15 FR45 with ± 2 cc. pre-feedings of S. K-3.

The solid line shows pause length after FR15
The dotted line shows pause length after FR45

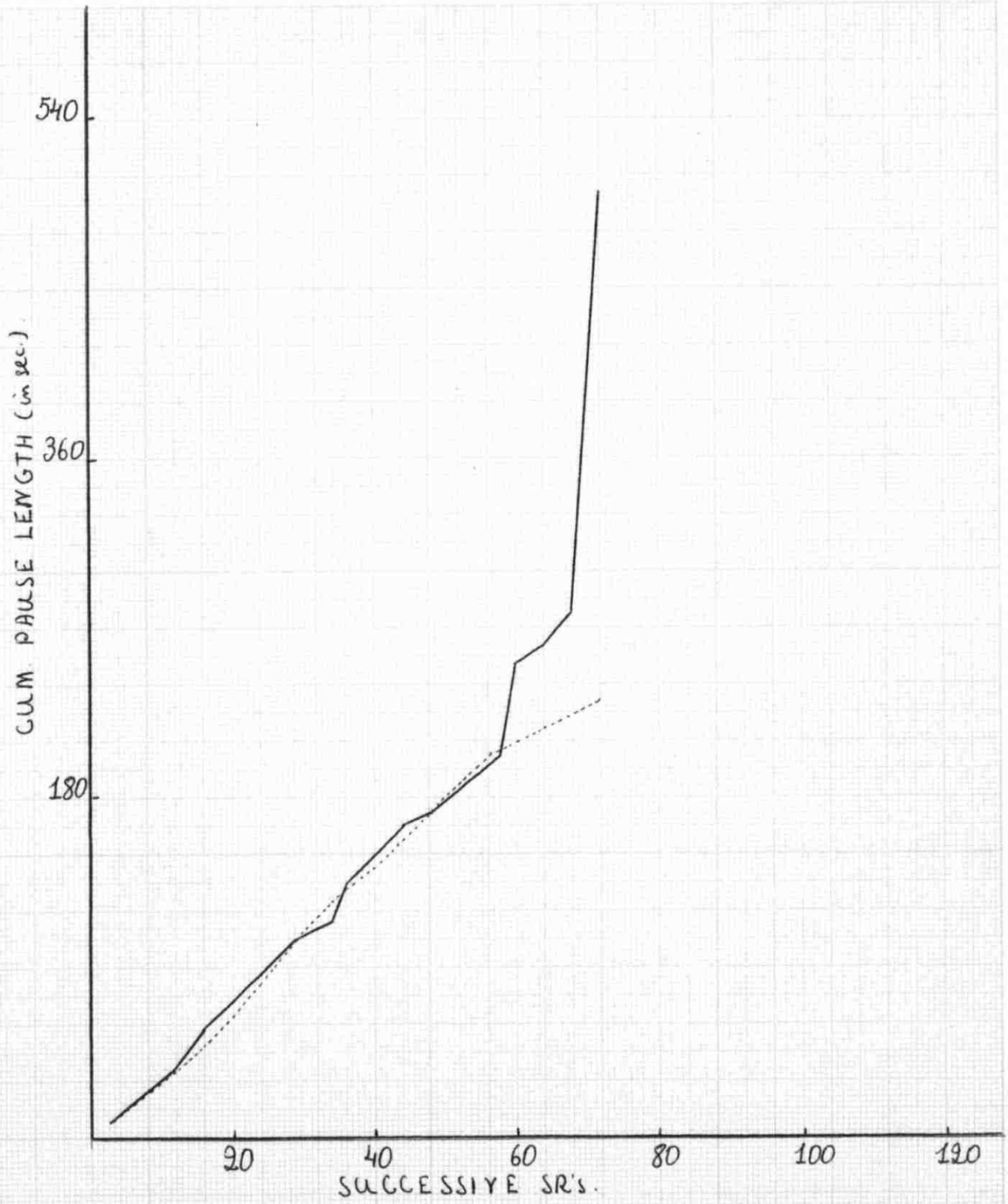

FIG. 16. Cumulative record of post-reinforcement length of the last session on alternating mix FR15 FR45 with « 2 Cc. pre-feedings » of S. K-4.

The solid line shows pause length after FR15
The dotted line shows pause length after FR45.

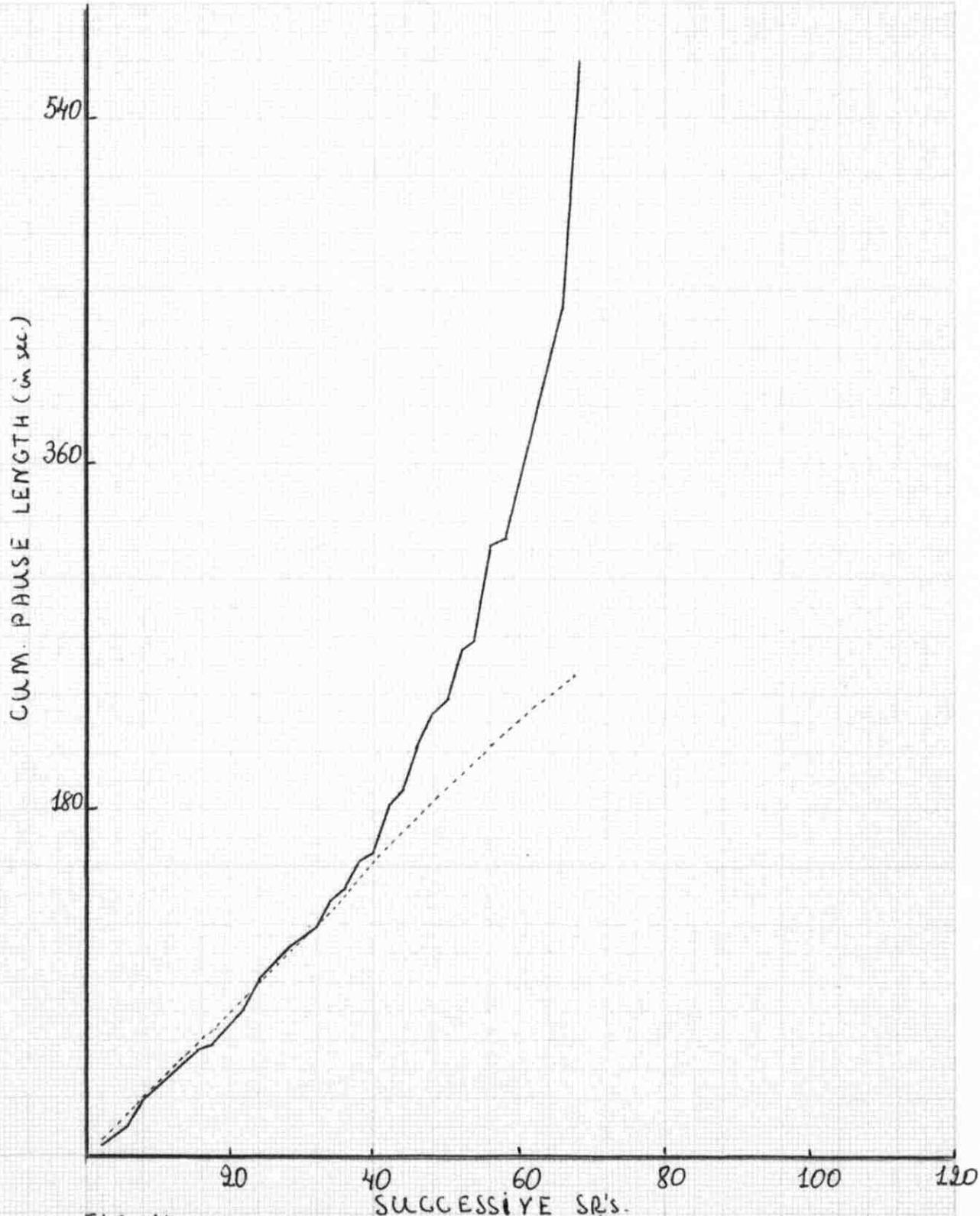

FIG. 17. Cumulative record of post-reinforcement pause length of the last session on alternating mix. FR15 FR45 with „4 c.c. prefeedings" of S. K-1.

The solid line shows pause length after FR15

The dotted line shows pause length after FR45.

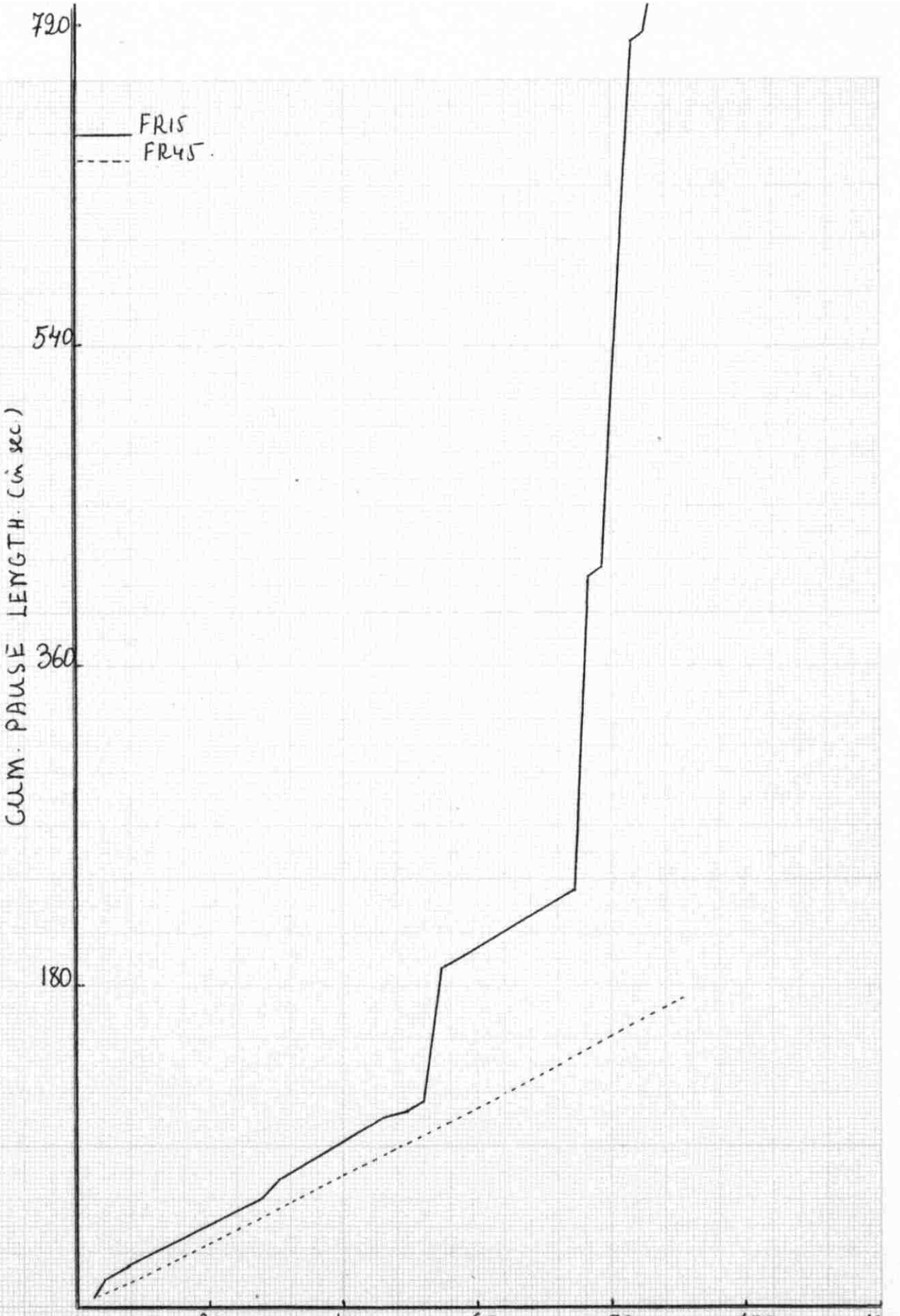

FIG 18. Cumulative record of post-reinforcement pause of the last session on alternating mix FR15 FR45 with «4 cc pre-feeding» of K-2.

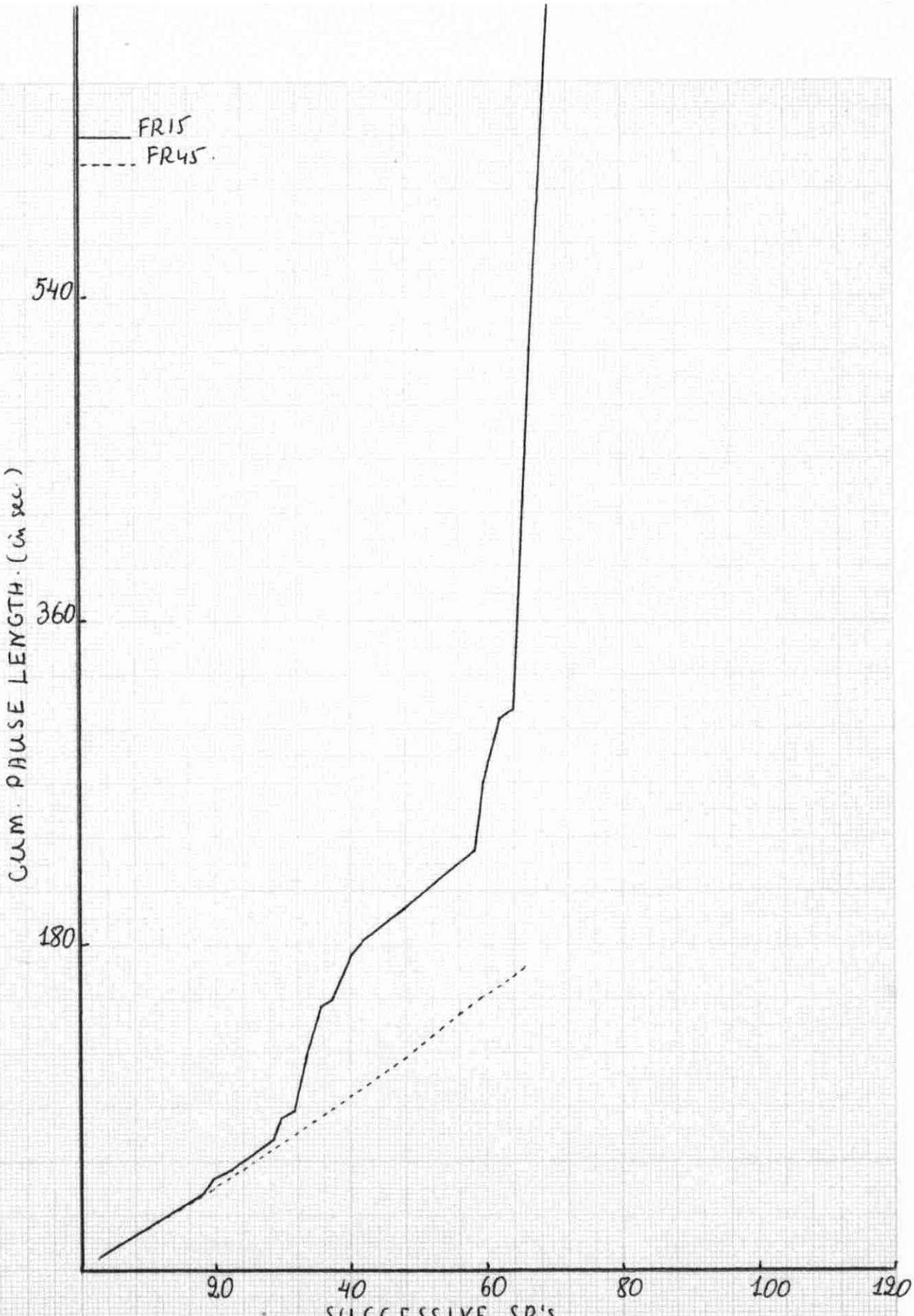

FIG. 19. cumulative record of post-reinforcement pause length of the last session on alternating mix. FR15FR45 with 4 cc. pre-feedings of S. R-3.

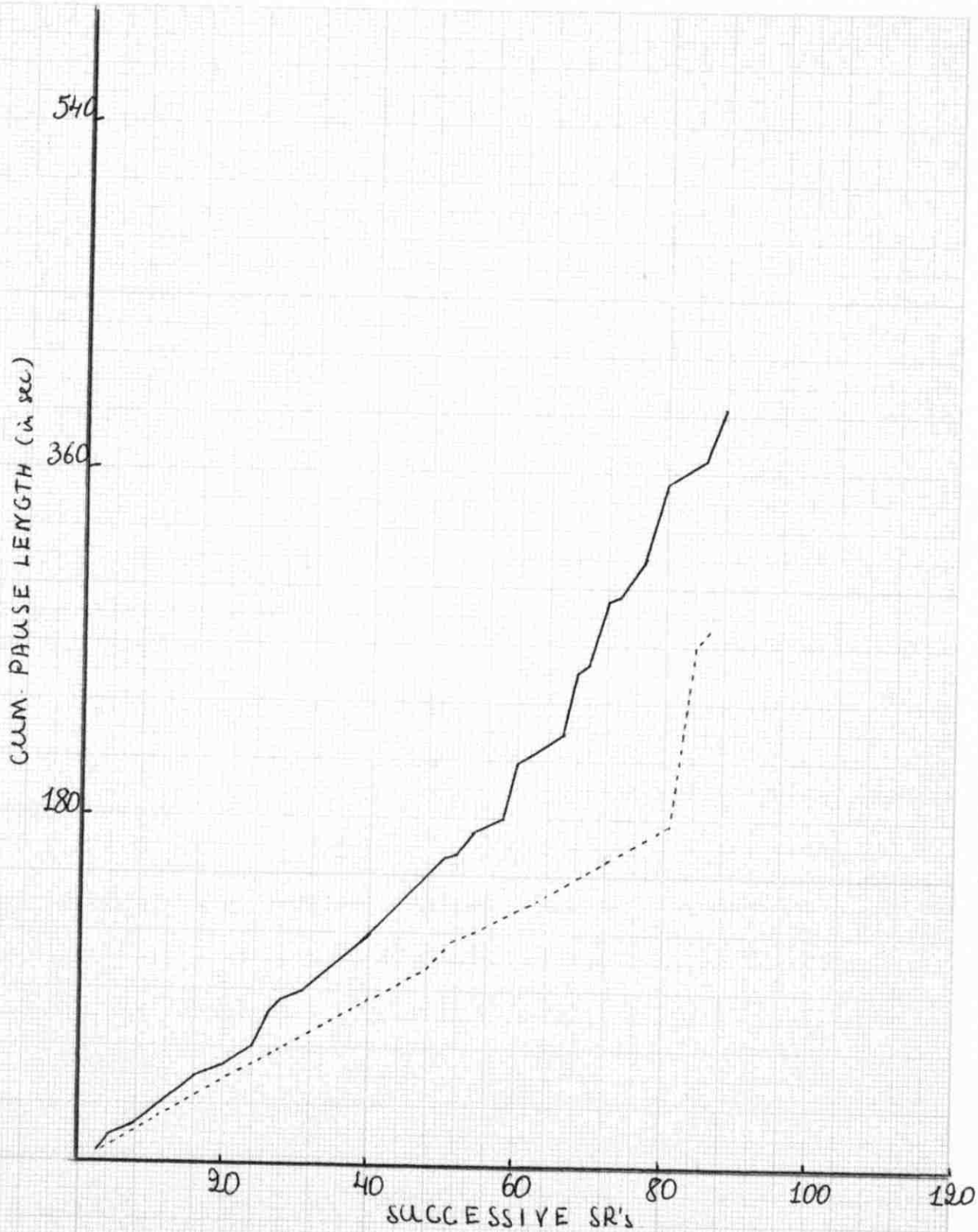

FIG. 20 Cumulative record of post-reinforcement pause length of the last session on alternating mix. FR15 FR45 with ~4 c.c. pre-feedings of 3. K-4.

