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# THE EFFECT OF REINFORCEMENT SCHEDULE ON THE EXTINCTION PROCESS OF VERBAL CONDITIONED RESPONSES

by

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## PROBLEM

The present problem was to investigate the extinction process of the verbal conditioned response, analogous to Humphreys verbal expectation<sup>(5)</sup>, as a function of the pattern of reinforcement-frequency distribution. In usual intermittent reinforcement procedure the distribution of reinforcement is homogeneous over all acquisition series, therefore every block on the series has almost the same reinforcement frequency, whatever blocks we may arbitrarily pick up. Keeping the total numbers of trials and reinforcement (reinforcement ratio) constant, however, it is possible to get several sub-reinforcement ratios and to arrange them in various orders. Thus it is possible to arrange all kinds of patterns of reinforcement-frequency.

The phenomena of intermittent reinforcement are considerably important subject and have aroused a good deal of experiment and theorizing.

Humphreys found greater resistance to extinction which follows to 50 per cent reinforcement schedule than that which follows to 100 per cent reinforcement in classical, operant and verbal conditioning<sup>(4,5,6,7)</sup>. Other investigators have confirmed these findings and then carried out the experiments with different percentages of reinforcement. Furthermore recent studies indicated that some other independent variables involved in the intermittent reinforcement schedules had special effect upon the resistance to extinction, such as pattern of reinforcement<sup>(1,3)</sup>, intertrial intervals<sup>(12)</sup>, number of trials number of reinforcement<sup>(8)</sup>, and reinforcement-frequency distribution.

The last variable was suggested by Keller<sup>(9)</sup>. He trained two groups of rats to press a bar with continuous reinforcement to insure adequate strength of conditioning. After that one group of rats went through a sequence of continuous reinforcement and immediately afterwards went through periodic reinforcement. The other group went through reversed sequence. The resistance to extinction of the latter group was significantly superior to that of other group for first five minutes of the extinction process. This finding was supported by another recent study<sup>(2)</sup>.

From these findings it appears that the difference in pattern of reinforcement-frequency distribution may introduce different effect upon the extinction process, although total number of trials and reinforcements are all the same. But no systematic investigation have yet been carried out

with these sequential effects.

We want to clear up the problem through exploring the effect of various reinforcement frequency distribution upon the extinction of verbal conditioned response.

#### METHOD AND PROCEDURE

(I) Method. It is generally difficult to make start the conditioned response of nonverbal response under low frequency of reinforcement<sup>(11)</sup>, so that we used human verbal response. Our method was similar to that of Humphreys in the sense that we employed anticipatory response of human subjects, but different in measure which was used to estimate the anticipation level of each subject. In Humphreys' method subjects were instructed to guess on each trial, during the first light (conditioned stimulus) was on, whether the second light (unconditioned stimulus) would or would not turn on (conditioned response). They were then to note whether or not they had guessed correctly. It is obvious from the above that, in so far as Humphreys' guessing method is employed, subjects' anticipation responses are forced to divide into only two categories, "Yes" or "No", and the measure of anticipation level is the relative ratio of the number of subjects who responded with "Yes". Human anticipation is, in general, not always so reliable as to be able to affirm decidedly that particular one of two alternatives would occur certainly. Therefore even when all subjects might respond with "Yes", we can not believe that their anticipation levels were all 100 per cent, but can only say they exceed 50 per cent. If we want to consider the acquisition and extinction process of the verbal conditioned response in relation to that of other classical and operant conditioned responses, it is desirable to estimate quantitatively the anticipation level of each subjects and to make it comparable to reaction magnitude, latency, rate of responding or other measures of habit-strength. In order to get the quantitative index of the anticipation level, we employed a game method which is proposed by Toda as method for the strict measurement of intuitive-probability<sup>(13)</sup>.

(II) Method of the Game. In advance of the play, experimenter prepared a large number of rectangular cards, 7 by 10 centimeter in size. These cards were called gambling cards, either figure "10" or "0" was printed on each card, as the required set of the exclusive events. Score recording sheets were prepared. The game was just like gambling. The rules and procedure were as follows.

1) An umpire and two players constituted the member of the game. The experimenter played a role of umpire, two subjects were players: one of them was named "Parent" (P), another "Child" (C).

2) The experimenter provided a large number of the gambling cards and piled up in the required order. About the order, subjects were not informed. The pile of the cards was turned down. Then subjects were introduced into the experimental room and instructed about their tasks until they understood them completely.

