PROPER CONTROL PROCEDURE IN THE "ON-THE-BASE-LINE" TYPE OF CER EXPERIMENT

TERUKO MIYASHITA

Department of Psychology, Kwansei Gakuin University

Two experiments were conducted in order to search for the proper control procedure in the on-the-base-line type of CER experiment, using rats as subjects and licking behavior as the criterion response. In the first experiment, both the TRC and the traditional control procedure in which the US (shock) was explicitly unpaired were shown to be inadequate control procedures, for the reason that both procedures contributed to the different basal emotional level of Ss from that of experimental group. In addition, there was evidence of conditioning of "inhibition" in the traditional control group. In the second experiment, the adequacy of Hammond's 'random control' procedure was confirmed.

The backward conditioning procedure and the "explicitly unpaired control" procedure in which CS and US are explicitly unpaired are most commonly employed control procedures for Pavlovian conditioning in recent years. In criticizing these conventional control procedures, Rescorla (1967) has pointed out that, in these procedures, "Instead of being a signal for the US, it (CS) can become a signal for the absence of the US" (p. 73), and hence an extent to which the "excitation" was conditioned to the CS in the experimental group cannot be legitimately assessed using such control procedures. In other words, in these conventional control procedures, "inhibition" would be conditioned to the CS as an active process as a consequence of a contingency of the CS and the absence of the US and there is ample evidence for this hypothesis (Rescorla & LoLordo, 1965; Rescorla, 1966; Weisman & Litner, 1969a, 1969b). Rescorla, therefore, proposed "truly random control" (TRC) procedure which was defined as a procedure in which both the CS and US are presented to S but there is no contingency whatsoever between them" (Rescorla, 1967, p. 73). It should be noted, however, that Rescorla and his groups have employed so-called the "off-the-base-line" situation in which the effects of Pavlovian conditioning (both excitatory and inhibitory) were tested in a separate situation.

In applying this TRC procedure to the "on-the-base-line" type of CER experiment, however, there seems to be a serious difficulty which was pointed out by Seligman (1969). In a procedure for the experimental group, the US (electric shock) is invariably preceded by a signal and hence it is predictable. On the other hand, in the TRC procedure, the US is presented without any signal and hence it is unpredictable. According to Seligman's (1969) "safety-signal hypothesis,"—when shock is not predicted, the absence of shock also is not predicted. When shock is reliably predicted by a CS, the absence of CS reliably predicts safety (p. 487). Thus, in an unpredictable shock situation, animals are assumed to be under chronically emotional state as compared with those in the predictable shock situation. Seligman has emphasized that because of this conceivable difference in the base-line-level of emotionality or BEL (basal emotional level, Imada, 1971; Imada & Soga, 1971), the TRC could not be a

1 The author is grateful to Dr. H. Imada of Kwansei Gakuin University, for critical reading of the manuscript and for his suggestions.
Proper Control Procedure in the On-the-Base-Line Type

Proper control procedure in the on-the-base-line CER experiment (Seligman, 1968, 1969). Present two experiments were addressed themselves to the problem of a proper control procedure in the on-the-base-line CER study in which licking response was used as a criterion response (Yoshida, Kai & Imada, 1969; Miyashita & Imada, 1971; Imada & Soga, 1971).

EXPERIMENT I

In Experiment I, two hypotheses were tested. First, the hypothesis that the BEL of the predictable shock group (forward conditioning group) would be lower than that of the unpredictable shock groups (TRC group and explicitly unpaired control group) was subjected to test. Second, the hypothesis that the “excitation” would be conditioned to the CS in the forward conditioning group and the “inhibition” would be conditioned to the CS in the explicitly unpaired group was tested. In the TRC group, no conditioning of whatever kind to the CS was expected.

METHOD

Subjects

Twenty-nine experimentally naive, male albino rats were 90 days old and their mean body weight was approximately 185 g at the beginning of the experiment.

Apparatus

The apparatus was four identical water drinking boxes used in the second experiment of Yoshida, Kai and Imada (1969). Each drinking box with a grid-floor was 20 cm long, 10 cm wide and 15 cm high (inside dimensions). In the lower part of the wall at one narrow end of the box was a hole (12 mm dia.) through which S could gain access to the drinking tube. The operations including the tube presentation and withdrawal, CS and US presentations were made by the E sitting in the adjoining room.

