CHANGES OF THE GENERAL ACTIVITY LEVEL OBSERVED DURING CLASSICAL CONDITIONING WITH ALIMENTARY REINFORCEMENT IN THE ALBINO RAT [1)]

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In discussing the training process in various types of learning experiments, stress has usually been placed on the acquisition and the extinction processes of the responses which are directly relevant to reinforcing agents, with less regard to the change of the general activity level under different experimental situations. But some researchers suggested, with experimental evidence to support them, that the response vigor in *frustrative* situations caused from early training procedures might have a tendency to increase (Miller, N. E., & Stevenson, S. S., 1936; Finch, G., 1942; Lawson, R., & Mark, M. H., 1958). For instance, Finch described how chimpanzees pressed response-bar down fiercely, immeditely after the reward contingent to the response had been removed. Although those emotional behaviors were familiar to some researchers as far as inspective observations were concerned, the descriptions referring to those phenonmena were based only upon the casual and ambiguous observations on the behavior of experimental subjects, without any relation to objective measurements.

Sheffield, F. D., & Campbell, B. A. (1954) and Amsel, A., & Roussel, J. (1952), however, dealt with those problems in a series of well-designed experiments with quantified mesures which seemd to indicate a change of the general activity level. Sheffield et al. observed the change of the restless activity under paired presentations of external stimuli and feeding which could be regarded as a kind of delayed classical conditioning procedure, whereas Amsel et al. measured the running speed of rats which was considered belonging to the instrumental behavior. The latter group of workers considered that the change of the response vigor in the frustrative situations was reflected in the instrumental behavior.

The purpose of the present article is to evaluated some problems concerned with the

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modifications of the general activity during learning processes on the bases of the findings of several experiments carried out by the present author and his co-workers, and to suggest that the emotional aspects in learning process should be taken into account in the formation and development of the behavior theory. In the present article, the problems concerned with the change of the general activity level during classical conditioning with alimentary reinforcement are dealt with.

GENERAL ACTIVITY LEVEL OBSERVED DURING EXPERIMENTS OF DELAYED CONDITIONING

Using stabilimeter activity cages of the contact type, Sheffield & Campbell found the increase in the general activity level in food deprived rats was produced by a change of external stimulation in an otherwise constant environment. For one experimental group and one control group, the environmental change consisted of turning off a masking sound and turning on lights in a normally dark environment ; for another experimental group and another control group, the change of stimulation consisted of turning off the sound and the lights in a normally lighted environment. For the experimental groups, the 5 min periods of the stimulus change in the auditory and visual fields were always followed immediately by the automatic dropping, into the activity cages, of the daily food ration. For the control groups, the stimulus change was not accompanied by food. Their daily ration was dropped automatically at a time different from the phase of the stimulus change. Animals of experimental groups showed a progressive rise over a 12-day period in the amount of activity during the 5-min stimulus change preceeding food dropping, while animals of control groups showed a decline over 12 days. Also, when the activity during the 5-min interval was plotted minute by minute in the experimental groups, it was found that the acquisition of increased activity during the last 3 days of the training was greater in the later portions of interval. According to their interpretation, the change of the activity level is regarded, not as direct results of learning, but as results of a correlated manifestation of the *frustration* consequently produced when a consummatory response is aroused by conditioned stimulus, but the goal object is not immediately accessible. Their assumption was called later "frustration-excitement hypothesis" by Hulse and Stanley (Hulse, S. H., & Stanley, W. C., 1956). In fact, it would not be always easy to assert that animals were frustrated when drive was present and the consummatory responses were stimulated but prevented from occurring, because any physiological measure or objective behavioral measure was not observed except for the change in the restless activity.