3) The whole play consisted of as many sets as the number of the cards. The two players were to be given some points at each finish of the sets and the final gain or loss of the players were determined in proportion to their total points after the whole play was over.

4) Each set went on in the following manner: (a) P chose an arbitrary positive number "X" ( $0 \leq X \leq 10$ ) and presented it to C. (b) C had to choose one of the next two alternative cases:

Case (1); To make "X" P's score, and "Figure of Card" C's score.

Case (2); To make "X" C's score, and "Figure of Card" P's score.

After C had decided his choice the uppermost cards on the pile was turned up by the experimenter, if the card was "0",

in case (1), zero was scored as C's score (P's was X)

in case (2), zero was scored as P's score (C's was X).

If the card was "10"

in case (1), ten was scored as C's score (P's was X)

in case (2), ten was scored for P's score (C's was X)

5) The experimenter recorded the "X" and the score of the two players at the finish of each set. The play continued until the last card was turned up. The experimenter carefully observed whether the subjects were followed the instruction.

(III) Measure of the Anticipation Level. We regarded "X" chosen by Parent in each set as the index of his anticipation level for the event the card being "10", according to the theory of this game<sup>(13)</sup>. "X" varies only between zero and ten.

(IV) Procedure. We regarded one set of game as one trial of acquisition and extinction series, occurrence of "10" card as reinforcement" and "0" card as "non-reinforcement". All subjects were given an acquisition series consisted of 20 trials and an extinction series of 15 trials. Four different reinforcement schedules were used with four groups of subjects. The reinforcement schedules varied merely in the pattern of reinforcement-frequency distribution, total number of trial and reinforcement was equal for all schedules (50 percent reinforcement). The four groups were called respectively Noncontinuous-Continuous reinforcement group (NC group), Continuous-Noncontinuous reinforcement group (CN group), Progressive Increase reinforcement group (PI group), Progressive-Decrease reinforcement group (PD group).

Present study consisted of two experiments. NC group and CN group were used in the experiment 1, and the PI group and PD group in the experiment 2.

In the schedule imposed on NC group, three reinforcements were given for the first 13 trials intermittently and the last seven trials were continuously reinforced. Just reversed one of this schedule was given to CN group. In the schedule of PI and PD group, 20 trials were divided into four successive five-trial blocks, and then one, two, three and four reinforcements were apportioned to four blocks respectively. All subjects were reinforced at some time more frequently and at other time less

frequently through the whole acquisition series.

(V) Subjects. A total of 96 subjects were used, 24 (12 pairs of player) in each of the four groups. But four subjects were discarded in each groups, because their data showed that they did not follow the instruction carefully. The subjects were male and female junior students. They were run in group of two, i. e., "Parent and Child". Table 1 shows the design of our experiment and reinforcement schedule.

Table 1 Design of experiment and Reinforcement schedules

		Acquisition trials																				Extinction trials												
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	1	2	3	...	n	...	15						
Exp. I	NC group	○	×	×	×	×	×	×	○	×	×	×	×	○	×	×	○	○	○	○	○	○	○	○	○	○	○	×	×	×	...	×	×	×
	CN group	○	○	○	○	○	○	○	○	×	×	×	×	×	×	○	×	×	×	×	×	×	○	○	○	○	○	○	×	×	×	...	×	×
Exp. II	PI group	○	×	×	×	×	×	×	×	○	×	×	×	○	×	×	○	×	×	○	○	○	○	○	○	○	○	×	×	×	...	×	×	×
	PD group	○	○	○	○	×	×	×	○	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	...	×	×	×

○ reinforced trial    × non-reinforced trial

RESULTS

(I) Experiment 1.

In his unique experiment Keller found the sequential effect of continuous and non-continuous reinforcement upon the extinction process of the conditioned bar pressing response of rats. The main problem of experiment 1