The solid line shows pause length after FR 15
The dotted line shows pause length after FR 45.

For all four subjects pauses after FR45 are relatively constant during a session. In the case of K-1, the two cumulative pause curves do not show earlier separation with more pre-feeding.

Records of the subjects, K-2, K-3, and K-4, however; show that post-reinforcement pauses after FR15 become longer during the session, and that with increasing pre-feeding the lengthening occurs earlier.

The most clear example is the case of K-2. In phase I with no pre-feeding the two cumulative curves separate after the animal had received 88 reinforcements, the separation of the two curves occuring earlier with more pre-feeding. With 2 cc. pre-feeding the curves separated after 72 reinforcements while with 4 cc. pre-feeding, separation occured after 52 reinforcements. Records of K-3 and K-4 parallel to those of K-2.

So the development of post-reinforcement pauses is affected by increasing pre-feeding - with more pre-feeding longer pauses occur earlier within a session, but only when they precede the longer of the two ratios.

The mean length of the pauses, of the final three sessions, before each procedural change show small difference with different amounts of pre-feeding, but there are indications that pauses after FR15 increase with more pre-feeding, while those after FR45 decrease slightly.

Animal K-1 pauses for a relatively shorter period after zero pre-feeding, and the same after 2 cc. and 4 cc. pre-feeding. The average pause over the three last sessions after FR15 without pre-feeding is 1.08 sec., with 2 cc. pre-feeding 1.39 sec. and with 4 cc. pre-feeding 1.39 sec., while the mean pause after long runs in the three last sessions is .96 sec., without pre-feeding, .84 sec. with 2 cc. pre-feeding and .72 sec. with 4 cc. pre-feeding.

The mean length of the pauses for animal K-2 shows that pauses after FR15 increase with 2 cc. pre-feeding, but with more pre-feeding the mean pause decreases; with 0 cc. pre-feeding the mean pause is .99 sec., with 2 cc. pre-feeding is 1.02 sec. and with 4 cc. pre-feeding .75 sec.

Pauses after FR45 decrease with decreasing drive from zero to 2 cc. pre-feeding but with 4 cc. pre-feeding pauses remain constant. The mean pause after zero, 2 cc. and 4 cc. pre-feeding is .42 sec., .39 sec., and .39 sec. respectively.

K-3's mean length of the pauses after FR15 increase with increasing pre-feeding. The mean pauses after FR15 are .79 sec., 1.39 sec., 1.84 sec. after zero, 2 cc. and 4 cc. pre-feeding respectively. The mean pause after FR45, as in the case of K-2, decreases with decreasing drive from zero to 2 cc. pre-feeding, but with 4 cc. pre-feeding pauses after FR45 remain the same. The mean pause after zero, 2 cc. and 4 cc. pre-feeding is .85 sec., .51 sec., .51 sec. respectively.

The mean length of the pauses for animal K-4 shows that pauses after FR45 segment decrease with decreasing drive. The mean pauses after FR45 are .85 sec., .71 sec., and .65 sec. respectively, while pauses after FR15 increase with 2 cc. pre-feeding from .98 sec. to 1.08 sec. with 0 cc. and 2 cc. pre-feeding respectively, with 4 cc. pre-feeding after FR15 decrease to .65 sec.

Means for the whole group I show a slight tendency for pauses after FR15 to increase with more pre-feeding, while pauses after FR45 decrease slightly. The means after FR15 are .96 sec., 1.22 sec., 1.26 sec., with 0 cc., 2 cc. and 4 cc. pre-feeding respectively. After FR45 mean post-reinforcement pauses are .77 without pre-feeding, .61 with 2 cc. pre-

feeding and .57 with 4 cc. pre-feeding.

Data of average pauses over the final 3 sessions under the different experimental conditions are summarized in Table 4.

Table IV

Pre-feeding	0 cc.		2 cc.		4 cc.	
Ratio-components	FR15	FR45	FR15	FR45	FR15	FR45
K-1	1.08	.96	1.39	.84	1.39	.72
K-2	.99	.42	1.02	.39	.75	.39
K-3	.79	.85	1.39	.51	1.84	.51
K-4	.98	.85	1.08	.71	1.05	.65
Means	.96	.77	1.22	.61	1.26	.57

Table IV: Mean post-reinforcement pauses, in seconds, made by subjects K1-4 after the FR15 and FR45 segments of the mixed schedule FR15 FR45 over the final 3 sessions of o cc., 2 cc. and 4 cc. pre-feeding.

Data on the average post-reinforcement pauses after FR15 and FR45 for subjects K-5, K-6, K-7 and K-8 are shown in Figures 21, 22, 23 and 24 respectively. The four phases show the changes in procedure during the experiment.

Phase I presents the average post-reinforcement pauses after odd and even reinforcements on FR15. Phase II shows the average post-reinforcement pauses on alternating mixed schedule FR15FR45 with the reinforcement conditions in which the subjects were stabilized. Phases III and IV present the post-reinforcement mean pauses under the change of drive level from no pre-feeding to 4 cc. and 6 cc. pre-feeding respectively.

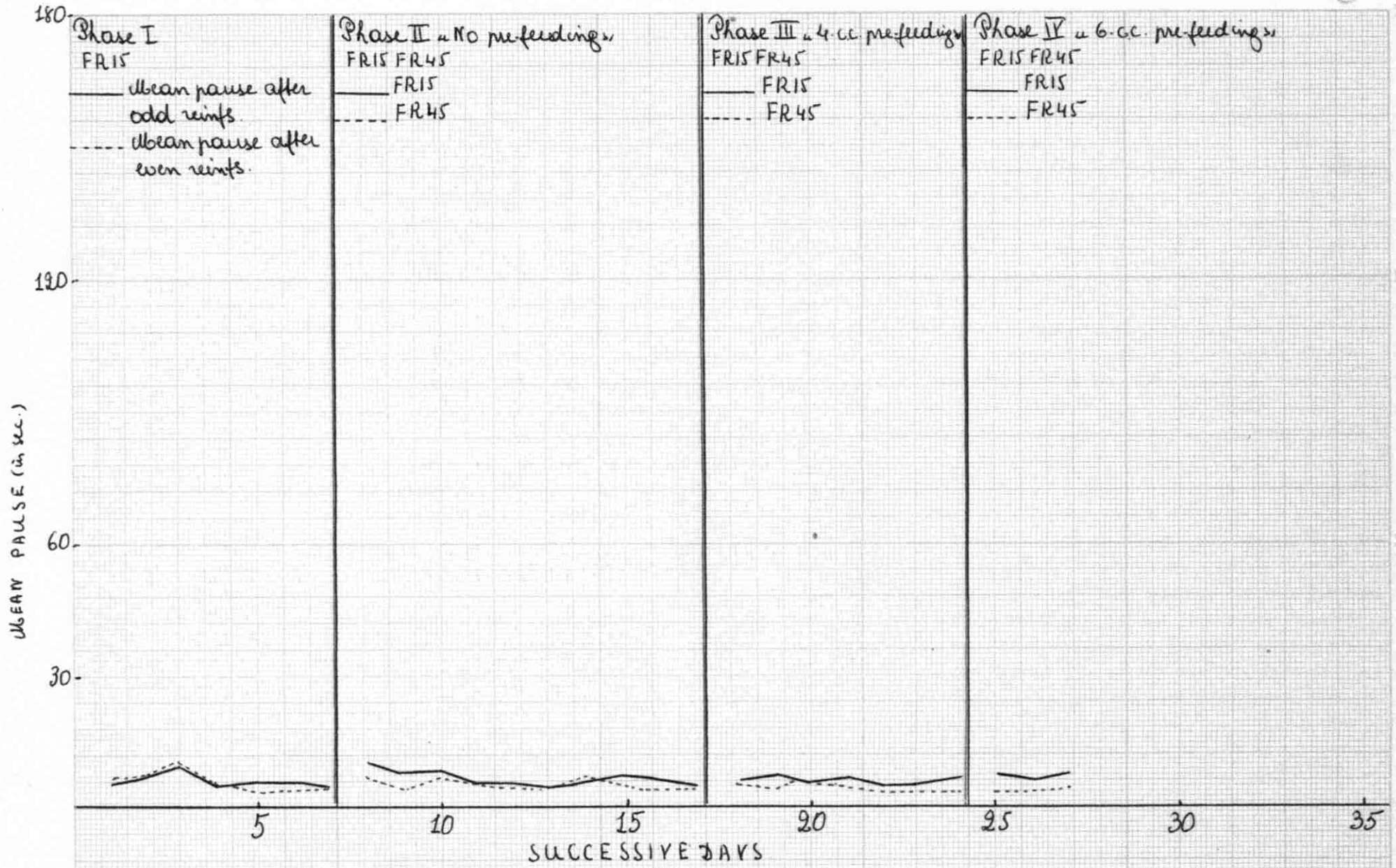

FIG. 21 Daily mean post-reinforcement pauses produced by S. K-S.

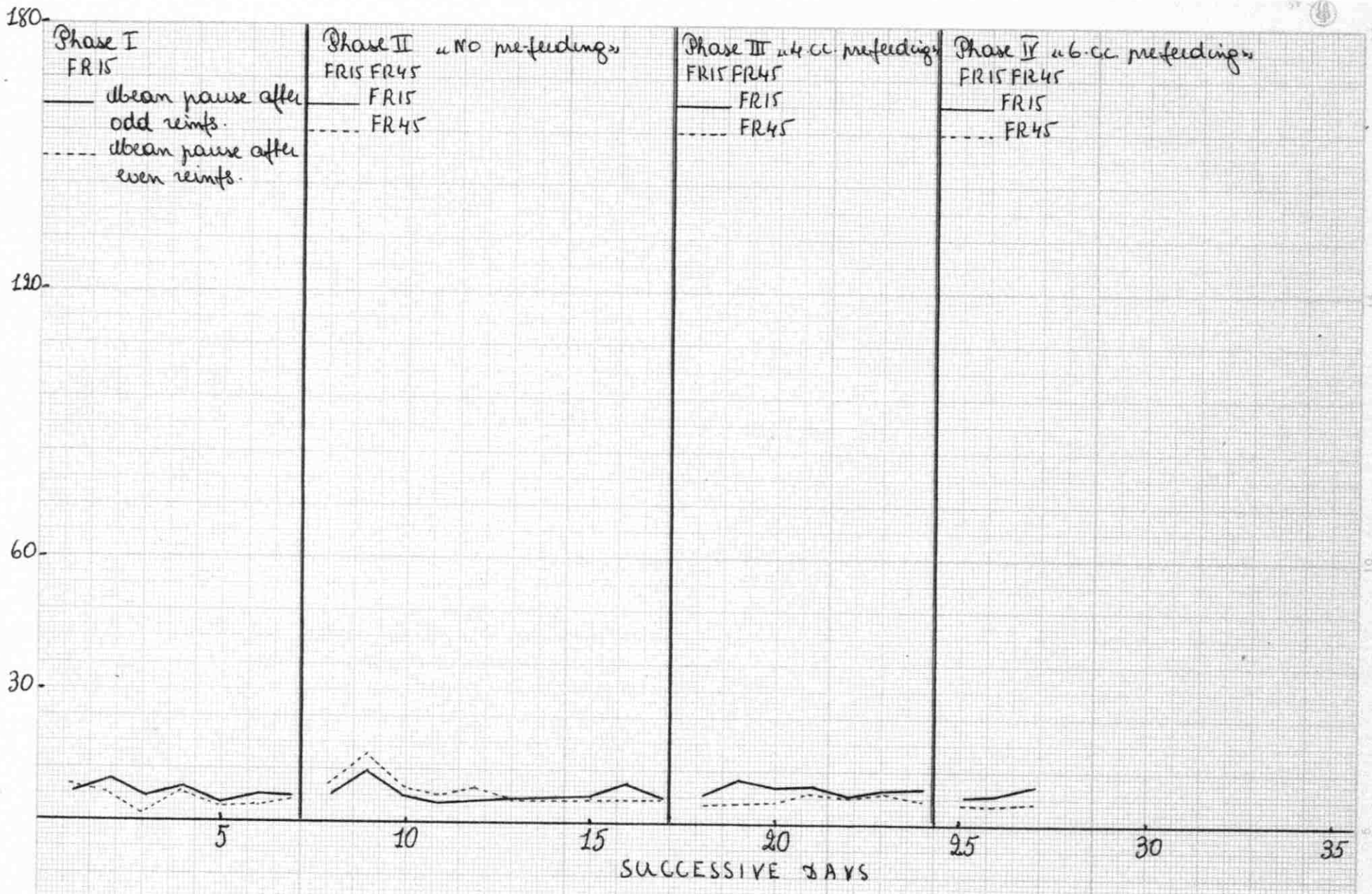

FIG. 22. Daily mean post-reinforcement pauses produced by S. K-G.

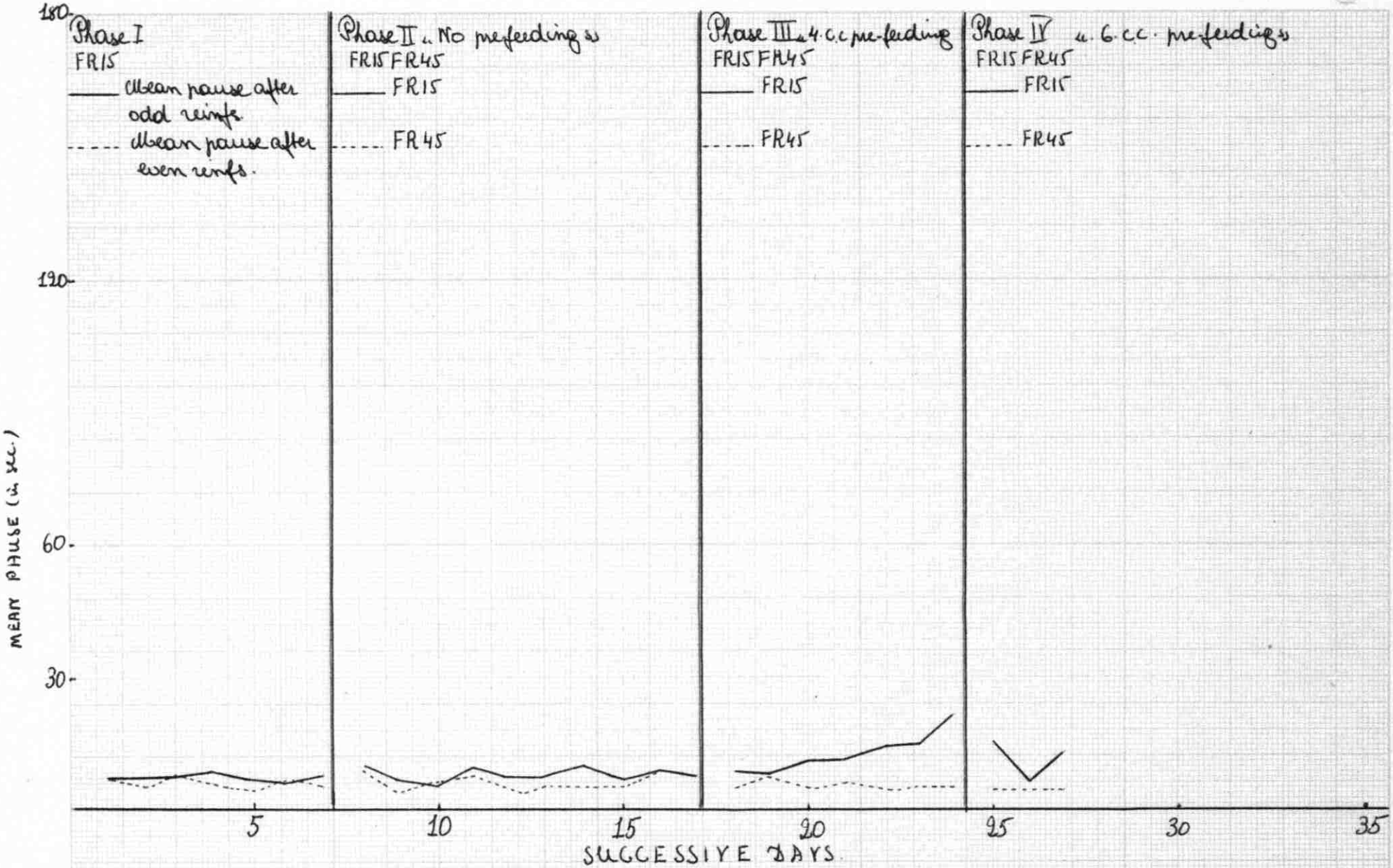

FIG. 23 Daily post-reinforcement pauses produced by S. K-7.

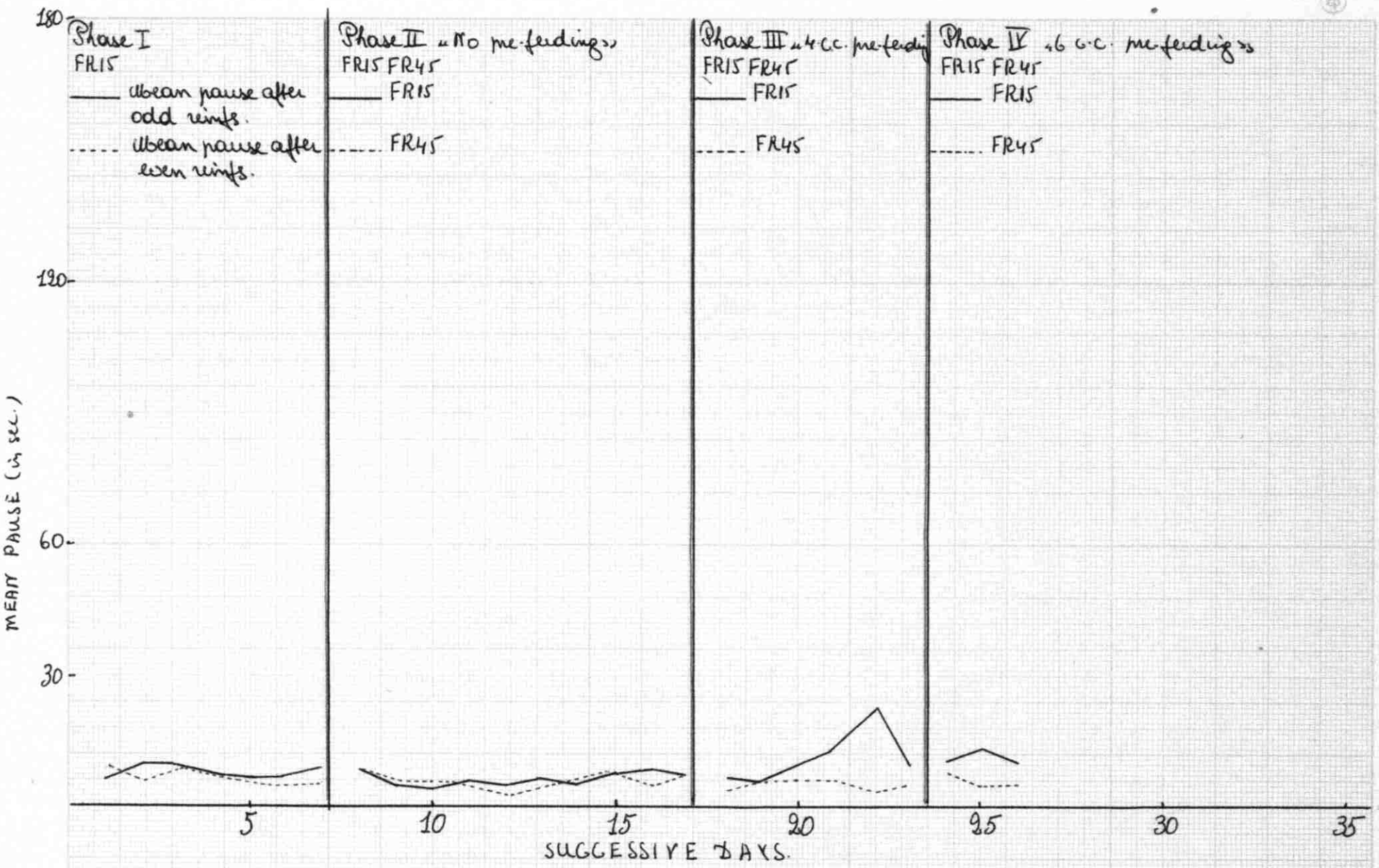

FIG. 24. Daily post-reinforcement pauses produced by S. K-8

These figures are similar to those of subjects K1-4 and in their major aspects show that pauses following FR15 slightly but consistently exceed those following FR45, when the subjects were pre-fed at the beginning of experimental sessions.