The present author carried out two experiments with Takenaka (Takenaka, H., & Iwamoto, T., 1960) which seemed to have a close relation to the experiment of Sheffield & Campbell. In Experiment I, the procedure used was similar to that of their experiment

except that the testing (extinction) sessions were added and activity wheels[2] were used instead of the contact-stabilimeters. The *Ss* were 32 male albino rats of in-bred Wister strain. They were experimentally naive and approximately 140 days old at the start of the experiment, weighing from 160 g to 240 g with a mean of 207 g. The *Ss* of the experimental group (N=16) were placed in an activity wheel, which was covered with a wooden cabinet having a flickering light and a feeding mechanism within it (Fig. 1). In the acquisition sessions after the adaptation session of one day, they received the flickering light of 1 cps in the apparatus. After 10 min, the light was turned off and the *Ss* were fed for 60 min, and then they were detained in the apparatus for 30 min without any stimulus change. The *Ss* of the control group (N=16), which were matched to those of the experimental group on the level of activity observed in the adaptation session, were given the same procedure except that the order of lighting and feeding was exchanged, that is, the feeding for them started 10 min after they were placed in the wheel, and given the flickering light for 10 min after the feeding for 60 min, and then, they were retained for 20 min in the wheel. It might be said that the *Ss* of the experimental group experineced the procedure of classical delayed forward conditioning. On the other hand, the *Ss* of the control group experienced that of classical delayed backward conditioning. The acquisition sessions were composed of one trial a day for 9 consecutive days. After that, the testing sessions of three days were given, which consisted of lighting for 10 min followed by detention for 20 min. They were not fed in the wheel in those sessions. Procedures used in the testing sessions were entirely identical in both groups. Records were obtained from the numbers of revolutions of the activity wheel, in which the unit of measurement was one fifth of 360° revolution.

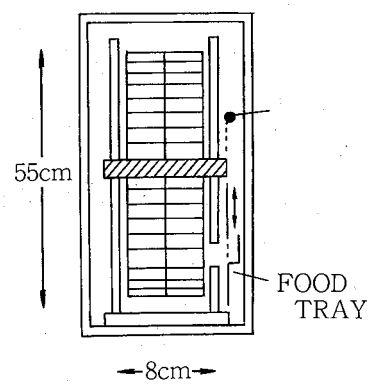

Fig. 1. Cross section view of activity wheel used experiments run by Takenaka, H., & Iwamoto, T., 1960.

In the acquisition sessions, as shown in Fig. 2 and Fig. 3, the amount of activity of the experimental group in the lighting phase was larger than that of the control group both in

2) The difference among the apparatuses used for measuring the general activity in the rat should be paid an important consideration (Strong, P. N. Jr., 1957). In a recent study which dealt with the factorial structure of the general activity in the rat of Wister strain using 8 kinds of the activity measures, the general factor was not found in any feeding condition, and only several specific factors were found (Iwamoto, T., & Umeoka, Y., 1966). But the results of factor analyses of the centroid method and the varimax rotation method revealed that the geometric distance between the stabilimeter of contact type and the activity wheel was considerably short.

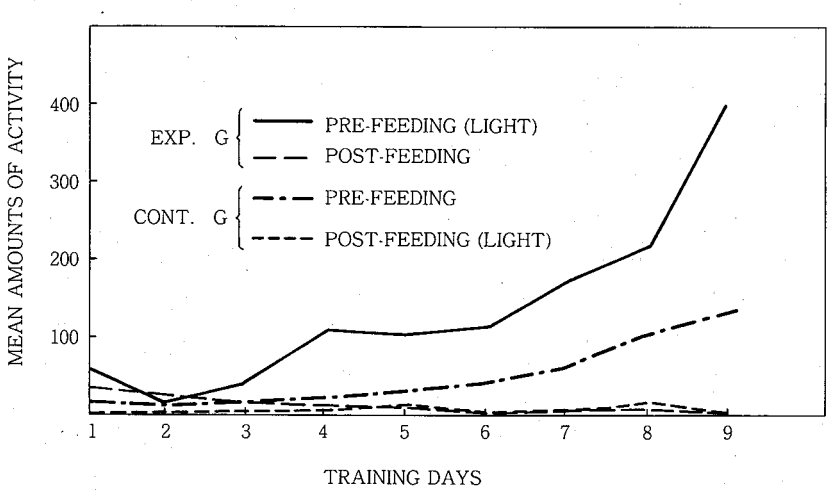

Fig. 2. Mean amounts of activity in each 10 min of the training sessions.