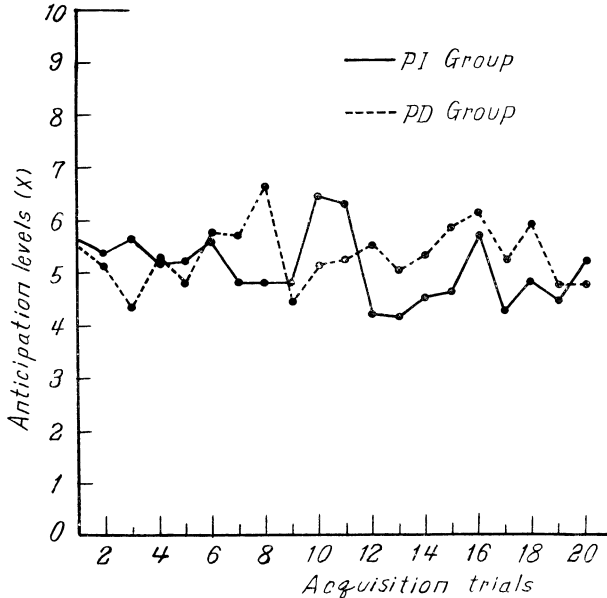


Fig. 1 Acquisition curves of NC and CN group, the mean of ten Xs in each trial is plotted.

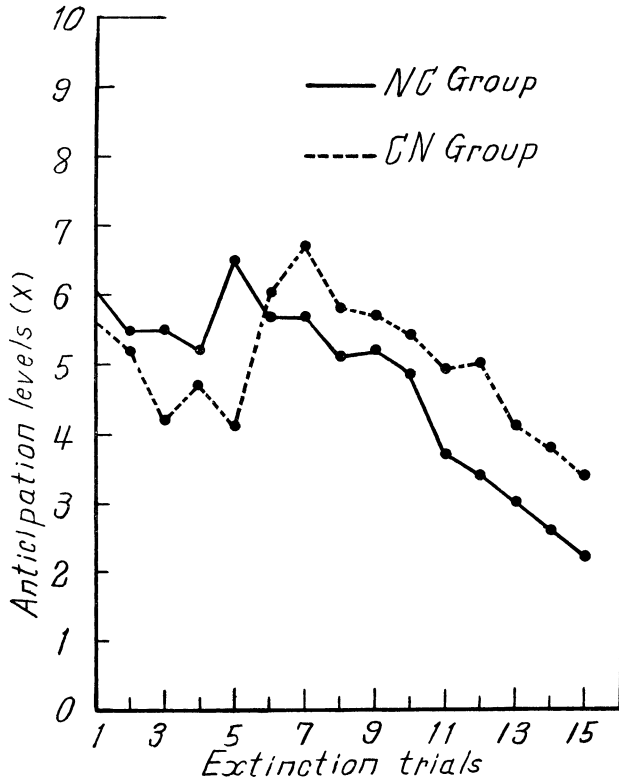


Fig. 2 Extinction curves of NC and CN group, the mean of ten Xs in each trial is plotted.

was to test whether the same sequential effect as appeared in rat behavior would or would not appear in human verbal conditioning. The essential findings of the experiment are shown in Fig. 1 and 2, in which the mean of ten "X"s chosen by Parents in each trial is plotted.

a) Acquisition. Both groups anticipated the card being "10" about 5 ~6 level at the start of the acquisition series. Thereafter the level varies irregularly. This fact seems to indicate that man used to expect generally the occurrence of particular one of two alternative events at about 50% level, unless he has any experience or information of its occurrence.

b) Extinction. Two groups are not significantly different from each other in their resistance to extinction as a whole, but the characteristics of two extinction curves are markedly different from each other. During the extinction series the anticipation level of both groups show initial rise before their progressive fall, and the maximum of the initial rise in NC group appears at the fifth trial, but in CN group at the seventh. Besides, the extinction curve of NC group progresses, in the first half of the series, keeping the anticipation level consistently superior to that of CN group. The curve beyond the maximum, however, drops off rapidly and crosses

other curve, thereafter the curve of NC group is always lower than the others. The difference between the anticipation levels of two groups was tested statistically at every trials. The results are shown in Table 2.

Table 2 The statistical test of difference between the anticipation levels of NC and CN group in each extinction trial

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	<i>n</i>
NC group	6.0	5.5	5.5	5.2	6.5	5.7	5.7	5.1	5.2	4.8	3.7	3.4	3.0	2.6	2.2	10
CN group	5.6	5.2	4.2	4.7	4.1	6.0	6.7	5.8	5.7	5.4	4.9	5.0	4.1	3.8	3.3	10
difference	+0.4	+0.3	+0.7	+0.5	+2.4	-0.3	-1.0	-0.7	-0.5	-0.6	-1.2	-1.6	-1.1	-1.2	-1.1	
t-test			*		***							*		*	*	

df=18 \* significant at or beyond 5% level of confidence

\*\*\* significant at or beyond 1% level of confidence

The anticipation level of two group is significantly different at the third, fifth, twelfth, fourteenth and the last trial. The direction of the difference reverses after the twelfth trial of the series.