Phase I "stabilization".

Figure 25 shows the last session, after 7 sessions on FR15 with 12% sucrose concentration as a reinforcing agent, under H.T. 23, for animal K-5. The total amount of pausing after odd and even reinforcements are almost equal. Similar curves for animals K-6 and K-7 are presented in Figures 26, and 27 respectively. In Figure 28 are presented findings for animal K-8. As can be clearly seen, pause lengths are irregular and unsystematic.

Phase II "no pre-feeding".

The cumulative post-reinforcement curves of K-5, after 10 sessions on schedule alternating mixed FR15FR45, are approximately equal in slope. They run parallel to each other as can be seen from Figure 29, although one long pause after FR45 displaced one curve above the other after 32 reinforcements. Similar data are shown in Figure 30 for subject K-6. The two curves after 10 sessions of no pre-feeding are equal in slope, although a long pause after FR15 separates the curves after 64 reinforcements. Figure 31 shows cumulative pauses on the last session for subject K-7. As it is seen there is no separation between the curves, with irregular pausing after long and short runs. K-8's cumulative pause curves are presented in Figure 32 and as it is shown there is no separation between the cumulative pause curves at the end of the session. Earlier in the session, however, there was a separation between the two curves after the subject had produced 92 reinforcements, but just before the end of the

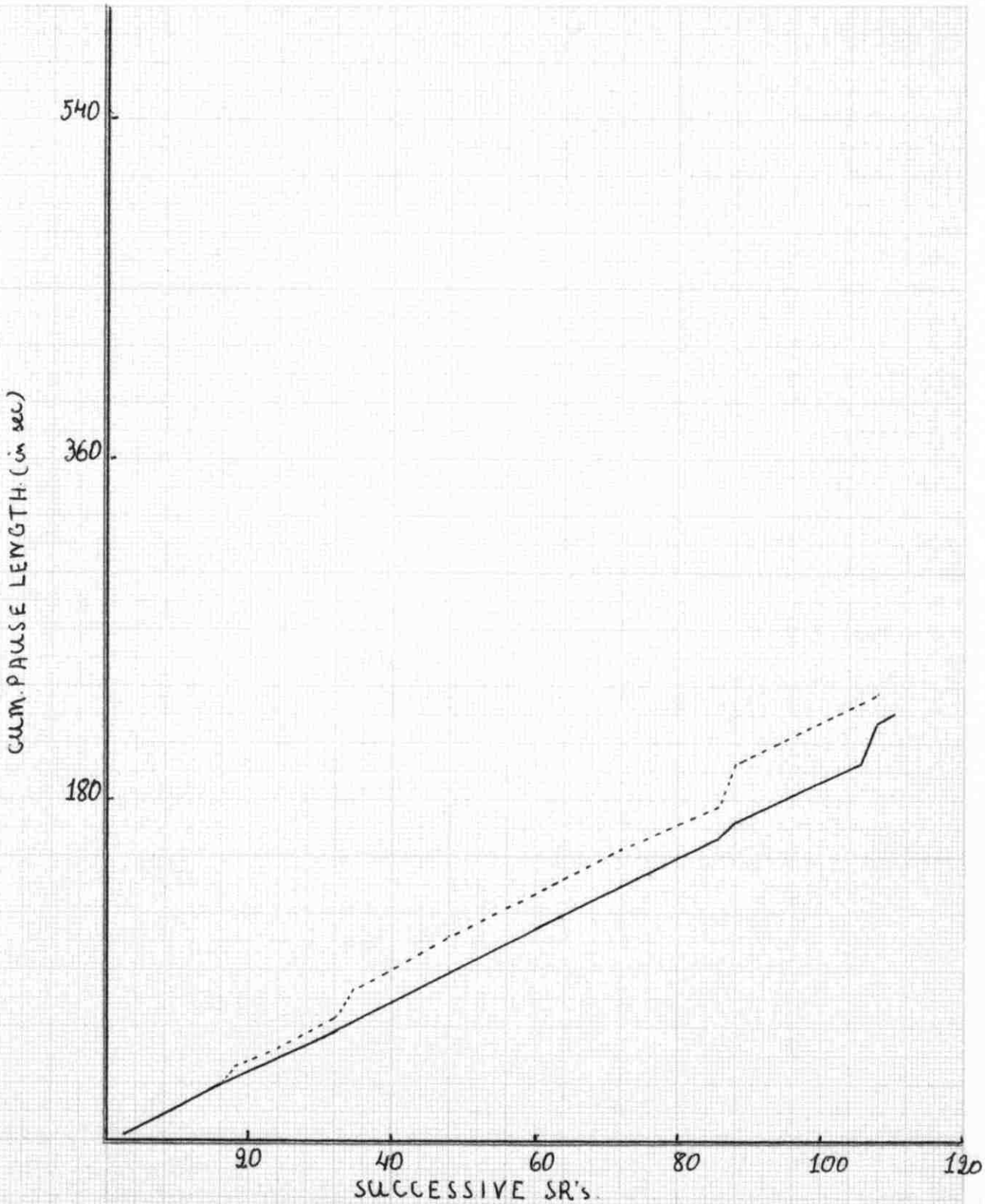

FIG. 25 Cumulative record of post-reinforcement pause length of the last session on FR 15 of S. K-5

The solid line shows pause length after odd reinforcements
The dotted line shows pause length after even reinforcements

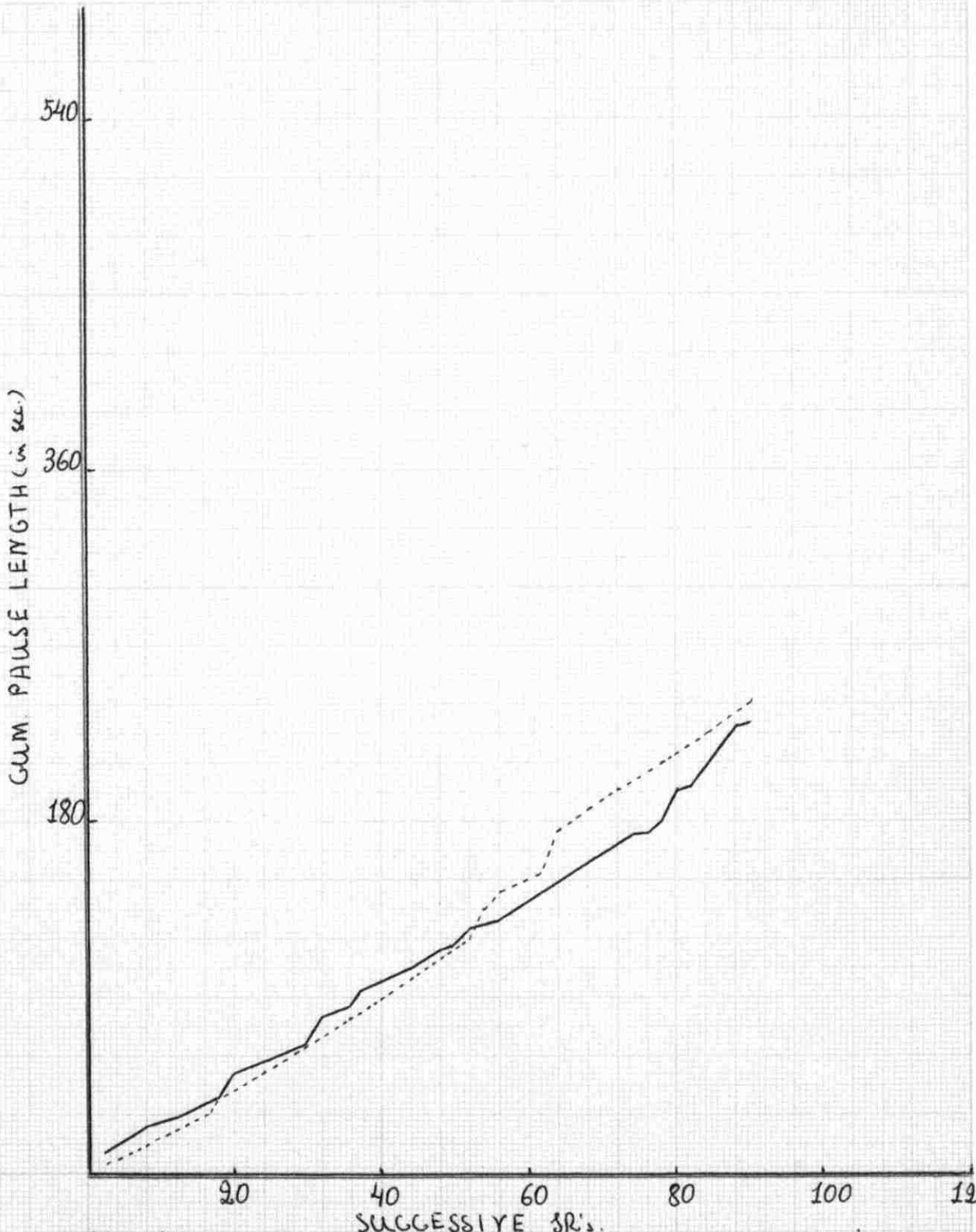

FIG. 26. Cumulative record of pause length of 1k last session on FR15 of S. K-6.

The solid line shows pause length after odd reinforcements.
The dotted line shows pause length after even reinforcements.

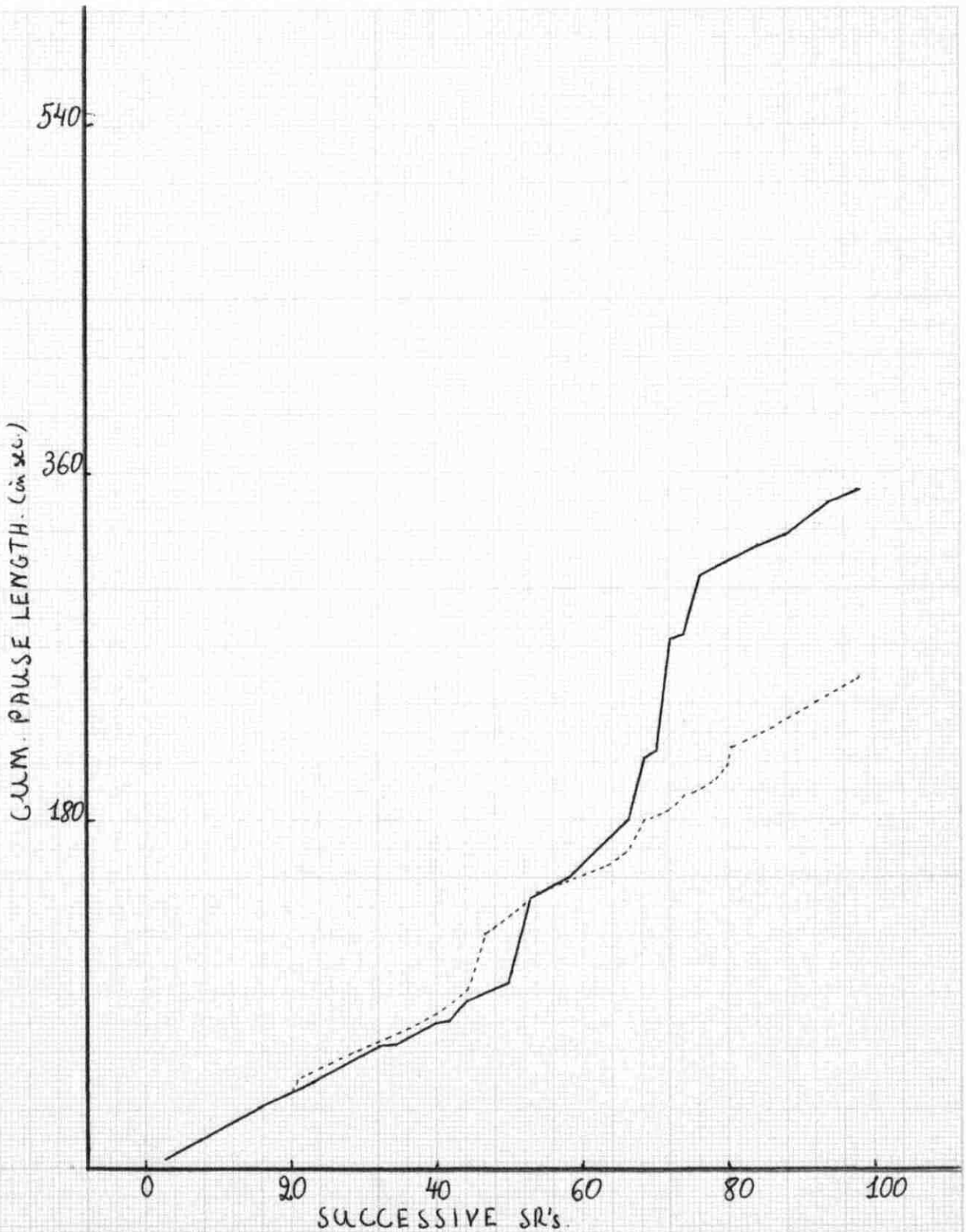

FIG. 27. Cumulative record of post-reinforcement pause length of the last session on FR15 of S. K-7.

The solid line shows pause length after odd reinforcements.
The dotted line shows pause length after even reinforcements.

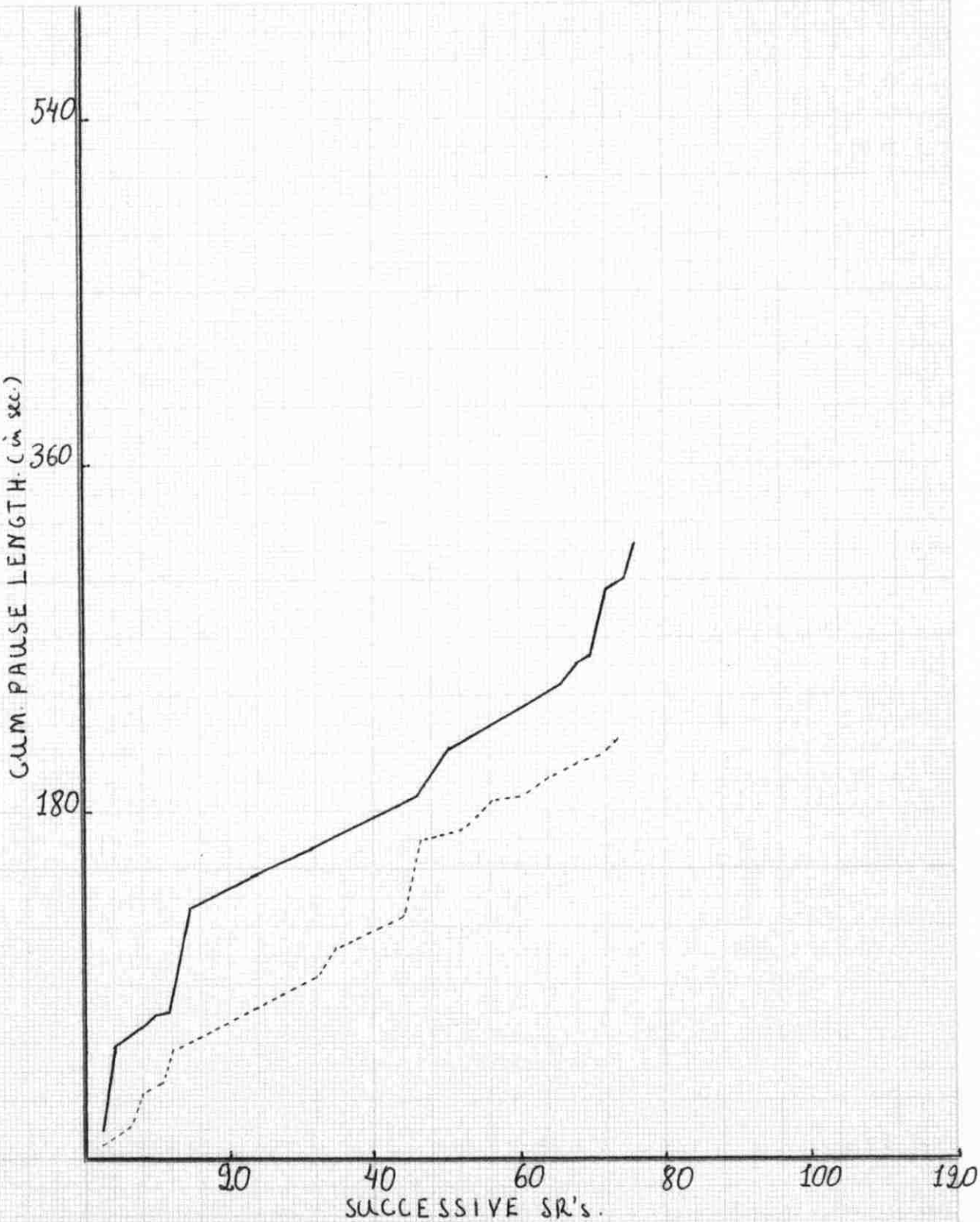

FIG. 28 Cumulative record of post-reinforcement pause length of the last session on FR15 of S. K-8.

The solid line shows pause length after odd reinforcements.
The dotted line shows pause length after even reinforcements.