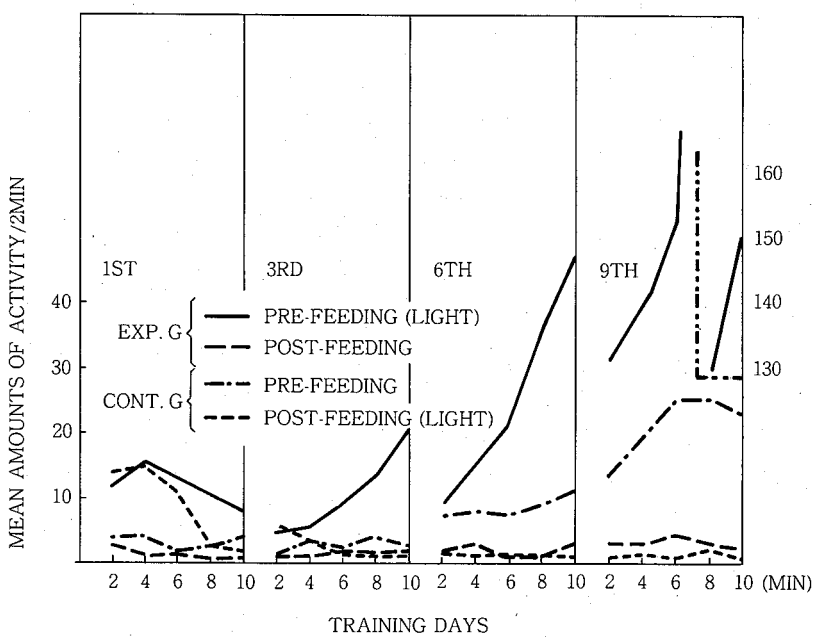

Fig. 3. Mean amounts of activity per 2 min in each 10 min period of 1st, 3rd, 6 th, and 9 th training day.

the lighting phase and in the pre-feeding phase. In the experimental group, the amount of activity in the lighting phase per minute was also larger than in the non-lighting phase of the same group. Also, when the activity during the 10 min interval was plotted every 2 min, it was found that the amount of the activity of the experimental group in the lighting phase increased as the periods came close to the feeding phase. These tendencies were more conspicuous at the later sessions of acquisition. In other phases in both groups, any distinctive trend was not observed. In the testing sessions, as shown in Fig. 4, the amount of activity of the experimental group for 30 min each day increased gradually during the lighting phase, achieved a peak at about 10 min after the onset of the session, and then decreased rather rapidly, while the control group did not show any distinctive shape and their activity levels were considerably lower. Both groups had the similar tendencies mentioned above througout the respective testing sessions, although the activity level of the experimental group and the control group became lower and lower as the testing days passed by. The results in the acquisition sessions coincided well with the findings of Sheffield & Campbell, and it was supposed that the results observed in the testing sessions which were not run in their experiment, were also in line with their hypothesis.

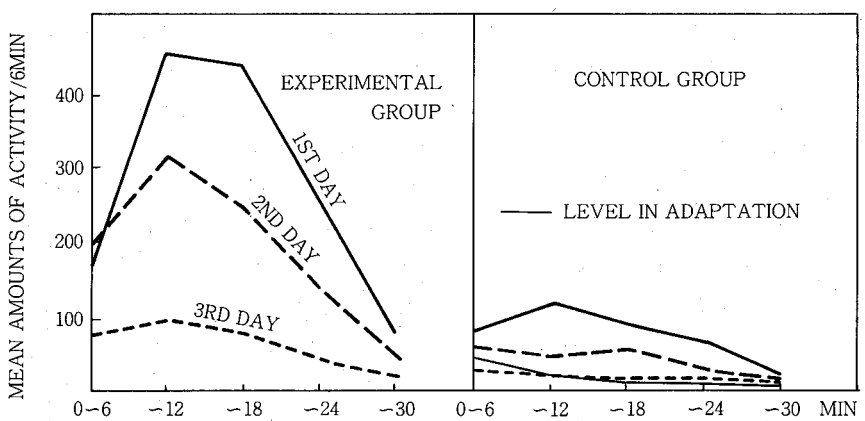

Fig. 4. Mean amounts of activity per 6 min period in each testing session.