Our results agree with the Keller's finding in the respect that the difference in reinforcement frequency distribution has different effect upon the extinction process, and that in the initial part of the extinction series the response level of group with continuous reinforcement just prior to extinction is superior to that of other group. But of the superiority of the latter group in the final part of our extinction series no other datum has ever reported.

#### (II) Experiment 2

From the data gained in experiment 1, it appeared to us that the every different patterns of reinforcement frequency distribution may introduce some different effect upon the extinction process, so we carried out the experiment 2.

Dividing the whole acquisition trials into four quarters, we apportioned different number of reinforcement to each quarter. There are 24 permutations of four things taken four at a time, we discarded 22 of them and focused our attention on only two representative patterns, i. e., general upward trend and downward trend in frequency. The finding of experiment 2 was summarized in Fig. 3 and 4.

a) Acquisition. Both groups of subject respond about the same level at the initiation of acquisition, and the curves do not swing largely. The largest swing occur at the middle part of the series. In the latter half of the series the curve of PI group runs consistently below that of PD group, though PI group was more frequently reinforced at that part. This is quite contrary to the fact generally found in other kinds of conditioned responses.

b) Extinction. Two groups are not significantly different in their resistance to extinction as a whole. Two extinction curves, however, progress taking different courses. The curve of PI group rises with steep gradient as far as the sixth trial, and then progressively drops off. On the other

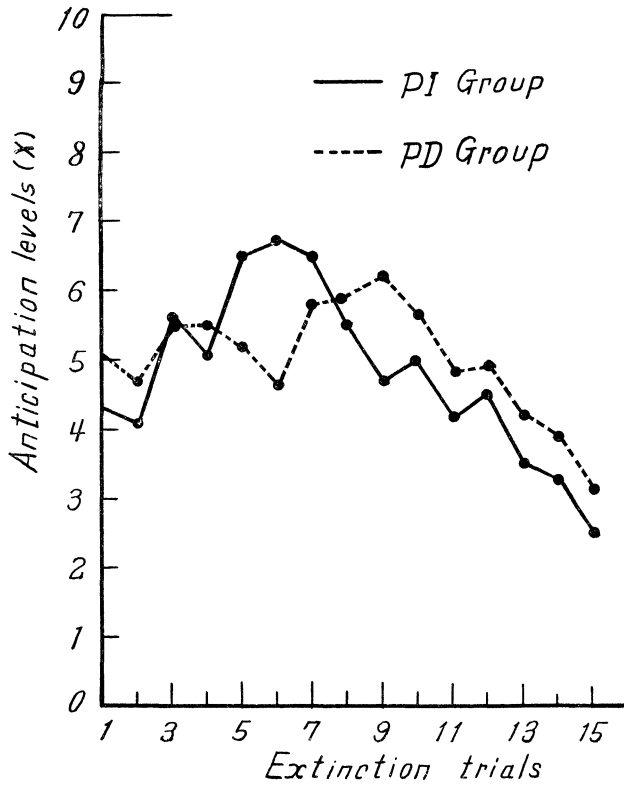


Fig.3 Acquisition curves of PI and PD group, the mean of ten Xs in each trial is plotted.

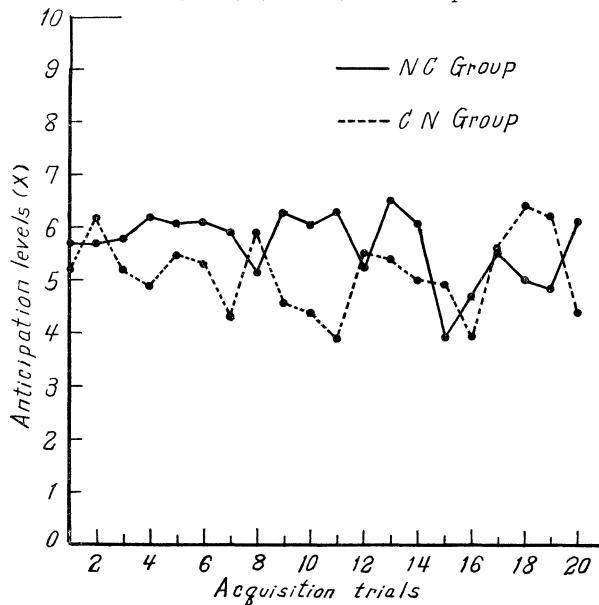


Fig.4 Extinction curve of PI and PD group, the mean of ten Xs in each trial is plotted.



hand the initial rising gradient of PD group is relatively gentle and does not get its maximum till the ninth trial.