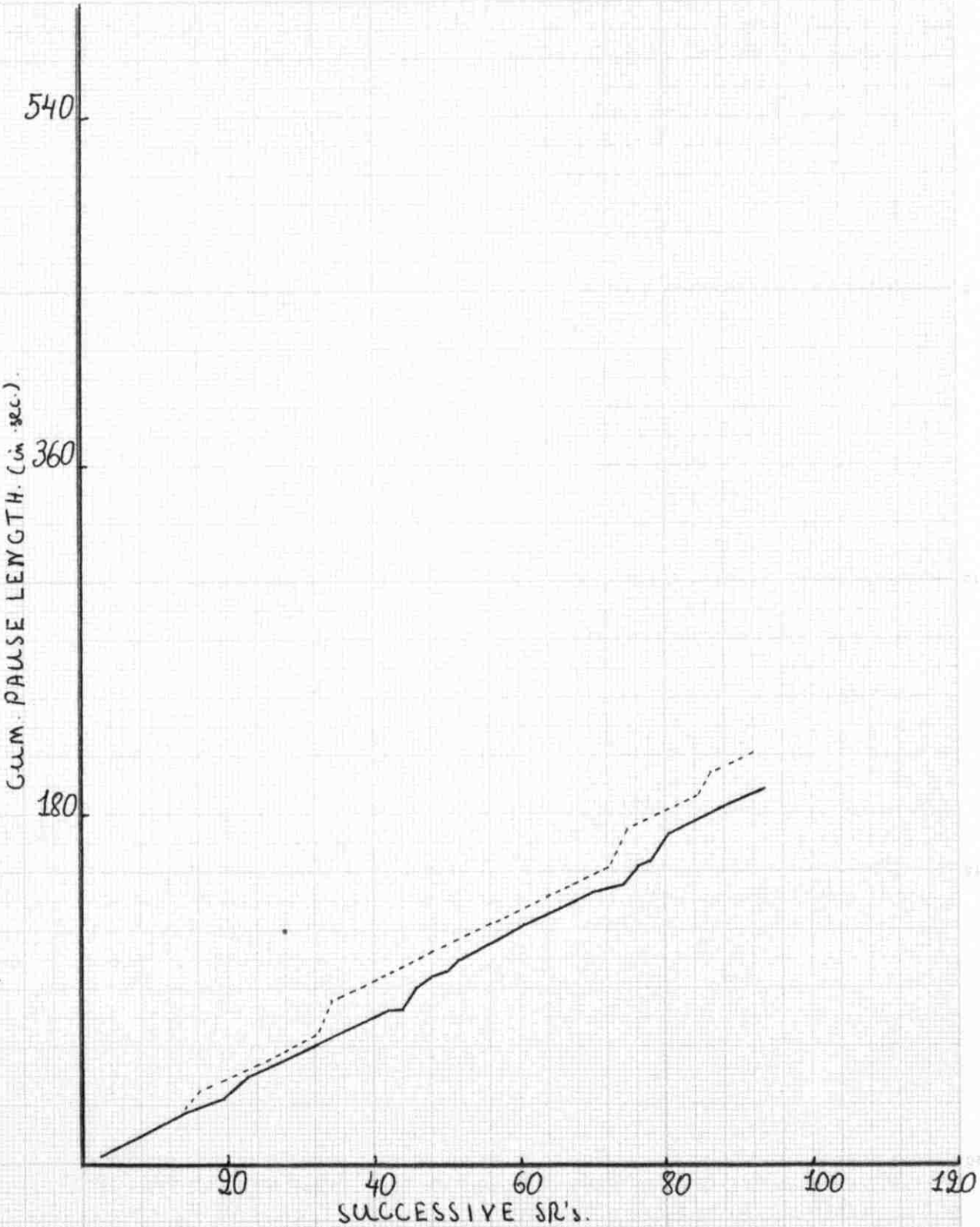

FIG. 29 Cumulative record of post-reinforcement pause length of the last session on alternating mix. FR15 FR45 with «no prefeeding» for S. K-5.

The solid line shows pause length after FR15
The dotted line shows pause length after FR45

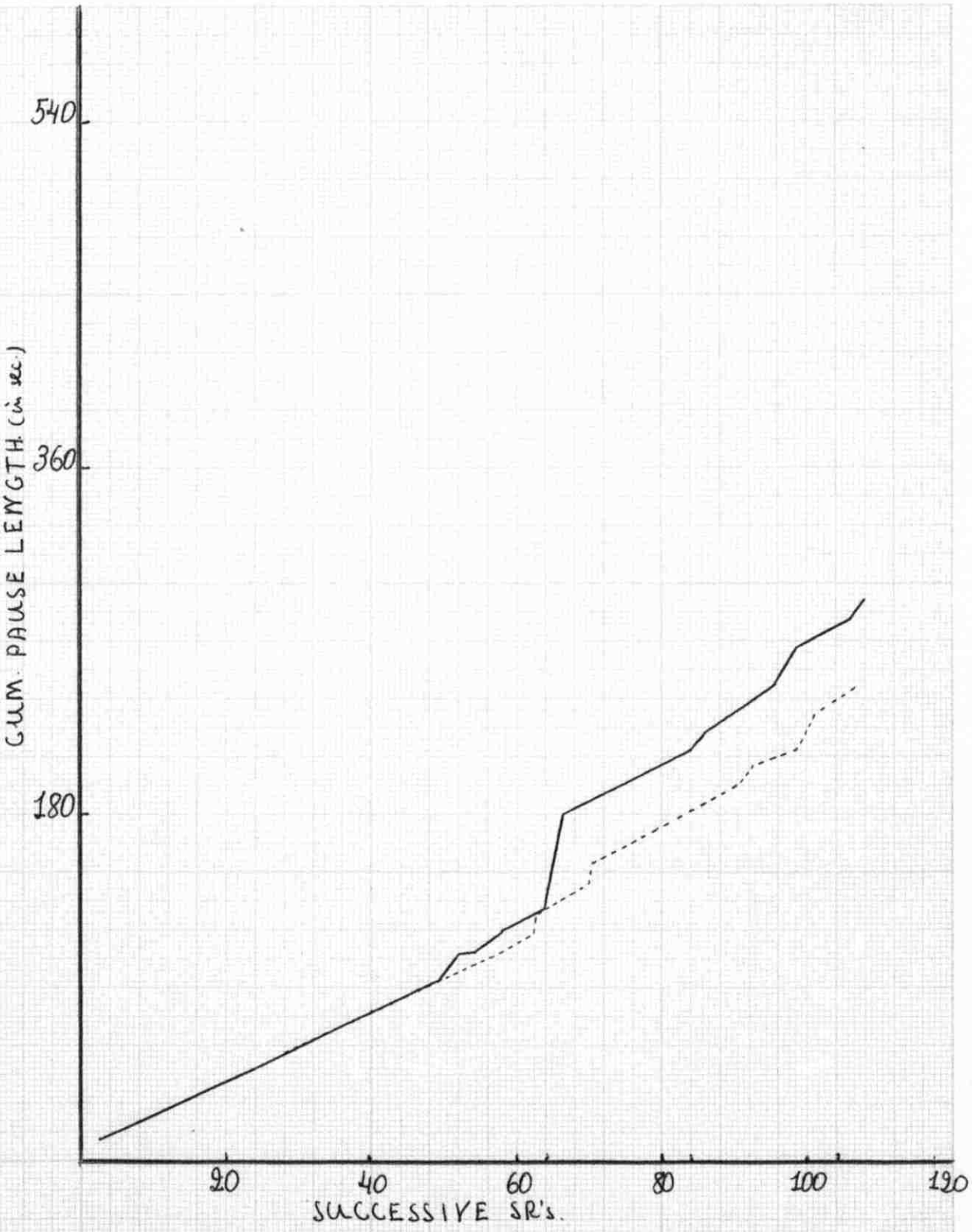

FIG. 30 Cumulative record of post-reinforcement pause length of the last session on alternating mix. FR15FR45 of S. K-6. with «No pre-feedings»

The solid line shows pause length after FR15
The dotted line shows pause length after FR45.

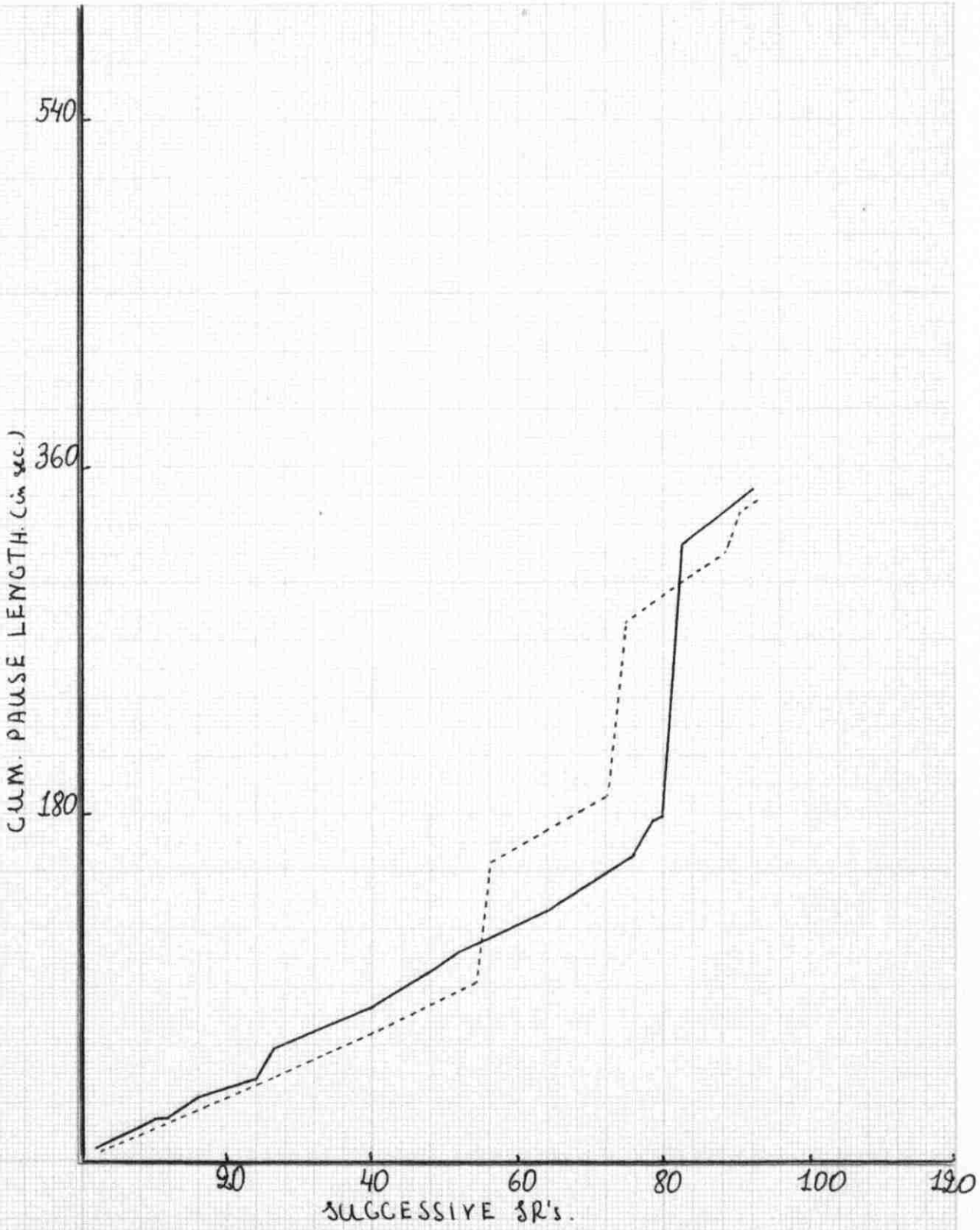

FIG. 31 Cumulative record of post-reinforcement pause length of the last session on alternating mix FR15FR45 of S. K-7 with «no-prefeeding»

The solid line shows pause length after FR15
The dotted line shows pause length after FR45

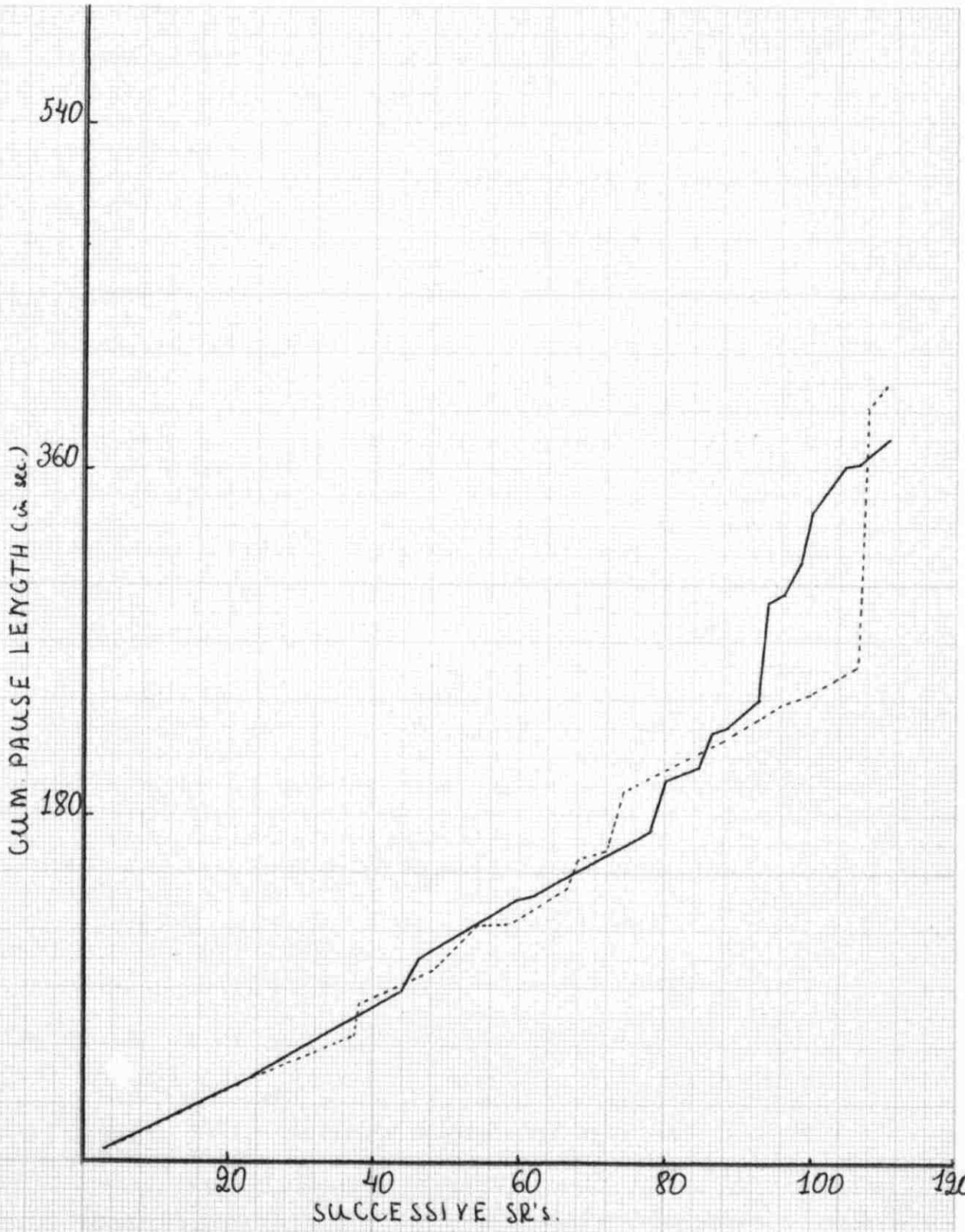

FIG. 32. Cumulative record of post-reinforcement pause length of the last session on alternating mix FR15 FR45 of S. K-8 with «no pre-feedings».

The solid line shows pause length after FR15
The dotted line shows pause length after FR45

session (after 106 reinforcements) pauses after FR45 became longer and totaled slightly longer then those after FR15.

Phase III "4 cc. pre-feeding".

Figure 33 shows the last session after 7 sessions with 4 cc. pre-feeding for K-5. The cumulative pause curves do not diverge before 82 reinforcements, but after that the pauses after FR15 lengthen abruptly.

Subject K-6's curves are parallel up to 60 reinforcements. After 60 reinforcements, the curves separated showing a lengthening of pauses after FR15, while pauses after FR45 remained relatively constant. Figure 34 presents subject's K-6 last session under this regime. Subject's K-7 record is shown in Figure 35. Quite long pauses after FR15 appeared relatively early in the session, namely, after 20 reinforcements; quite long pauses, however, appeared after 52 reinforcements. This subject's record show constant pauses after FR45. Subject K-8's record shows slightly longer pauses after FR15, than those after FR45 from the beginning of the session. The length of pauses, however, increased abruptly after both ratios, after the subject had consumed 78 reinforcements.

These changes are presented in figure 36.

Phase IV "6 cc. pre-feeding".

Records of subjects K-5 and K-6 on the last session after 3 sessions with 6 cc. pre-feeding are shown in Figure 37 and 38 respectively. The cumulative post-reinforcement curves for subject K-5 diverged after 72 reinforcements (there was, however, one long pause after FR15 after 16 reinforcements), while for subject K-6, the curves were separated after 6 reinforcements.

K-7 pauses constantly after FR45, but there is a lengthening of

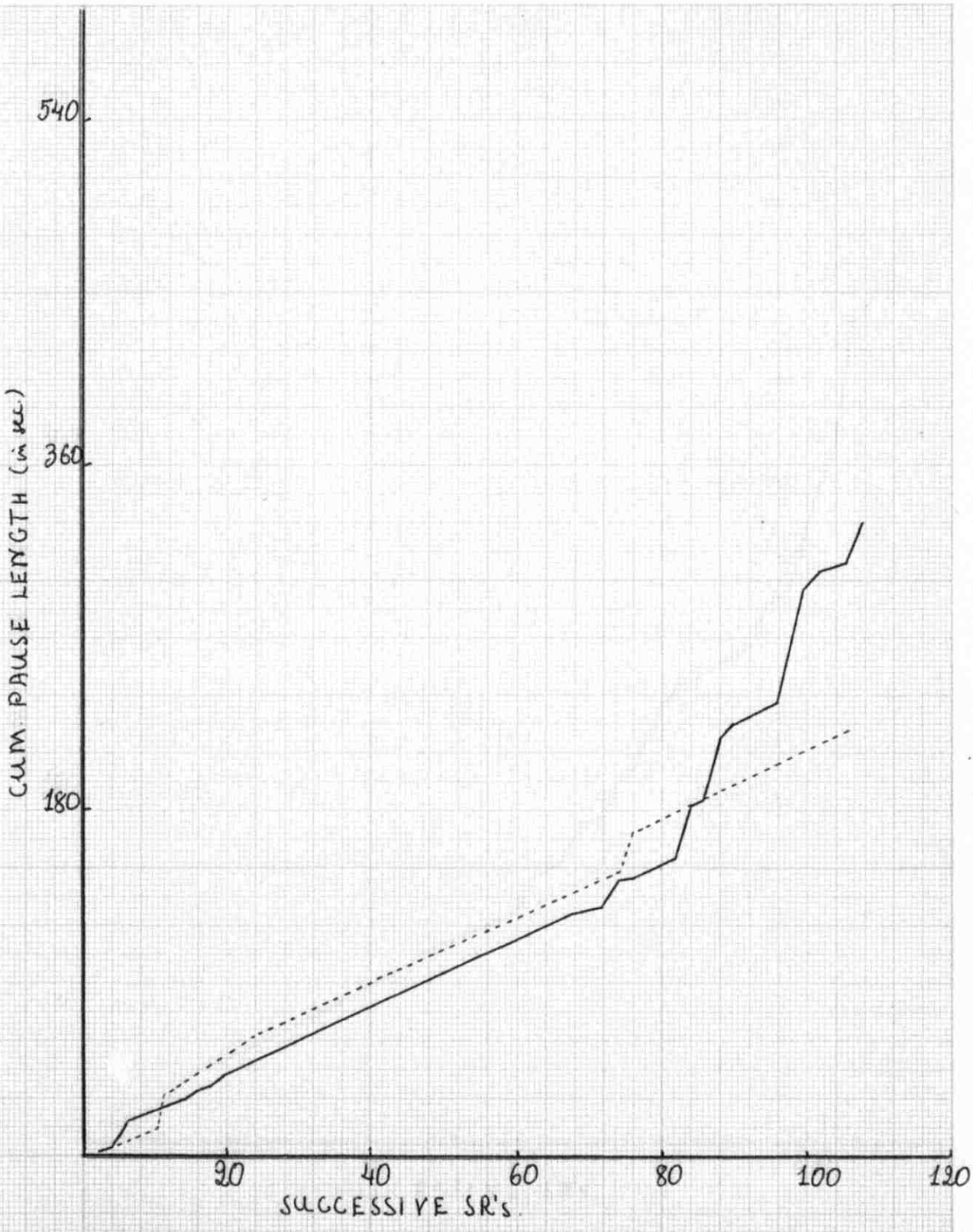

FIG. 33. Cumulative record of post-reinforcement pause length of the last session on alternating mix FR15 FR45 with 4 c.c. pre-feeding of S. K-5