It is clear that the feeding procedures used by them and by Takenaka & Iwamoto are extremely different from the procedure used in the familiar type of classical conditioning. First, the *Ss* of their experiments received the whole quantity of food required for a day at a time, while the *Ss* of usual classical conditioning experiments using food as reinforcement received only a small quantity of food, accompanied with the change of external stimulation in every trial each day, and they were given the remaining quantity of daily ration without any relation to learning after daily session had finished. Second, the former received an unconditioned stimulus after a conditioned (or cue) stimulus was presented for 5 min or 10

min once a day, while the latter received unconditioned stimuli many times a day respectively, immediately after every conditioned stimulus was presented for a few seconds. From the differences referred to above, it seemed necessary to run a mediating experiment, in order to apply the findings of Sheffield & Campbell and those of the present author and his co-workers to the situations in the familiar learning experiments. An experiment was designed to test this consideration.

In Experiment II, the *Ss* of the experimental group (N=16) and the control group (N=16) were given the same order of lighting and feeding as in Experiment I, respectively. But there were much differences from Experiment I in the duration of lighting time, in the amount of food given in each paired presentation, as well as in the number of paired presentations of lighting and feeding; lighting duration in each trial was 20 sec, the amount of food in each feeding was limited to 250 mg, and the number of paired presentation of lighting and feeding of 5 sec was 10 each day in the acquisition sessions. The apparatus used in Experiment II was essentially similar to that in Experiment I, and the *Ss* consisted of 32 male albino rats of in-bred Wister strain. They were experimentally naive and approximately 130 days old at the start of the experiment, weighing from 170 g to 210 g with a mean of 191 g. There were no difference between the experimental group and the control group except for the reversed order of paired presentation consisting of lighting and feeding. The acquisition sessions were composed of 10 paired presentations a day for 3 consecutive days. The inter-trial intervals were varied from 120 sec to 210 sec with a mean of 180 sec. They were tested for 30 min for a day without feeding. The results of Experiment II differed from those of Experiment I as far as the acquisition sessions were concerned. The amount of activity observed in the experimental group did not differ significantly from in the control group in early acquisition sessions, and the amount of activity in both groups gradually decreased as the acquisition procedure proceeded in each day (Fig. 5.). It was found that the

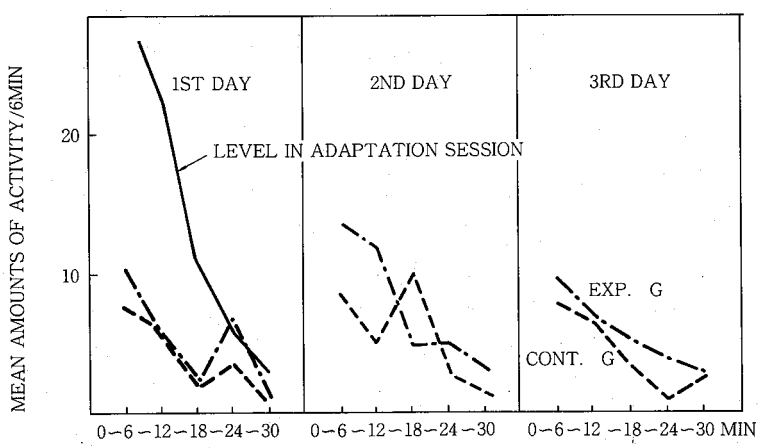

Fig. 5. Mean amoun s of activity per 6 min period in each training session.

differences between the amount of activity in the lighting phase in the experimental group and that in the control group were statistically significant, and difference between the density of activity in the lighting phase and in the non-lighting phase in the experimental group was also significant. There was no statistically significant difference on the same measurements in the control group. These findings might be attributed to the small magnitude of consummatory response caused by the small reinforcing value of every trial and the short duration between external stimulation and feeding. But in the testing session, as Shown in Fig. 6, the enhanced activity level was observed again in the experimental group, while the amount of activity in the control group was similar to that of the testing sessions of the contorol group in Experiment I. It would be difficult to decide from the reason referred to above, whether the *Ss* in the situation that were given only the change of external stimulation previously associated with reinforcement were *frustrated* or not. However, it may be concluded at least the *Ss* that had received paired presentations of conditioned stimulus and food showed a remarkable increase of activity level in the situation in which only conditioned stimulus was presented. In view of these facts, it might be suggested that the operant responses relevant to reinforcement might be facilitated apparently by the result of the enhanced general activity level in a situation which is *frustrative* but has no "outlet" of the enhanced activity such as the activity wheel in these experiments.