The anticipation level of PI group, after the eighth trial, never rises above the level of PD group. The differences of the anticipation level of the two groups were tested by t-test at each trial. Table 3 shows the results.

They are significantly different at the sixth and the ninth trial. These difference means that the difference in reinforcement schedules had effected differently upon the extinction process itself of anticipation response, through there is no difference between the resistances of extinction as a whole.

Table 3 The statistical test of difference between the anticipation levels of PI and PD group in each extinction trial

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	<i>n</i>
PI group	4.3	4.1	5.6	5.0	6.5	6.7	6.5	5.5	4.7	5.0	4.2	4.5	3.5	3.3	2.5	10
PD group	5.0	4.7	5.5	5.5	5.2	4.6	5.8	5.9	6.2	5.6	4.8	4.9	4.2	3.9	3.1	10
difference	-0.7	-0.6	+0.1	-0.5	+1.3	+2.3	+0.7	-0.4	-1.5	-0.6	-0.6	-0.4	-0.7	-0.6	-0.6	
t-test						***			**							

df=18

\*\* significant at or beyond 2% level of confidence

\*\*\* significant at or beyond 1% level of confidence

## DISCUSSION

The results of the experiment 1 and 2 indicated the following two facts.

1) The maxima of the initial risings of the two groups (NC & CN) which were given higher frequency reinforcement just prior to extinction and low frequency in the initial part of the acquisition series appear at relatively early extinction trials. But the maxima of other two groups which were reinforced with low frequency just prior to extinction and high frequency in the initiation appear at later trials. These facts mean that the anticipation level of NC and PI groups are relatively higher in the initial part of extinction than that of CN and PD group, and at the final part of the extinction CN and PD group are superior to NC and PI group in their anticipation levels. The differences between the levels of two groups in respective experiment were significant at several extinction trials.

2) The maxima of the initial rise of two groups in experiment 1 appeared at relatively early extinction trials in comparison with the position of the maxima of the groups in experiment 2. This is just in contradiction to the theory of response unit to which we shall refer later.

Present findings pose some problem of interpretation. Several hypotheses which have ever been proposed to account for the findings intermittent reinforcement are not adequate for explanation of our findings. Thus an explanation in term of simple expectancy<sup>(5)</sup> is inadequate. Granted that the subjects responded according to their expectancy as to the occurrence of

particular one event, it is impossible to account for the reason why the different reinforcement schedules we used had influenced differentially on the expectations of subjects, or at least it is impossible to predict the results.

The response unit hypothesis<sup>(10)</sup> is inadequate too. According to the response unit explanation, a set of non-reinforced responses which are reinforced by a terminal reinforcement forms an unit of response. As the maximum number of continuously given non-reinforced trials are the same for both groups in each of our experiments, the largest "unit" of response formed in the acquisition series should be equal for both groups. Therefore, according to the hypothesis, the extinction process must be alike for the two groups. Our results are, however, contrary to the prediction from the view point of response unit hypothesis.

The hypothesis recently proposed by Scheffield would predict that the maximum of initial rising gradient appears at about the same trial for the two groups in each experiment, because they were equally conditioned to high frequency and low frequency of reinforcement, though the sequence of frequency distribution was reversed. This is also contrary to our results.

There are three possible factors which seem to determine the position of maximum on the extinction series. The first is to reinforce with low frequency in initial part of acquisition trials, the second is to reinforce with a high frequency in the final part of the acquisition and the last is to change the reinforcement frequency through the whole acquisition series. We cannot determine, on the basis of above gained results, which is the most essential factor of the three. The further refined and exact experiment on the other kinds of conditioned response might possibly offer the clear analysis for the dominant factor of these three.

## SUMMARY

The acquisition and extinction process of the verbal conditioned response was studied as a function of the reinforcement frequency distribution. The four groups of subjects were trained with four different reinforcement schedules to anticipate the occurring of the particular one of two exclusive events. The anticipation levels of each subjects were measured by a game method just like gambling. All reinforcement schedules had the acquisition series which are consisted of 20 trials and the extinction of 15 trials, while keeping the reinforcement ratio constant (50%). The schedules are varied in the pattern of reinforcement frequency distribution, i. e., Non-continuous-Continuous reinforcement, Continuous-Noncontinuous reinforcement, Progressive increase reinforcement and Progressive decrease reinforcement schedule. The first two schedules were employed in experiment 1 and the others in experiment 2.