The solid line shows pause length after FR15
The dotted lines shows pause length after FR45

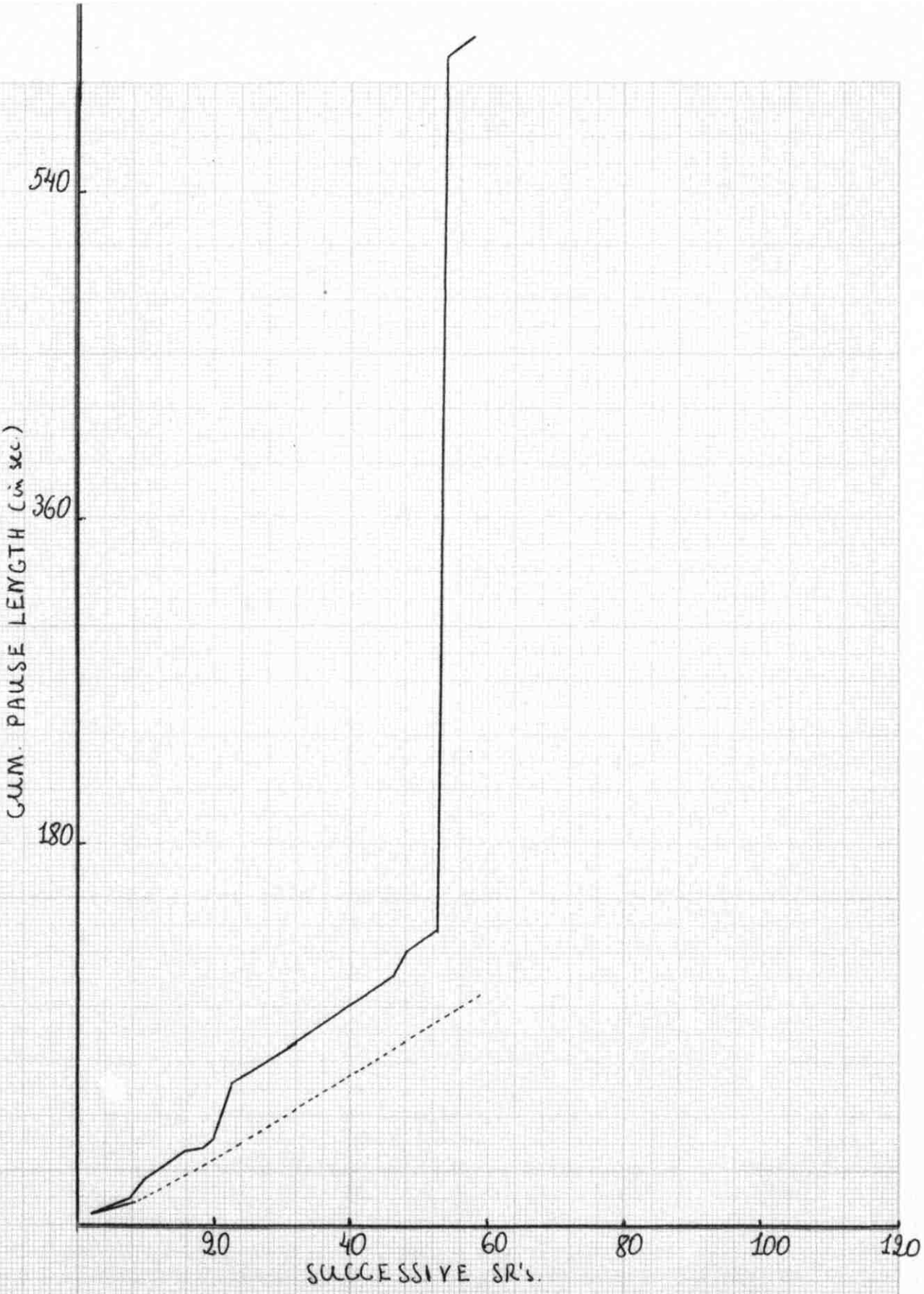

FIG 35 Cumulative record of pause length of the last session on alternating mix FR15 FR45 with «4 cc pre-feeding» of J. K-7.
The solid line shows pause length after FR15
The dotted line shows pause length after FR45

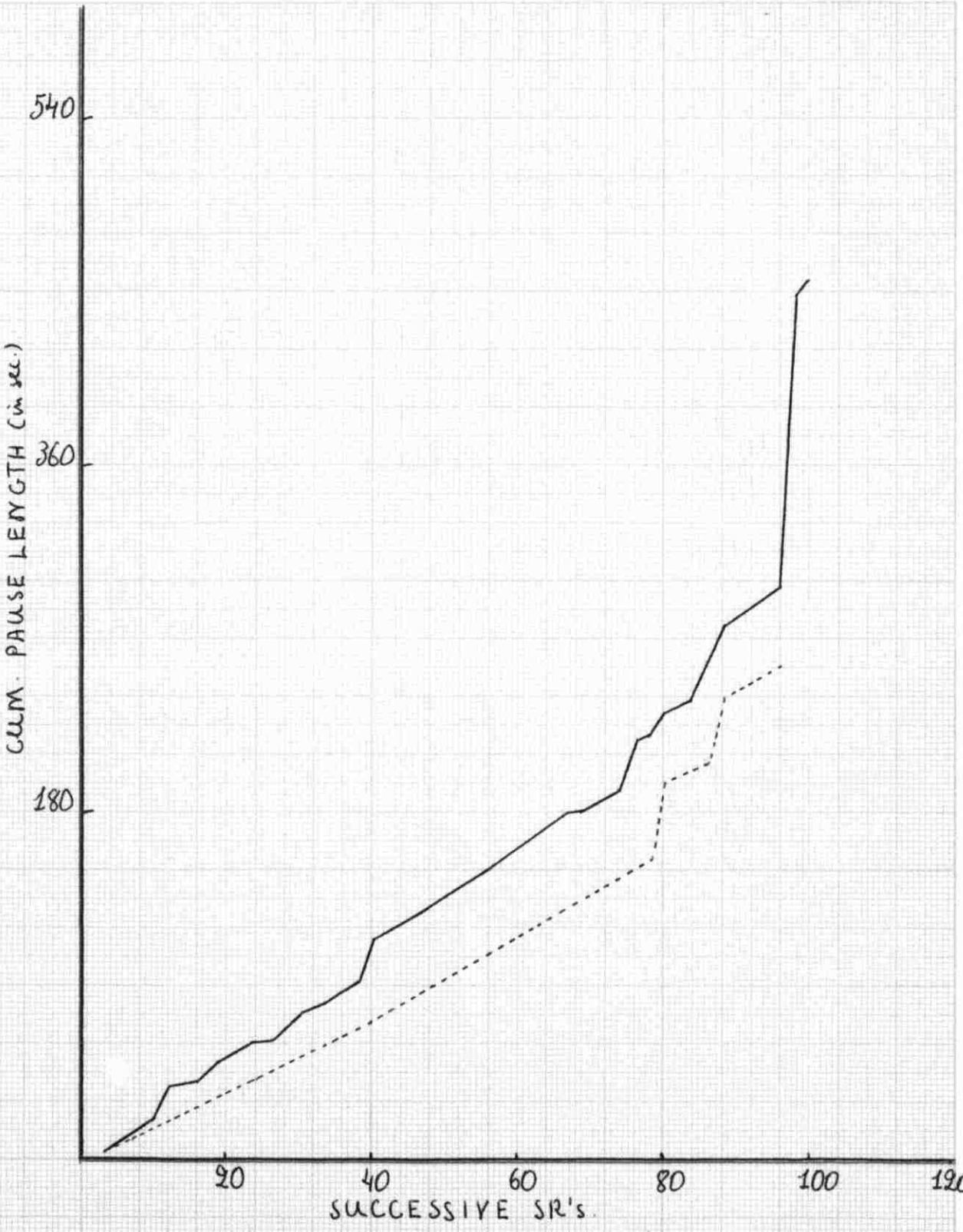

FIG. 36. Cumulative record of post-reinforcement pause length of the last session on alternating mix FR15 FR45 with 4 c.c. pre-feedings of S. K-8.

The solid line shows pause length after FR15
The dotted line shows pause length after FR45

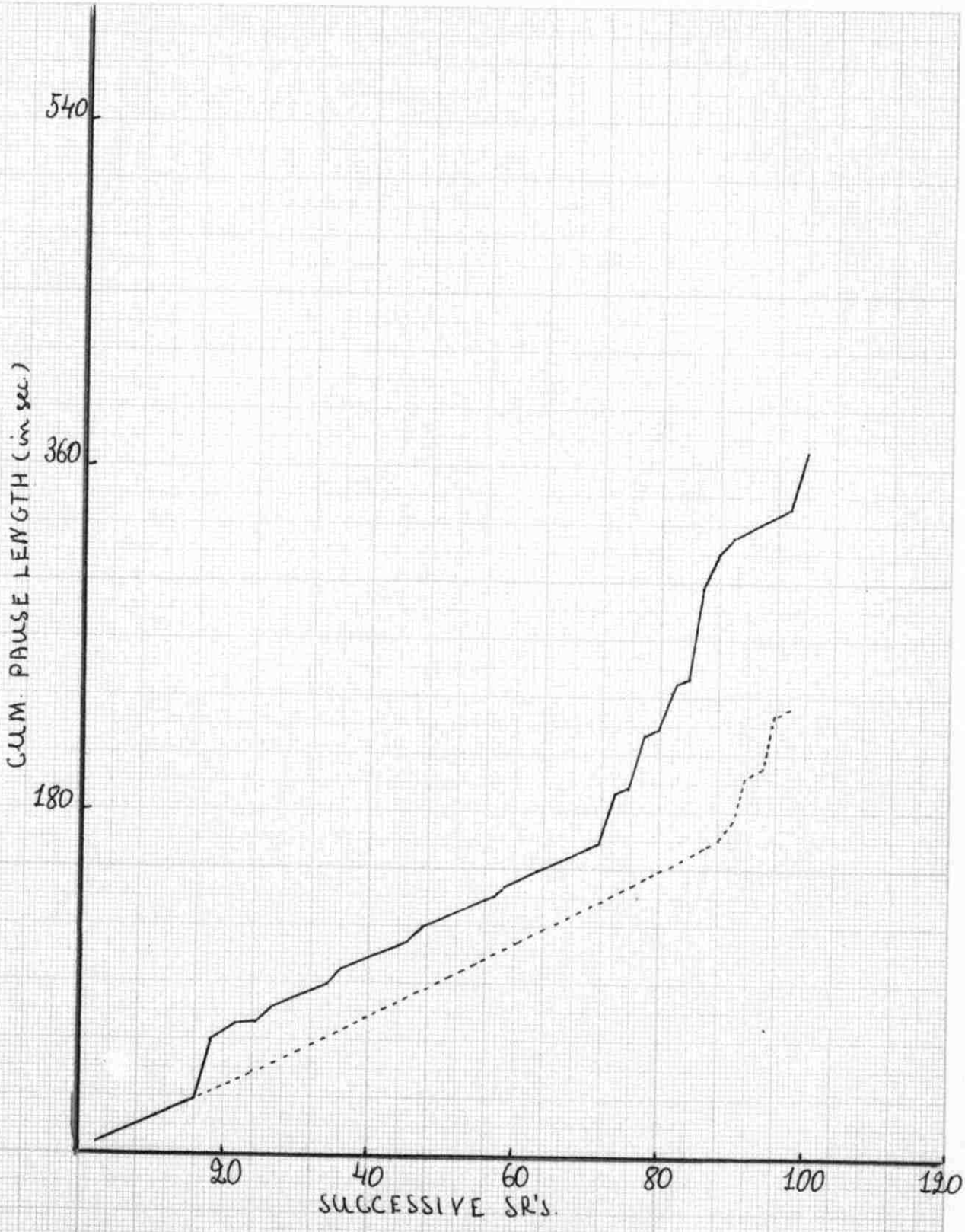

FIG. 37 Cumulative record of post-reinforcement pause length of the last session on alternating mix FR15FR45 with «6 c.c. me-feeding» of S. K=5.

The solid line shows pause length after FR 15
The dotted line shows pause length after FR45

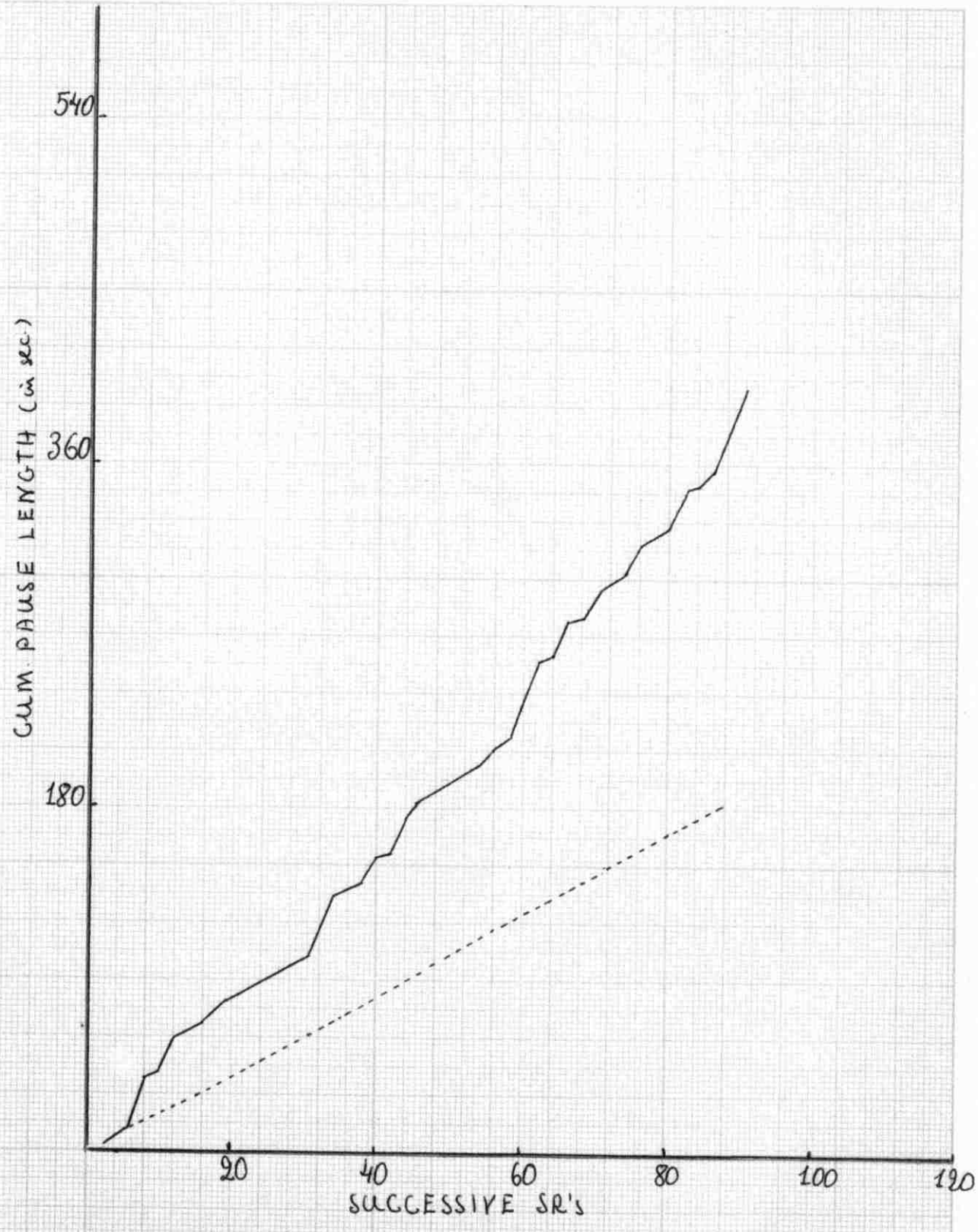

FIG. 38. Cumulative record of post-reinforcement pause length of the last session on alternating mix FR15 FR45 with 0.6 cc. pre-feedings of S. K-6.

The solid line shows pause length after FR15
The dotted line shows pause length after FR45

the pauses after FR15, after the subject had received 46 reinforcements. Figure 39 presents the last session with 6 cc. pre-feeding for this subject. Figure 40 presents data for subject K-8 under similar conditions. Pauses after FR15 begun to increase after 54 reinforcements. The curve after FR45 steepens at about 84 reinforcements.

As in the case of subjects K1-4, the average lengths of the pauses over the final 3 sessions of each pre-feeding condition show slight changes with more pre-feeding. There is a tendency for 3 of the animals of this group (Ss K6-7-8) to increase pausing after the first ratio segment FR15 with the first drive change from zero to 4 cc pre-feeding, but with 6 cc. pre-feeding pauses became shorter. As for the pauses after the long ratio FR45 parallel to that of the animals in the first group, they either remained constant or decreased with decreasing drive and in the case of 3 of the animals (Ss K5-6 and 7).

Animal K-5 paused after FR15 about the same under the contitions of zero cc. to 4 cc. pre-feeding but for a longer time with 6 cc. pre-feeding. The mean post-reinforcement pause over the three last sessions is .55 sec., .54 sec. and .69 sec. with no prefeeding, 4 cc. pre-feeding and 6 cc. pre-feeding respectively, after FR45 the mean pauses are .46 sec. with no pre-feeding, .39 cc. with 4 cc. pre-feeding and .39 sec. with 6 cc. pre-feeding.

Subject K-6 paused for a longer period after FR15 with the first pre-feeding showing a mean .65 sec. without pre-feeding and .73 sec. with 4 cc. pre-feeding while it paused relatively shorter period with 6 cc. pre-feeding showing a mean pause .71 sec.

The mean pause after FR45 decreases with decreasing drive from .48 sec. to .41 sec. and .40 sec. with zero, 4 cc. and 6 cc. pre-feeding, respectively.