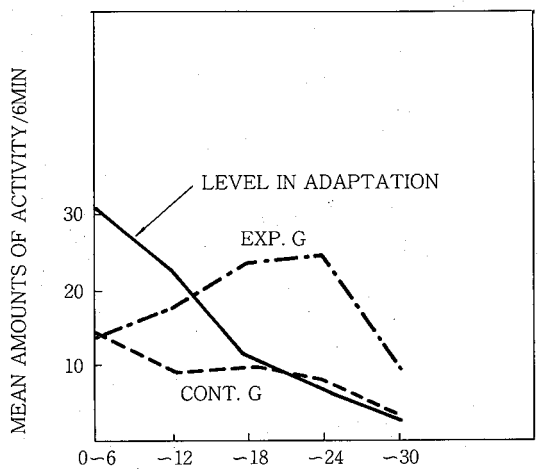

Fig. 6. Mean amounts of activity per 6 min period in the testing session.

GENERAL ACTIVITY LEVEL OBSERVED DURING EXPERIMENT OF SECONDARY CONDITIONING

The re-examination and re-analysis based upon these findings were performed on the data obtained from the experiments concerned with the secondary reinforcement procedure using a Skinner box as the apparatus and the bar-pressing response as a function of the secondary reinforcement effects. Bersh submitted a hypothesis that the effectiveness of the secondary reinforcement is a function of the duration of a neutral stimulus presented prior to the presentation of a primary reinforcing agent (Bersh, P. J., 1954). In his Experiment I,

the duration of a light prior to the dispensing of food was systematically varied, and the effect of such variation upon the acquisition by the neutral stimulus of power to reinforce a previously untrained operant was measured. The 6 groups different in respect to the length of intervals between light and food were given 160 pairings in the training sessions of 6 consecutive days. Subsequently, in the testing sessions the bar absent during the training sessions was again made available, and each bar-pressing produced the light for 1 sec which had been presented by Experimenter in the training sessions. He suggested that the obtained curve, based upon bar-pressing totals for 1.5 hr in the testing sessions of three days, showed clearly a maximum value in the range between 0.5 sec and of the duration, and concluded that those results were attributable to the secondary reinforcing effect of light which had previously associated with the primary reinforcing agent, since the number of the bar-pressing of all groups in the testing sessions was significantly above the respective operant levels. However, when his experimentation is examined in detail, it will be noticed that the procedure used by him had some parts closely similar to those of Experiment II run by Takenaka and the present author, as mentioned in the earlier parts of this article. The main difference relating to the experimentation between them seems to be only in the procedure of light stimulation in the testing sessions, that is, the *Ss* of Bersh's experiment received light stimulation by their own bar-pressing responses, whereas the *Ss* of the present author's experiment received light stimulation, at a pre-determined inter-trial intervals, by Experimenter in the testing session as well as in the training sessions. If the difference of the experimental procedures between the two studies did not cause so much variations in the emotional aspects in the testing session, and if the *Ss* of Bersh's experiment were *frustrated* according to the hypothesis of Sheffield & Campbell, it seems to leave a room for another version on the results observed in Bersh's Experiment I, and also, on the results obtained from other experiments of the secondary reinforcement using similar procedures.

A further experiment was designed to investigate directly the alleged facilitating effects of the general activity level on the relevant responses (bar-pressing, in this case) during the testing process in the secondary reinforcement training (Iwamoto, 1962). In Iwamoto's Experiment I, the procedure used as essentially similar to Bersh's Experiment I, mentioned above, except that, instead of a Skinner box, an activity wheel similar to that shown in Fig. 3, which had a bar for the operant response, a lighting source, and a feeding device contained within the wheel or the wooden cabinet, was used to record the changd of the general activity level as well as the bar-pressing response associated with the secondary reinforcer through the learning course. The *Ss* were 28 male albino rats of in-bred Wister strain. They were estimated to be about 130 days olds at the start of the experiment, and weights ranged from 140 g to 180 g with a mean of 167 g. Prior to the training, the adaptation sessions of three consecutive days were given in which each bar-pressing response