The results of two experiments indicated that the difference in reinforcement frequency distribution had the marked effect upon the extinction process: The positions of the maximum of initial rising gradient were different between four groups, especially, in extinction of two groups reinforced with high frequency just prior to extinction, the maximum of gradient appeared at relatively initial trial, but in the extinction of the other two groups which were reinforced with low frequency just before the extinction, the appearance of maximum was relatively late.

The theories which have ever been proposed to account for the intermittent reinforcement phenomena are inadequate to explain the present findings without some supplementary constructs.

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## RÉSUMÉ

Le procédé de l'acquisition et de l'extinction de la réponse verbale conditionnée a été étudié comme une fonction de l'arrangement du fréquence de renforcement. Les quatre groupes de sujets ont été exercés, avec quatre cahiers à différent renforcement, pour anticiper l'occurrence d'un évènement particulier des deux évènements exclusifs. Les niveaux d'anticipation de chaque sujet ont été mesurés par un méthode de jeu comme l'on fait au "gambling". Tous les cahiers de renforcement avaient des séries d'acquisition composées de 20 épreuves et l'extinction de 15 épreuves, le rapport de renforcement se tenant constamment (50 %). Les cahiers ont été variés selon le modèle de l'arrangement du fréquence de renforcement, c'est-à-dire, renforcement noncontinu-continu, renforcement continu-noncontinu, renforcement d'augmentation progressif, et renforcement de décroissement progressif. Les premiers deux cahiers ont été employés dans l'expérimentation 1 et les autres dans l'expérimentation 2.

Les résultats de deux expérimentations ont indiqué que la différence dans l'augmentation du fréquence de renforcement avaient un effet remarqué sur le procédé d'extinction: Les positions du maximum de l'initiale rampe montante ont été différents entre quatre groupes, surtout, dans l'extinction de deux groupes renforcés par une haute fréquence toute antérieure à l'extinction, le maximum de rampe apparue relativement à l'épreuve initiale, mais dans l'extinction des autres deux groupes qui étaient renforcés par une basse fréquence toute avant de l'extinction, l'occurrence de maximum a été relativement tarde.

Des théories qu'on a proposées jusqu'à présent pour expliquer les phénomènes du renforcement intermittent étaient insuffies d'expliquer et découvertes sans quelque construction supplémentaire.

## ZUSAMMENFASSUNG

Die Erlernung-und der Erlöschungsvorgang der wörtlich bedingten Reaktion wurde als die Funktion der Verteilungsweisen der Verstärkungshäufigkeit erforscht. Vier Gruppen der Vpn. wurden je nach den vier Aufstellungen der Stärkungshäufigkeit eingeübt. In jedem Versuch sollten die Vpn. vorhersagen, welcher von den zwei alternativen Fällen vorkommen werde. Die Antizipationsniveau jeder VP. wurde nach der Methode gemessen, welche derjenigen eines Würfelspiels ganz ähnlich ist. Jede experimentelle Einrichtung enthielt 20 Versuche der Erlernung und 15 Versuche der Erlöschung, dabei war aber die Verstärkungsratio immer konstant (50 %). Die Einrichtungsweisen der Verstärkungshäufigkeit in vier Gruppen waren wie folgende: die unterbrochen-kontinuierliche Stärkung, die kontinuierlich-unterbrochene, die nach und nach zunehmende und die nach und nach abnehmende. Die ersten zwei Einrichtungsweisen wurden in dem Experiment 1 und die zwei anderen in dem Experiment 2 verwandt.

Die Versuchsergebnisse zeigten, dass die Verschiedenheit der Einrichtungen der Verstärkungshäufigkeit eine entscheidende Wirkung auf den Prozess der Erlöschung ausübt. Vor allem in den zwei Gruppen, wo ganz häufige Stärkung gerade vor der Erlöschungsperiode gegeben war, kam das Maximum der ersten Steigung verhältnismässig früher vor. In den anderen zwei Gruppen, wo seltene Stärkung gerade vor der Erlöschungsperiode gegeben war, kam das Maximum relativ später vor.

Die Theorie, welche bisher vorgebracht wurde, um die Vorgänge der intermittierenden Verstärkung zu erklären, gilt nicht von unseren Ergebnissen ohne irgendeine Ergänzung.