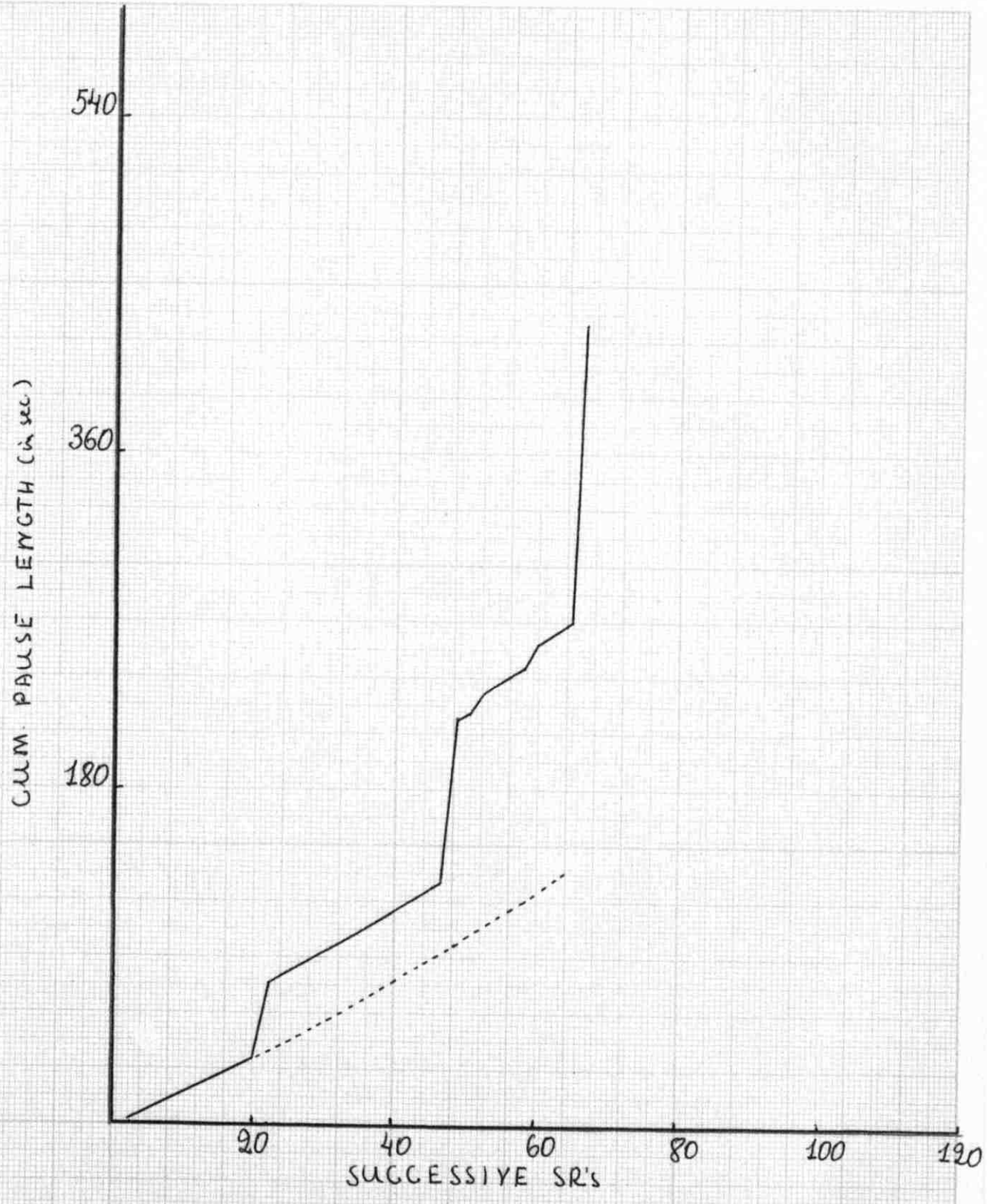

FIG. 39. Cumulative record of post-reinforcement pause length of the last session on alternating mix FR15FR45 with «6 cc. pre-feeding» of S. K. 7.

The solid line shows pause length after FR15
The dotted line shows pause length after FR45

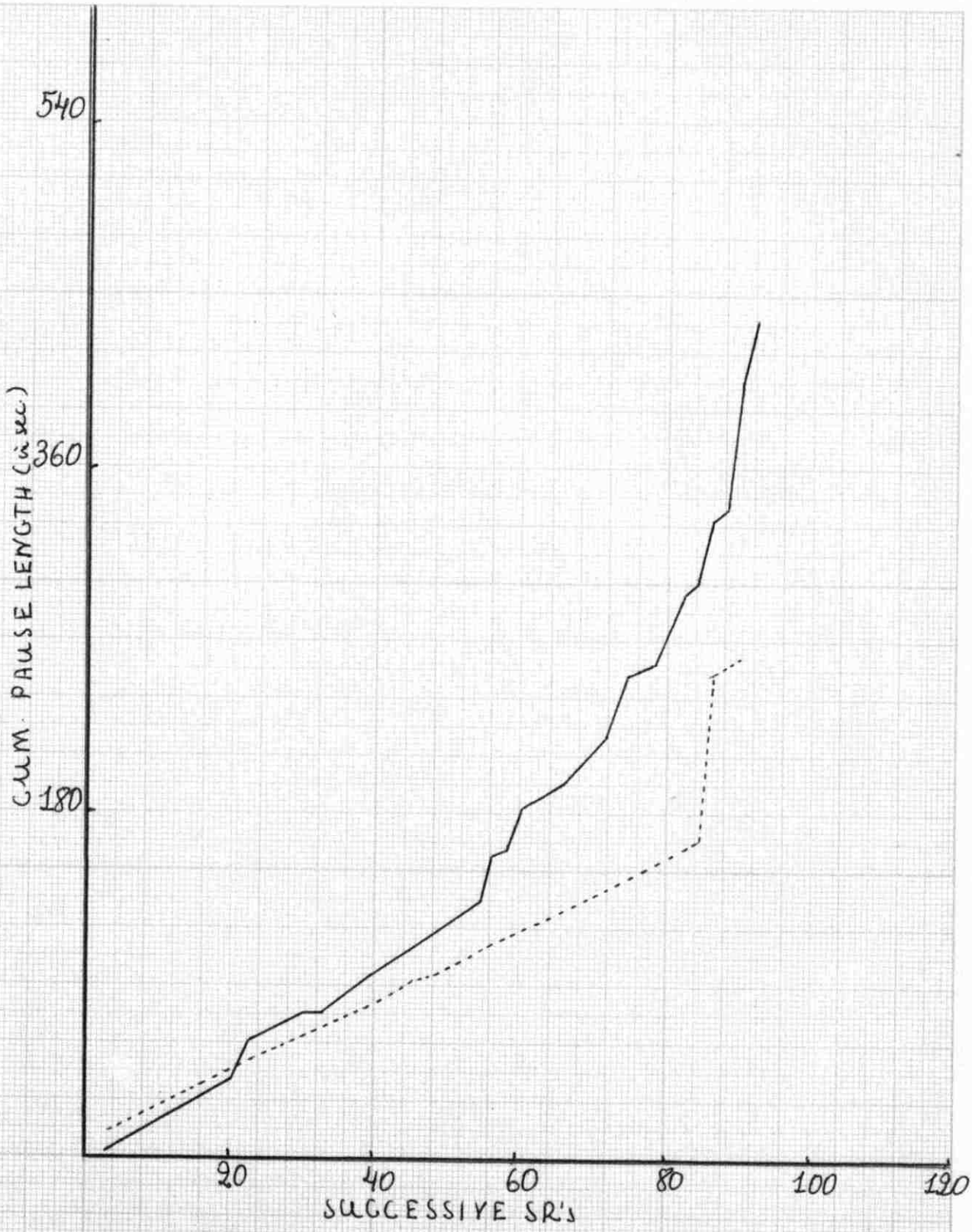

FIG. 40. Cumulative record of post-reinforcement pause length of the last session on alternating mix FR15FR45 with a 6 GC. pre-feeding of S. K-8.

The dotted line shows pause length after FR45
The solid line shows pause length after FR15.

Records of Subject K-7 are about the same to that of K-6, showing an increase in mean pause after FR15 from .74 sec. without pre-feeding to 1.70 sec. with 4 cc. pre-feeding and decreasing to 1.19 sec. with 6 cc. pre-feeding. The mean pause after FR45 decreases with more pre-feeding from .73 sec. to .43 sec. and .41 sec.

Subject K-8 shows the same tendency to pause for a longer period after FR15 with increasing pre-feeding from zero to 4 cc. showing a mean .70 sec. without pre-feeding and 1.49 sec. with 4 cc. pre-feeding but with 6 cc. pre-feeding the mean pause decreases to 1.09 sec.

Length of post-reinforcement pauses after FR45 for this animal is irregular changing from .63 sec. to .52 sec. and .59 sec. without pre-feeding, 4 cc. pre-feeding and 6 cc. pre-feeding respectively.

The average pauses over the final 3 sessions under the different experimental conditions for animals K5-8 are summarized in Table V below.

Table V

Pre-feeding	0 cc.		4 cc.		6 cc.	
Ratio components	FR15	FR45	FR15	FR45	FR15	FR45
K-5	.55	.46	.54	.39	.69	.39
K-6	.65	.48	.73	.41	.71	.40
K-7	.74	.73	1.70	.43	1.19	.41
K-8	.70	.63	1.49	.52	1.09	.59
Means	.66	.88	1.12	.44	.92	.45

Table V: Mean post-reinforcement pauses, in seconds made by subjects K5-8 after the FR15 and FR45 segments of the mixed schedule FR15FR45 over the final 3 sessions of 0 cc., 4 cc., and 6 cc. pre-feeding.

As it is seen from the means of all these animals (k5-8), there are indications that pauses after the first segment of the schedule increase with decreasing drive from zero cc. to 4 cc. pre-feeding but with 6 cc. pre-feeding the mean post-reinforcement pauses after FR15 decreases. Pauses after FR45 decrease slightly with more pre-feeding.

CHAPTER IV

Results in subsidiary experiment

The results of changing the components of the alternating mixed FR15FR45 are reported in this chapter.

Experiment II.

Rat K-1. Data for this animal are presented in Figure 41. This graph is representative of the period during which the animal was reinforced on complex alternating mixed schedule FR15FR45FR15FR5 with 4 cc. prefeeding of 12% sucrose, the reinforcing substance. It shows the 26th session over 27, ½ hour experimental sessions.

As can be seen from this graph there is no systematic difference between any of the curves, except that pauses following the FR15 component of the schedule and preceding the longest run FR45 lengthened towards the end of the session after 124 reinforcements. Pauses after FR5 increased after 120 reinforcements.

The mean of the mean pauses after FR15 preceding the longest run is 8.22 sec. and that one of FR15 preceding the shortest ratio is 5.97 sec.

Rat K-2. Reinforcement for this animal was scheduled on the same complex mixed ratio as Rat K-1, and the reinforcement conditions remained the same.

Figure 42, presents the last session after 27 sessions on this schedule. The curves diverged after 64 reinforcements. The cumulative curves of the pauses preceding the three components of the schedule (FR5FR15FR15) show consistent regular short pauses which stabilized and remained short within a session, while pauses preceding the long run (FR45) while short at the beginning of the session lengthened at the end.

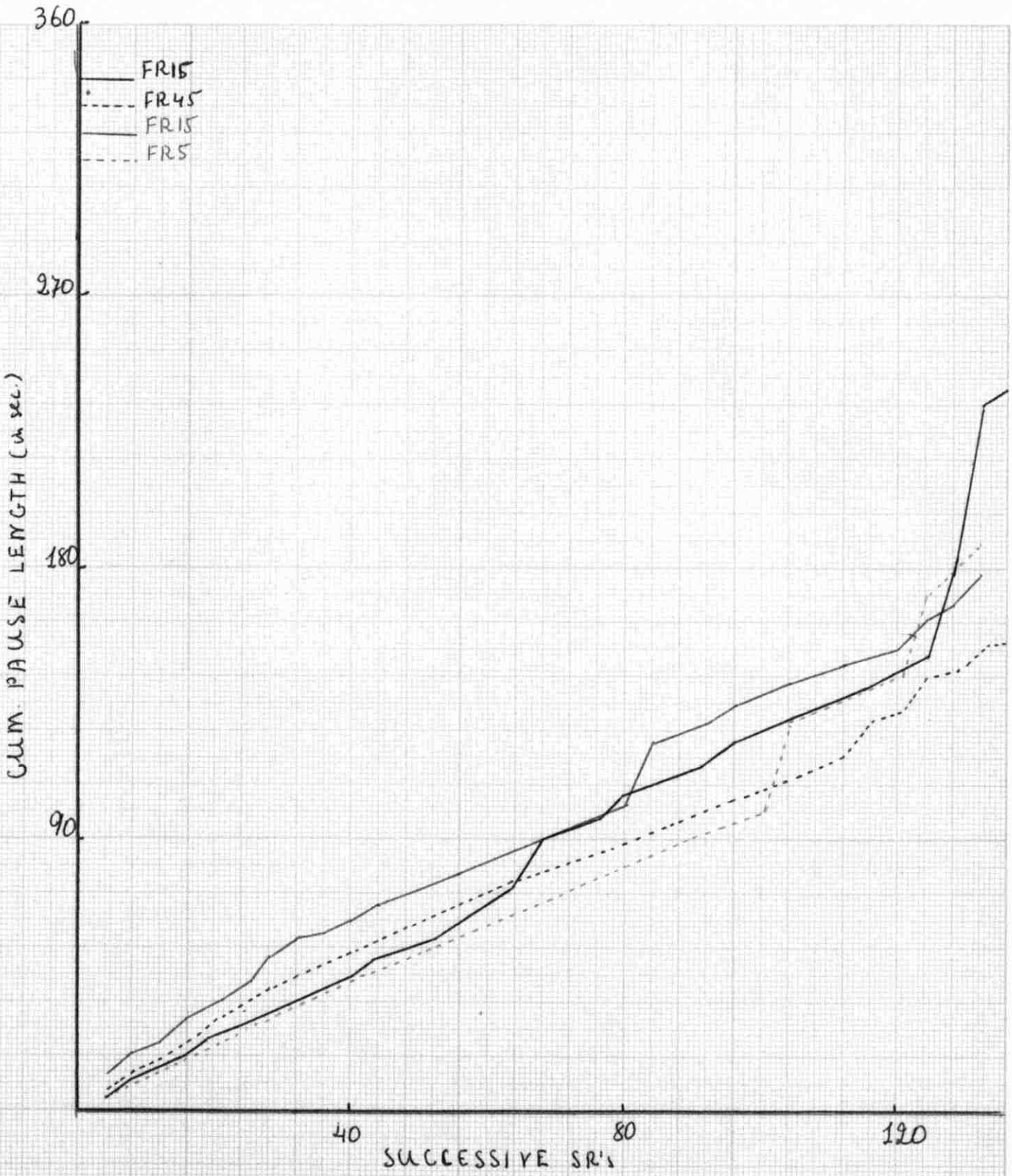

FIG. 41. Cumulative record of post-reinforcement pause length on complex alternating mixed schedule FR15FR45FR15FR5 with u 4 c.c. prefeedings of S. K-1.

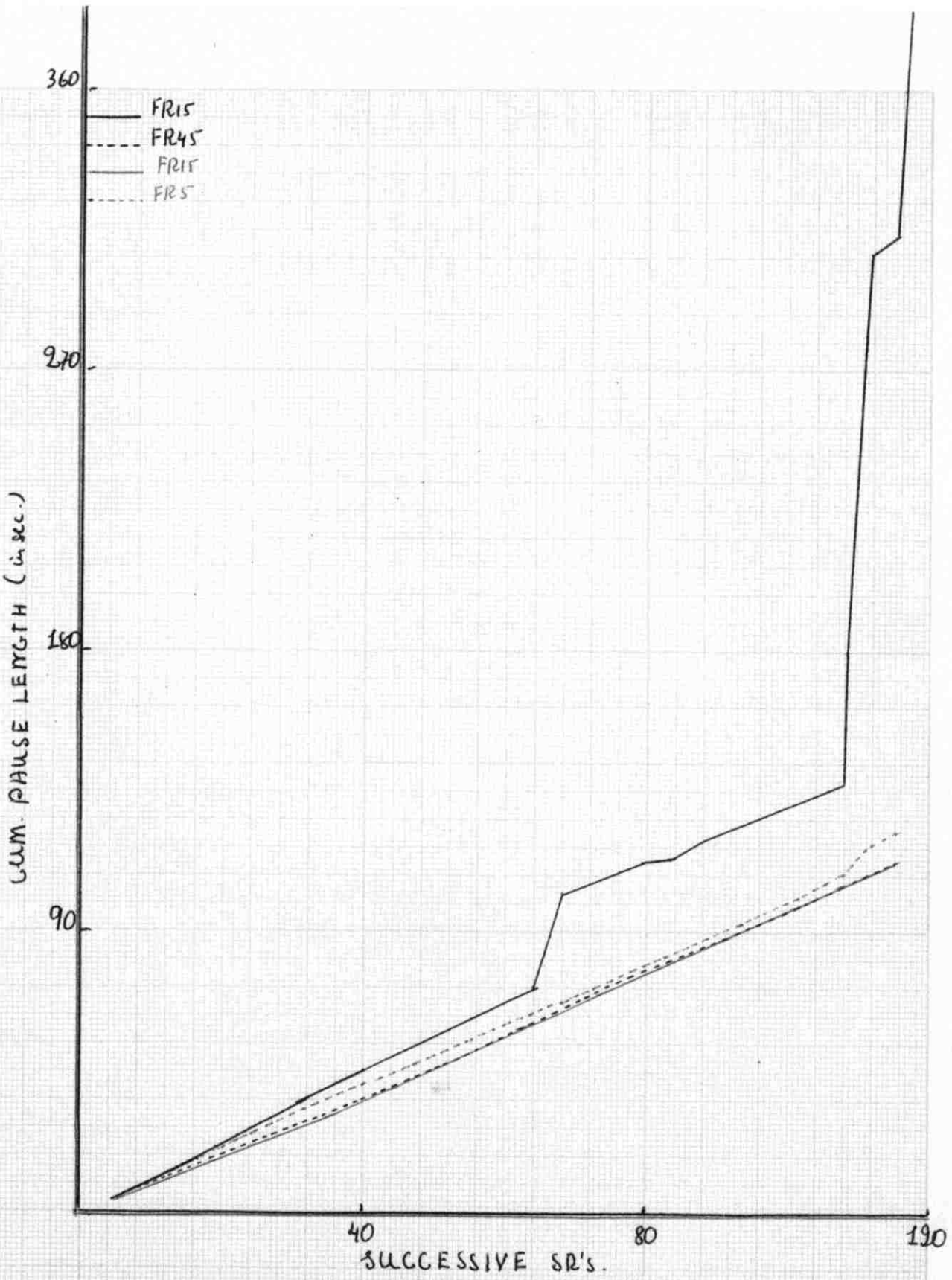

FIG. 42. Cumulative record of post-reinforcement pause length of the last session on complex alternating mix FR15FR45FR15FR5 with «4.cc. pre-feeding» of S. K. 2.

The mean of the mean daily pauses of FR15 preceding the longest run is 9.06 sec. and that one preceding the shortest run is 5.4 sec.

Rat K-3. Reinforcement for Rat K-3 was scheduled on complex alternating mixed FR15FR45FR15FR135, with 4 cc. pre-feeding of 12% sucrose of the reinforcing substance.

Figure 43 shows the 24th session under this regime. (The animal was run 25 sessions but data on the final session were atypical.) Note that differentiation occured after 20 reinforcements. Pauses following the FR15 that precedes the longest run, FR135, increased abruptly, while all the other 3 cumulative pause curves remained constant in slope within a session.

The mean of the mean pauses preceding the longest run is 18.9 sec.

Rat K-4. Data of this animal are shown in Figure 44. Reinforcement conditions are similar to those of animal K-3 and the components of the schedule were the same.

The usual abrupt rise of the cumulative curve preceding the longest run occured after 36 reinforcements. The cumulative curves of the other components developed brief pauses and remained constant throughout the session. Pauses following FR15 that precedes FR45 are relatively longer than those of the other components.

The mean of the daily mean pauses of the curve preceding the longest run, FR135, is 12.4 sec.

In general we can conclude from these findings that when reinforcements are scheduled on complex alternating mixed schedules with 4 cc. pre-feeding of 12% sucrose concentration, pauses preceding the longest run, while short at the beginning of a session, soon become longer and that the longer the magnitude of the component the longer the pause preceding the long run.