by animals produced a light for 3 sec, and the operant level of the bar-pressing was recorded for each animal for 30 min on the third day. In the training sessions, the bar was withdrawn, and according to the score of the operant level and the amount of activity in the adaptation sessions, the *Ss* were divided into two groups of the same size; the F (paired-presentation of forward conditioning) group and the B (paired-presentation of backward conditioning) group. The *Ss* of the F group were given 30 presentations of 3 sec light followed by two pellets of 50 mg of food for each day and for 6 consecutive days. The *Ss* of the B group received the same pairings of light and food, but in a reversed order. Then, in the testing session, the bar was re-inserted, and each group was further sub-divided into two groups of the same size; the Lc (light contingent to bar-pressing responses) group and the NLc (non-light contingent to bar-pressing responses)group, respectively (Table 1). The procedure in the testing session for the Lc groups was the same as in the adaptation sessions, whereas in the NLc groups, the light was presented by Experimenter, independetly of *S*'s bar-pressing responses. But there were the restrictions that the number of light presentations as well as the distribution their intervals were the same both in the F-N Lc group and in the F-Lc group, and both in the B-NLc group and in the B-Lc group. The order of experimentation for each *S* could not be randomized perfectly on account of the experimental restrictions, that is, each *S* of the F-Lc group and of the B-Lc group was followed by each *S* of the F-NLc group and of the B-NLc group, respectively. Each *S* of the F-Lc group and of the F-NLc group on the one hand, and each *S* of the B-Lc group and of the B-NLc group on the other had been matched by the level of the general activity and the operant response in the adaptation sessions, respectively. The summarized results of this experiment were as follows.

TRAINING SESSIONS	TESTING SESSION: LIGHT CONTINGENT	TESTING SESSION: NON-LIGHT CONTINGENT
FORWARD PAIRED PESENTATION	F-Lc GROUP (N=7)	F-NLc GROUP (N=7)
BACKWARD PAIRED PRESENTATION	B-Lc GROUP (N=7)	B-NLc GROUP (N=7)

Table 1. Summary of experimental design

In the training sessions, only the amount of activity was measured and it was decreased as the training sessions proceeded. The result of a chi square test for the difference of the activity level between the F group and the B group in the last training day revealed no-significant difference. In the testing session, the result of Wilson's test (Wilson, K. V., 1956) for the number of bar-pressings on 2 x 2 factorial design showed that only the factor of light contingency in the testing session was significant at 5% level, and the number

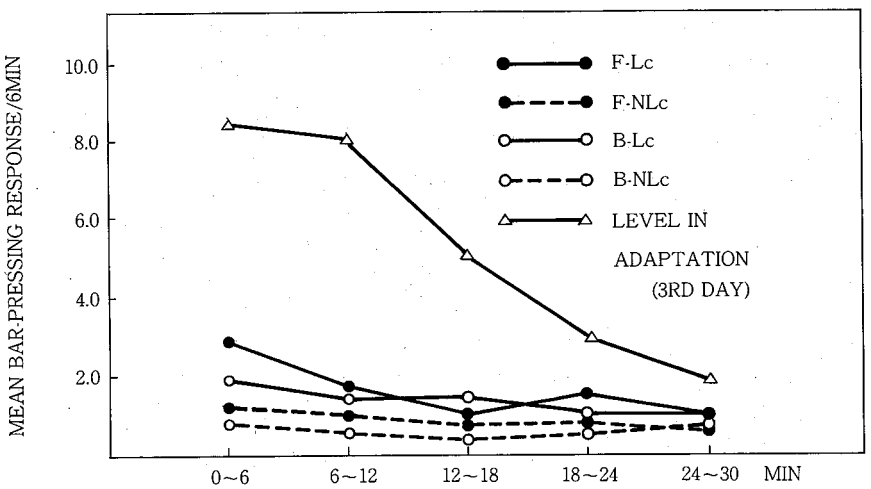

Fig. 7. Mean number of barpressing responses in the testing session.

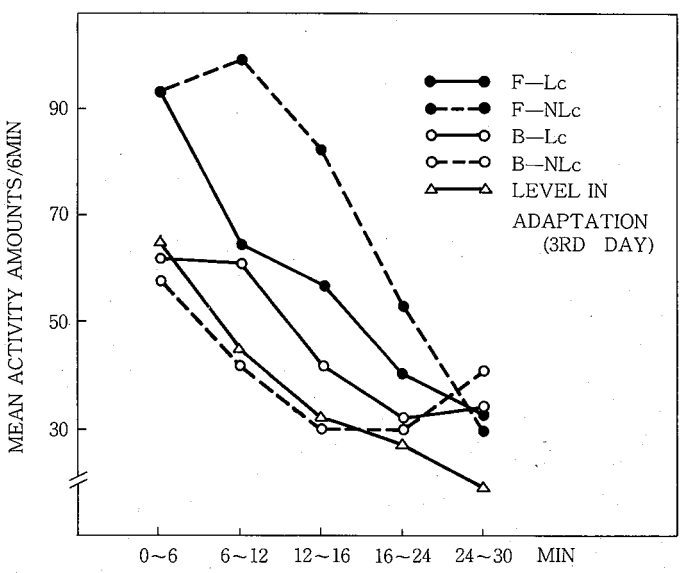

Fig. 8. Mean activity amounts in the testing session.

of bar-pressings in the light contingency was slightly greater than in the non-contingency (Fig. 7). The change of the general activity level with the time course in the testing sessions is shown in Fig. 8. After getting homogeneity of variances with the square root transformation of the raw scores in the activity amount, an analysis of variance of 2 x 2 x 3 was applied to these transformed values. The analysis was for paired-presentation in the training sessions (forward vs. backward), light contingency to the operant response in the testing session (light contingent vs. non-light contingent), and the time block (first stage, second stage, and third stage, 10 min, respectively). The results of this analysis showed significant differences at 5% or 1% level in all factors and the interaction between light contingency and the time block.

It should be emphasized that the difference was found only on the light contingency in the testing session. The evidence for the reinforcing effects on the manipulandum when some neutral stimuli were contingent to it has been reported (Marx, M. H., Henderson, R. L., & Roberts, C. L., 1955; Kling, J. W., Horowitz, L., & Delhagen, J. E., 1956). This effect has been known as the sensory reinforcement.

On the other hand, it is difficult to understand that the factor of the paired presentation in the training sessions has not any difference in the bar-pressing in the testing session. From the procedure used in this experiment, the *Ss* of the F-Lc group, being trained forward paired presentations of light and food, and given the light stimulation contingent to the bar-pressings in the testing session but without alimentary reinforcement, would be affected in the bar-pressing behavior with the secondary reinforcement effect (S effect), the sensory reinforcement effect (Lc effect), and the frustration effect (F effect) caused from the extinction of the primary reinforcement which had been presented regularly with the light stimulation in the training sessions. Since the light stimulation presented with the backward conditioning procedure used for the B groups is not supposed to have acquired the efficient property as a conditioned stimulus practically (Kimble, G. A., 1961), the effects of three factors mentioned above upon the bar-pressing response might be estimated as follows.

F effect·····A comparison between the F-NLc group and the B-NLc group
Lc effect·····A comparison between the B-Lc group and the B-NLc group

For the analysis of these effects, U tests were applied and Lc effect turned out to have a significant difference at the 5% level, but the F effect was not significant statistically though there was a little difference in the anticipated direction. The unitary effect of the secondary reinforcement cannot be verified from the experimental design used in this experiment. But if the interactions between the factors treated are not significant, the secondary reinforcement effect upon the bar-pressing response may be estimated from the

next operation.

S effect·····(F · Lc + B · NLc) vs. (B · Lc + F · NLc)

A U test was applied for the verification of this effect, but no positive effect was found. The result of Wilcoxon's sign-rank test applied for the comparison of the number of the bar-pressing between the adaptation sessions and the testing session showed a significant difference, but in the contra-distinction to the Bersh's results, the former was less than the latter in any group. The effect of the length of intervals between light stimulation and feeding can be also understand as the differences in magnitude of the conditioned consummatory response, which will arouse the development of the general activity according to the view of Sheffield et al. Since the effect of the secondary reinforcement upon the bar-pressing response was not found, and the level of the general activity of the F groups in the testing session increased highly, there might be the possibility of the application of the *frustration-excitement hypothesis.* At least, it would be concluded the effect of frustration upon the running behavior of the experimental subject in the wheel was dominant over the effect of the secondary reinforcement upon the bar-pressing response in the wheel, and also the effect of the sensory reinforcement upon the bar-pressing response was dominant over the effect of the secondary reinforcement upon the bar-pressing response, under the testing situation used in this experiment. In the Bersh's experimental procedure, the sensory reinforcement effect and the frustration effect upon the bar-pressing response cannot be tested as independent factors from the secondary reinforcement effect.