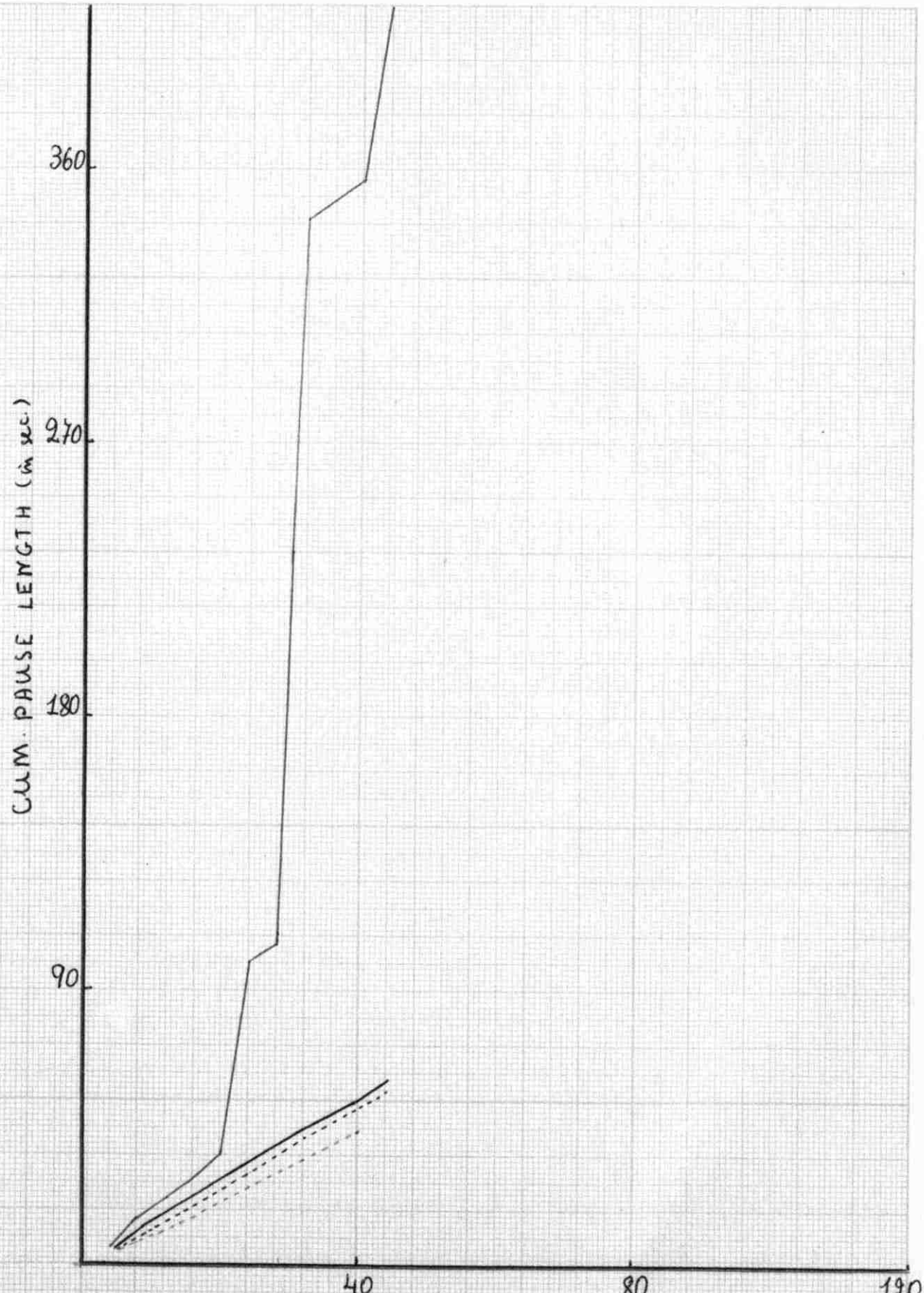

FIG. 43. Cumulative record of pause length on alternating mix FR15 FR45 FR15 FR135 with a 4 cc. pre-feeding of S. K-3.

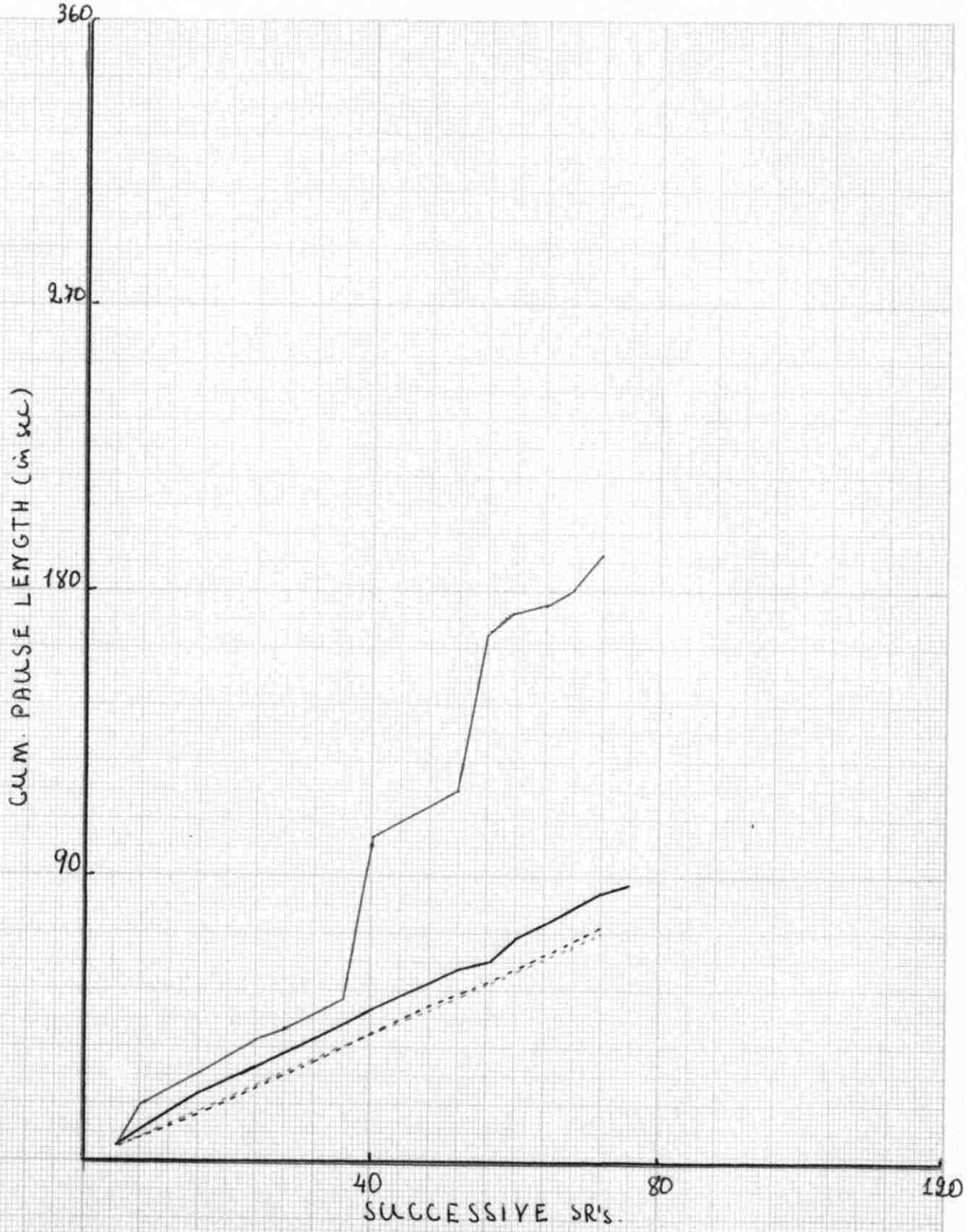

FIG. 44. Cumulative record of post reinforcement pause length on alternating mix FR15 FR45 FR15 FR135 with «4 cc. pre-feeding» of 1. K.4.

Moreover, when two components of the same magnitude in the schedule, pauses are longer after that one that precedes the longest ratio. In the cases when reinforcement was scheduled on mixed complex alternating mixed FR15FR45FR15FR5 short pauses occured after FR15 segment preceding FR5, indicating that the pause was under the control not only of the preceding FR15 but of the FR5 that followed.

This finding is consistent with previous findings[37] that the animals are able to discriminate the schedule as a whole.

Simple mixed ratios.

Rat K-5. Reinforcement was scheduled on mixed FR25FR45 with 6 cc. pre-feeding of the reinforcing agent. Figure 45 shows the last session after 29 sessions on this regime. The slopes of the curves diverged after 30 reinforcements when pauses after FR15 began lengthening. Pauses after FR45 remained relatively constant; towards the end of the session, however, after the animal had consumed 56 reinforcements, the pauses after FR45 also began to lengthen.

Rat K-6. Results of this animal are shown in Figure 46. Reinforcement density was decreased and scheduled on alternating mixed FR25FR45 with 6 cc. pre-feeding of 12% sucrose, the reinforcing agent.

Figure 46 shows a cumulative curve of pause length on the last session after 12, ½ hour experimental sessions.

Separation of the two curves occured fairly early in the session after the animal had consumed 20 reinforcements, with relatively long

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(37) Salman, M.A. Determinants of post-reinforcement pauses on fixed ratio schedules. Unpublished M.A. thesis, Amer. Univ. Beirut, 1962, p. 40.

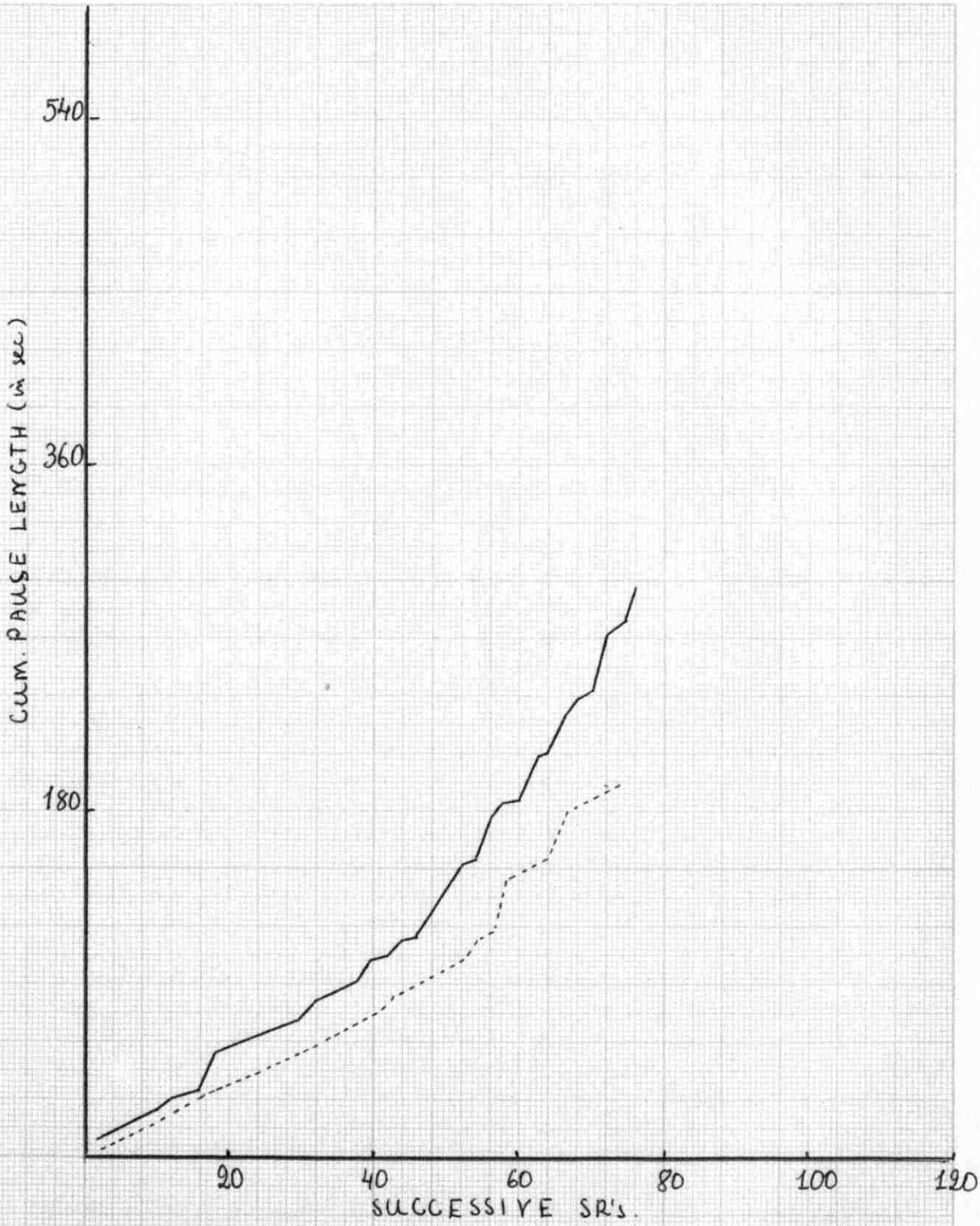

FIG. 45 Cumulative record of post-reinforcement pause length of the last session on alternating mix FR25 FR45 with «6 c.c. pre-feedings» of S. K-5.

The solid line shows pause length after FR 25
The dotted line shows pause length after FR 45

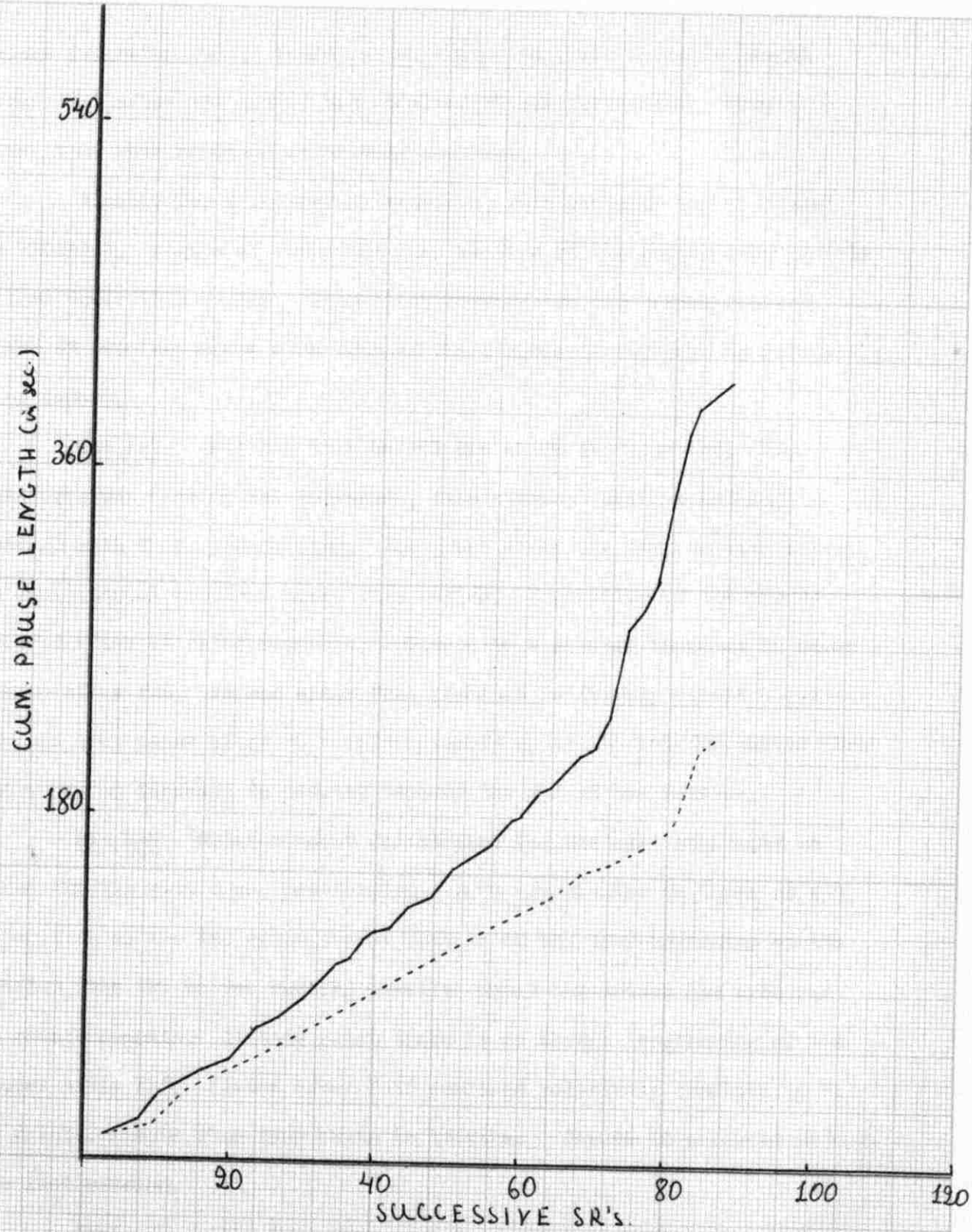

FIG. 46. Cumulative record of post-reinforcement pause length of the last session on alternating mix FR 25 FR 45 with «6 c.c. pre-feeding» of S. K-G.

The solid line shows pauses after FR 25
The dotted line shows pauses after FR 45

pauses following FR15. There was an abrupt increase in pause length after FR25 after the animal had received 20 reinforcements. Pauses after long runs remained relatively constant.

Finally for a further 18 sessions, reinforcement was scheduled on FR35FR45. Figure 47 shows the last session of the performance of this animal under this regime. Separation between the two curves occured after 58 reinforcements with both of the components followed by relatively long pauses.

Rat K-7. Data for this animal are shown in Figure 48. The reinforcement density was increased, reinforcement being scheduled on FR5FR15 with 6 cc. pre-feeding. The graph shows the last session after 29 experimental sessions under this regime. Separation of the curves occured after 54 reinforcements, followed by a gradual increase in pause length after FR5. Pauses after FR15 remained relatively constant (except for one long pause after 76 reinforcements) up to 140 reinforcements when there was an increase in pausing towards the end of the session.

Rat K-8. Reinforcement for subject K-8 was also scheduled on mixed FR5FR15 with 6 cc. pre-feeding. Data are similar to those of K-7. Separation of the two pause curves occured at the very beginning of the session, the two curves running parallel until the animal has received 26 reinforcements. At this point there is an abrupt lengthening of the pauses after FR5. Pauses after FR15 remained relatively constant up to 70 reinforcements when they began to lengthen. Figure 49 presents data of the last session.

Table VI on the following page demonstrates changes in schedule, drive level and number of sessions of subjects K5-8.