Besides the present author's results, some negative instances for the effect of the secondary reinforcement have been reported. An experiment by Ratner (Ratner, S. C., 1956) appears to present an interesting result from the present author's point of view. A group of Sprague-Dawley rats was trained to approach a water dipper at the sound of a click. After this training , water was removed and a response-bar was inserted into the apparatus and, for half of the *Ss*, a click followed each bar-pressing. Both the goal approaching responses and the bar-pressing responses were observed. A significant difference in the number of the bar-pressing for the click and non-click group was obtained, but there was little difference in the number of the goal approaching responses or in the number of the bar-pressings followed by the goal approaching responses. He concluded that, despite the acquisition of the secondary seinforcing properties in the training sessions, the click was not a discriminative stimulus for the goal approaching responses during the testing (extinction) trials.

Another experiment by Wyckoff, et al. casts doubt on the general concept on the sensory reinforcement itself (Wyckoff, L. B., Sidowski, J., & Chambliss, D., 1958). They pointed out that if the bar and the reinforcement magazine were close together, any stimulus which had become a discriminative stimulus for the goal approaching would tend to keep the

subject in the vicinity of the bar, thus increasing the probability that the bar would be pressed. In the apparatus used by them, the bar was placed at the opposite end of the box from the reinforcement magazine. The *Ss* were initially trained to approach and lick a dipper at the sound of a buzzer. During the subsequent testing session, the buzzer was presented to the experimental group after each bar-pressing, and to the control group after each 10-sec interval of no bar-pressing. In spite of the fact that the buzzer was firmly established as a discriminative stimulus, and in spite of the fact that the situation was designed so that one group would be reinforced for the bar-pressing and the other group for no bar-pressing, no difference was obtained in the rate of the bar-pressing. These results are very suggestive and enable one to interprete the differences between the Bersh's results and the present author's.

The present author had suggested in his paper (Iwamoto, T., 1962) that the genuine effect of the secondary reinforcement which was obtained only from the contingency of the neutral stimulus to the primary reinforcement seemed to be considerably small in its magnitude compared with the secondary reinforcement effect which was obtained from the cases such as the experiment of Wolfe (Wolfe, J. B., 1936) in which the token given after the instrumental response could be exchanged readily for the primary reinforcement in a short period of time.

CONCLUSTON

From the fact that were obtained in several experiments mentioned above, as discussed in the present article, it might be suggested that the operant response might be facilitated with the enhanced activity level in a situation which is "frustrative" but has no "outlet" of the enhanced activity such as the activity wheel, or something equivalent to it.

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CHANGES OF THE GENERAL ACTIVITY LEVEL OBSERVED DURING CLASSICAL CONDITIONING WITH ALIMENTARY REINFORCEMENT IN THE ALBINO RAT

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The level of the general activity during classical conditioning was observed using an activity wheel having a food tray connected to a feeding device. When the procedure of delayed conditioning with the paired presentation of the external stimuli of 10-min and the whole quantity of food required for a day, was applied to the rat, the enhanced activity level was obtained in the training sessions as well as in the testing (extinction) sessions. But under the procedure of the paired presentation of the external stimuli of 20-sec and food of 250 mg, the enhanced activity was observed only in the testiog session. In view of these facts, the experiments of the secondary reinforcement using the Skinner box were reconsidered and the posibility of the facilitated operant response by the enhanced activity level in a situation which is *frustrative* but has no "outlet" of the enhanced activity was discussed. An experiment closely similar to Bersh's experiment (Bersh, P. J., 1951), using an activity wheel having a bar and a food tray, instead of the Skinner box, was designed. In the testing session, the secondary reinforcement effects on the bar pressings were not significant, and the level of the general activity was very much increased in the forward paired presentation groups.