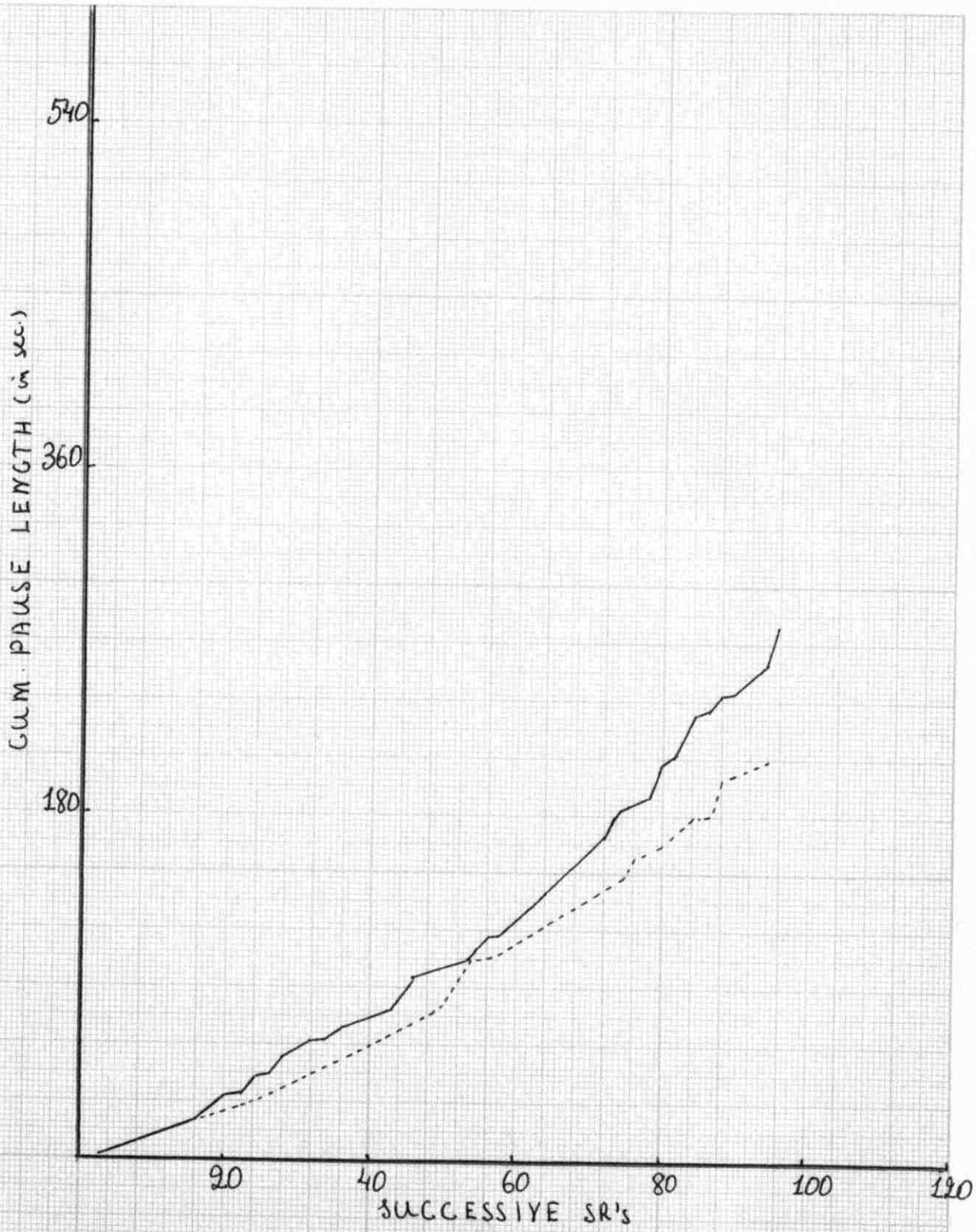

FIG. 47. Cumulative record of post-reinforcement pause length of the last session on alternating mix FR 35 FR 45 with «6. cc pre-feedings» of S. K-G.

The solid line shows pauses after FR 35
The dotted line shows pauses after FR 45

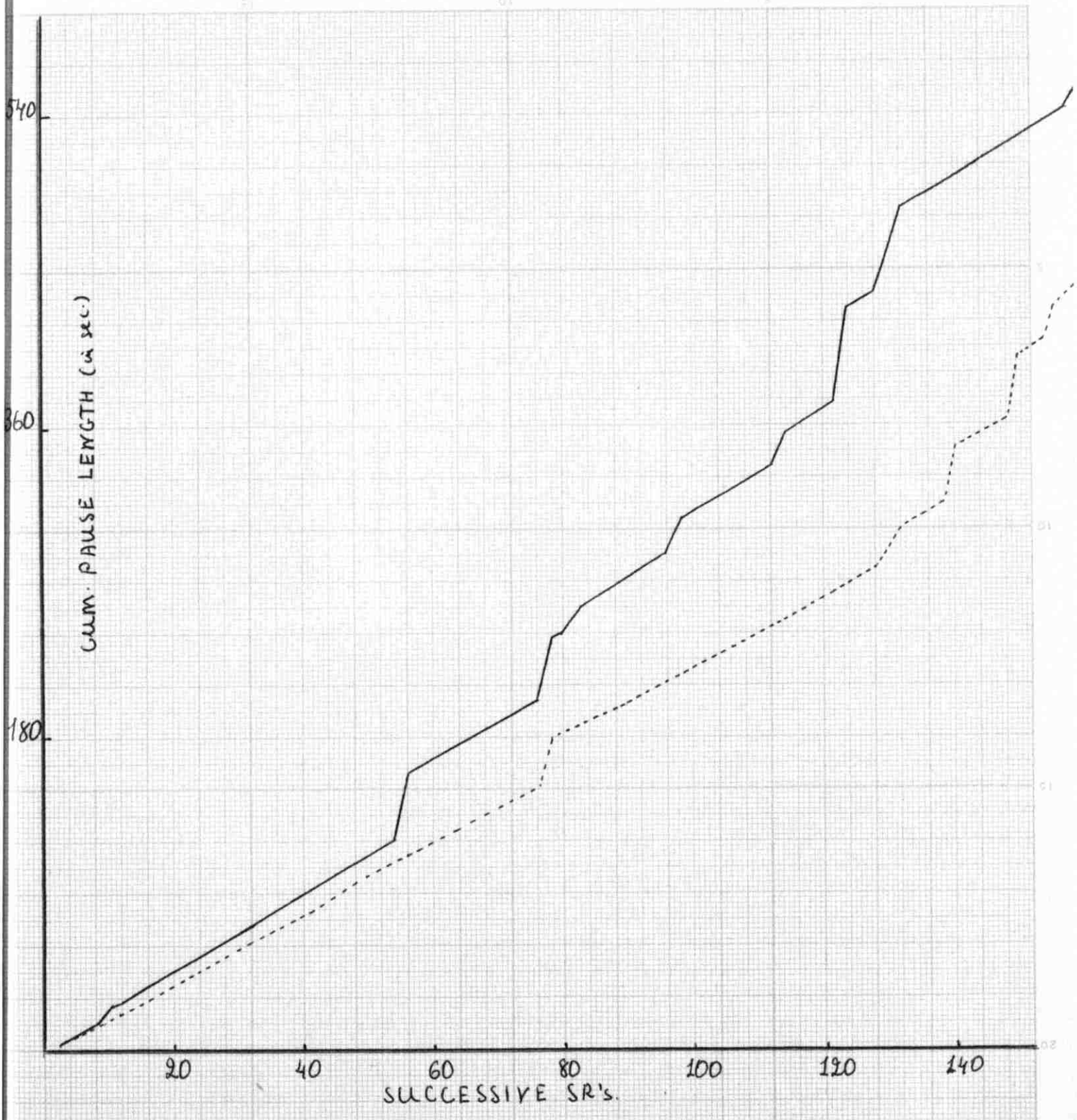

FIG. 48 Cumulative record of pause length of the last session on alternating mix FR5 FR15 with 0.6 c.c. pre-feedings of S. K-7.

The solid line shows pause length after FR 5

The dotted line shows pause length after FR15

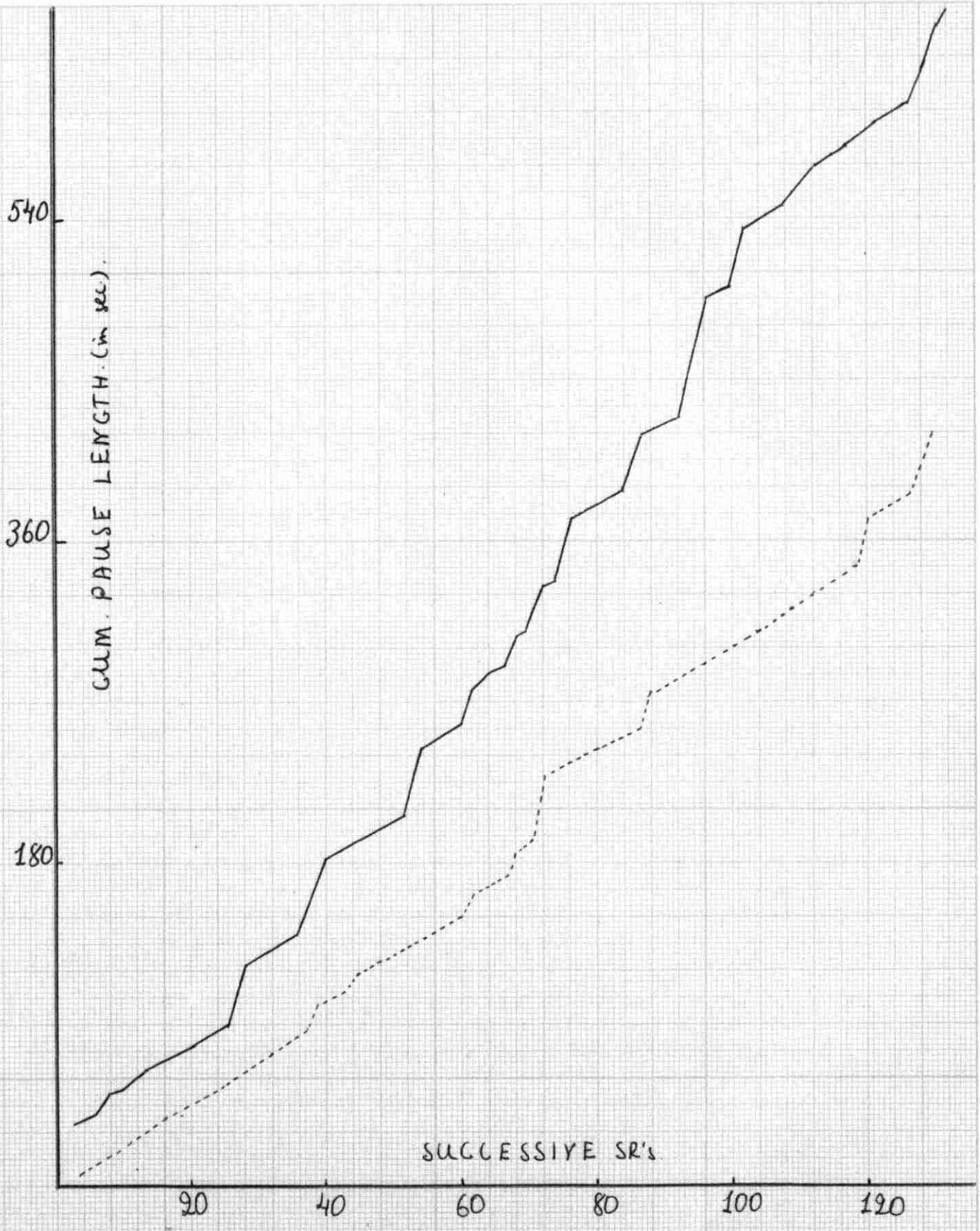

FIG. 49 Cumulative record of post-reinforcement pause length of the last session on alternating mix FR5 FR15 with «6.0.0. pre-feeding» of S.K.8
The solid line shows pauses after FR5
The dotted line shows pauses after FR15

Table VI

Changes in schedule, drive level, and number of sessions with 12% sucrose reinforcement for Ss K5-8.

Changes in schedule	Drive level	Subjects	Reinforcement agent	Number of sessions
FR25FR45	6 cc. pre-feeding	5	12% sucrose	29
"	"	6	"	11
FR35FR45	"	6	"	18
FR5FR15	"	7	"	29
"	"	8	"	28

In this subsidiary experiment of ours it was noted that when reinforcement was scheduled on alternating mixed FR25FR45 with 6 cc. pre-feeding (subjects K-5 and K-6) the cumulative curve of pauses after the longest ratio remained relatively constant with long pauses following the short runs. This is in agreement with previous findings of ours reported in Chapter III page 53.

In addition it was noted that when responses were reinforced on alternating mixed FR35FR45 (subject K-6) with 6 cc. pre-feeding differentiation of the cumulative curves occured later in a session with pauses following both short and long runs.

In those cases that the magnitude of both of the components was decreased and reinforcement was scheduled on FR5FR15 differentiation occured fairly early at the start of the session with long runs following the shorter component and shorter runs following the longer one, but the curve of the longer component did not remain constant within a session.

CHAPTER V

General discussion

In the first chapter it was shown that recent experimental evidence supports the notion that post-reinforcement pauses after reinforcements scheduled on fixed ratios are not merely determined by events that immediately precedethem, and that under certain conditions a given pause may be controlled by both the pre- and post-reinforcement runs.

The explanation given to the above findings is that post-reinforcement pauses are in fact determined by the preceding pattern of ratio runs but after repeated trials the animal discriminates the schedule as a whole and that the animal's performance is eventually controlled by stimuli arising from the animal's own behavior.

Some studies, also referred to in the first chapter, imply that post-reinforcement pause may be controlled by some other variables, such as motivation.

In this study we have been concerned with possible effects of motivation on post-reinforcement pause lengths on mixed alternating schedules of reinforcement. Particularly the interest has been to see the effect of the decrease in drive and change in reinforcement on pause lengths on mixed alternating schedules of reinforcement FR15FR45.

Results of other reinforcement schedules are also reported but these are of secondary importance.

Drive change.

In this experiment we showed that with mixed alternating schedules FR15FR45, the total amount of pausing following FR15 exceeds that after

FR45 under all four conditions of drive: 0 cc., 2 cc., 4 cc. and 6 cc. pre-feeding of 12% sucrose solution, the reinforcing substance, following 23 hours food and water deprivation. This finding is in agreement with recent experimental evidence and confirms Salman's[38] rejection of Hull's concept of reactive inhibition as an explanation of post-reinforcement pause lengths.

The present study does not support Boren's[39] explanation of the fatigue effect, in which there is an implication that since more responses are required for a larger ratio than for a smaller one, longer pauses should follow long runs.

It should, however, be remembered that Boren's study utilized simple FR schedules, and in these schedules it is not possible to tell which one of the two response sequences determines the length of the pause, the pre-reinforcement response sequence or the post-reinforcement response sequence, since runs before and after reinforcements are equal.

The fatigue effect as well as Hull's specific concept of reactive inhibition (Ir) is further challenged by another of our findings, which showed that there is a systematic effect in the development of post-reinforcement pauses with changing drive in mixed FR15FR45.

In the case of seven of our subjects (K2-8) the lengthening of pauses before FR45 increase earlier in the session with increasing amounts of pre-feeding, when the reinforcing substance is 12% sucrose solution.

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(38) Ibid., p. 39.

(39) Boren, J.J. Response rate and resistance to extinction as functions of the fixed ratio. Unpublished doctoral dissertation, Columbia Univ., 1953, p. 26.

If pauses were due to reactive inhibition or fatigue, they would be independent of pre-feeding. As fatigue increases with continued responding during a session, post-reinforcement pauses after both ratios should increase later in a session, but the experiment showed that with increasing pre-feeding pauses after short runs FR15 increased earlier in a session, but not those after FR45, thus demonstrating that with increasing training the animal comes to discriminate the schedule as a whole.

This latter finding also is not in agreement with the explanation of post-reinforcement pauses given by Sidman and Stebbins.(40) These investigators attributed the increase in the length of post-reinforcement pauses in long sessions of FR training solely to the effect of satiation.

But if increase of length pauses is only due to satiation then post-reinforcement pause length should increase after both short and long ratio runs with increasing satiation. This was not the case in the present experiment.

Another finding of ours is in agreement with Sidman and Stebbins(41) finding that with partial satiation there was an earlier and more frequent appearance of no responding.

In this experiment also, we found that the effect on post-reinforcement pauses of different amounts of pre-feeding is small, but we found that there are indications when pauses after FR45 decrease and those after FR15 increase slightly with more pre-feeding.

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(40) Sidman, M., and Stebbins, W.C. Satiation effects under fixed-ratio schedules of reinforcement. J. comp. physiol. Psychol., 1954, 47, pp. 114-115.

(41) Ibid., p. 115.

Shifts of reinforcement substance.

It was found in the present study that when the animals are trained with 12% sucrose concentration changing the reinforcing substance to water causes pauses to lengthen and become more variable, on the average, from day to day (K1-4).

Results of alterations in reinforcement schedules.

Results of alterations in the reinforcement schedules parallel to those of previous studies and the explanation given that post-reinforcement pauses are mostly determined by events immediately preceding them, but that the animal, after considerable training, comes to discriminate the schedule as a whole.(42)

In this subsidiary part of our study, it was found that when two components in the complex schedule were equal, pauses were longer after that one that preceded a long ratio than after the one preceding a short ratio. In the cases when reinforcement was scheduled on mixed alternating FR15FR45FR15FR5 shorter pauses occured after the FR15 segment preceding FR5, indicating that the pause was under the control not only of the preceding FR15 but of the FR5 that followed it.

Moreover, when reinforcements were scheduled on alternating complex mixed schedules with 4 cc. pre-feeding of 12% sucrose concentration, pauses preceding the longest run, while short at the beginning of a session soon become longer (K1-4) and that the larger the magnitude of the component the longer the pause preceding the long run (K3-4). This is in agreement with Findley's(43) findings mentioned previously in which it was

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(42) Findley, J.D. An experimental outline for building and exploring multi-operant behavior repertoires. J. exp. anal. Behav., 1962, 5, p. 132.
Salman, op.cit. p. 40.

(43) Findley, op.cit. p. 132.

shown that pauses after the equal ratios (FR132, FR132, FR132) were relatively uniform, whereas the pauses following FR132 before FR528 were considerably longer.

Two of our subjects (K-5 and K-6) confirmed findings from subjects K1-4 that when responses are scheduled on alternating mixed FRFR the cumulative curve of pauses after the largest ratio remained relatively constant with long pauses following the short runs.

One of our subjects (K-6) exhibited different behavior when reinforced on FR35FR45. Its performance demonstrated that differentiation occured later in the session, with pauses following both short and long runs. We cannot draw any reliable conclusion from this finding because data are the results of one animal only.

A tentative conclusion may be drawn from the finding that when reinforcement is scheduled on FR5FR15 with 6 cc. pre-feeding (K-7 and K-8) differentiation occurs very early at the start of the session with long runs following the shorter component and shorter runs following the longer one, but the curve of the longer component did not remain constant within a session.

Conclusions on the findings in this subsidiary experiment of ours, for all four animals (K5-8) are considered tentative, because of the relatively short period (3, ½ hour experimental sessions) that our subjects were reinforced during the second drive change from 4 cc. to 6 cc. pre-feeding.

SUMMARY

The basic characteristics of the performance observed in animals reinforced on FR schedules of reinforcement, as mentioned in the first chapter is (a) responding begins almost immediately after reinforcement and maintained at a fairly constant rate, (b) pauses occur immediately after reinforcement.

Explanations of these pauses are attributed to behavior that precedes them, as well as, that which follows them.

This study tests the effects of motivation on the relative lengths of post-reinforcement pauses after the component ratios of mixed FRFR schedules. The thesis tested also the results of alterations in the reinforcement schedules.

Two experiments were performed with 6 male and 2 female rats of local stock in the Skinner box apparatus.

Experiment I. In this experiment a group of 4 male rats were reinforced on mixed alternating FR15FR45 with 12% sucrose solution; and then the reinforcing agent was changed. With the reinforcing agent adopted (12% sucrose) the motivational level of the subjects was decreased. The animals were provided with varying amounts of pre-feeding with the reinforcing substance employed.

The experiment was repeated with a second group of 2 male and 2 female rats. Results obtained from this experiment showed that with mixed alternating schedules FR15FR45 changing drive from 0 cc. to 2 cc., 4 cc. and 6 cc. pre-feeding of 12% sucrose solution following 23 hours food and water deprivation, the total amount of pausing following FR15 exceeded that after FR45 in all four conditions. Moreover the length of pauses after FR15 during sessions increase earlier in the session

with increasing amounts of pre-feeding, when the reinforcing agent is 12% sucrose solution.

It was found also that when the animals are trained with 12% sucrose concentration, changing the reinforcing substance to water caused pauses to lengthen and become erratic from day to day.

Experiment II. Results obtained from alterations in the reinforcing schedules indicate that when two components in a complex schedule are equal, pauses are longer after that one that precedes the longest ratio.

Conclusions on the findings of the subjects K5-8 in this subsidiary experiment were considered tentative, because of the relatively short period (3, $\frac{1}{2}$ hour experimental sessions) that our subjects were reinforced during the second drive change from 4 cc. to 6 cc. pre-feeding.

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