Procedure

Handling and habituation to the watering schedule (4 days). For four days immediately preceding the experiment, all rats were tamed by handling for 10 min per day, and were adapted to one-hour-per-day watering schedule. This watering schedule was maintained throughout the experiment.

Preliminary training of drinking (16 days). For the first four days, all Ss were trained to drink water from the tube for 5 min everyday after approximately 23 hr of water deprivation. The initial training procedure were described in detail elsewhere (Yoshida et al, 1969). After the initial drinking training, regular drinking training was continued for 12 days, 5 min per day. By the end of the 12th day, the drinking curve had approached the apparent maximum level.

Fear conditioning (16 days). The Ss were assigned to three groups which were matched in the number of tongue licks during the last six days of the preceding training. While the Ss were in the drinking boxes, CS and US were presented three times each in each session. The CS was a pure tone of 1000 Hz, 80 db, and the duration was 5.7 sec. The US was an electric shock, 0.7 sec and 90 V ac, given through current limiting resistor of 250 K ohm put in series with rat. The CS–CS interval ranged from 20 sec to 135 sec, with an average of 80 sec. Four different schedules of CS–CS interval were used, but the same schedule was used for all groups on any particular day. The groups differed in terms of a relation of the US to the CS. For Group P(N=10), CS was always paired with the US. The last 0.7 sec of the CS overlapped with the US. For Group TRC2(N=10), the US’s were presented independently of the CS presentations. More specifically, the 5 min session was divided into sixty 5-sec periods and the periods at which US’s were to be presented were selected randomly using a table of random numbers. But there were some restrictions: the US was not presented in the 60th period or the last sec

* Not in a strict sense of the term.
of 5 min session and during 5 sec periods immediately before and after the CS presentations. For Group UP (N=9), the CS and the US were never paired. The minimum CS-US interval was 60 sec and the minimum US-CS interval was 10 sec. In all groups, positions at which CS's were presented during the sessions were identical, which were varied in four different ways.

**Measures**

The index of BEL was a total number of licks emitted during 5 min sessions. The index of CER was a ratio SR suggested by Hoffman and Fleshler (1961):

\[ SR = \frac{A - B}{A} \times 100 \]

where A was the number of tongue licks during 5 sec before the CS onset, and B was the number of licks during the CS presentation.

**Results and Discussion**

Regarding BEL

Fig. 1 shows the mean total number of licks during 5 min sessions for three groups in blocks of two days. The B on the abscissa in Fig. 1 indicates the last day of the preliminary training of drinking where no shock was given. There was no significant difference between groups at B (F<1).

The analysis of variance conducted between groups over the entire range of 16 days of training revealed that the groups effect was significant (F=3.72, df=2, 26, p<.05). Paired comparison showed that the difference between Groups P and UP was significant (p<.02) and the difference between Groups P and TRC approached the conventional level of significance at 5% (p<.10).

In line with Seligman's safety-signal hypothesis, the BEL was lower in a group in which the shock was made predictable than in groups in which it was not. The results were also consistent with the empirical findings obtained in the present writers' laboratory (Imada & Soga, 1971; Imada, 1971) and those obtained in other laboratories (Seligman, 1968; Seligman & Meyer, 1970; Davis & McIntire, 1969).

The present result, in some minor point, contradicts with the present writer's hypothesis that the BEL of Group TRC would be higher than that of Group UP. This is because in Group UP, the shock termination guaranteed a safety period of at least 45 sec in the present experiment whereas in Group TRC, no such safety-period was deliberately and systematically arranged. Extending the safety-signal hypothesis so as to include "time" as a signal, it is expected that rats in Group UP would have licked more than those in Group TRC after each US presentation. The post-
US bursts of licking in a condition comparable to the Group UP was clearly shown by Imada and Soga (1971). The present result indicated, contrary to the above expectation, that the total number of licks per session was generally higher in Group TRC than in Group UP, although not significantly.

Regarding CER

The results regarding CER are summarized in Fig. 2 in terms of SR. The SR value is 100 when the drinking behavior is suppressed completely during the CS presentation and the SR = 0 indicates no suppression by the CS presentation. The negative SR values mean that the rats licked more during the CS than before the CS presentation. In line with the hypothesis and the previous findings (Ray & Stein, 1959; Rescorla & LoLordo, 1965; Rescorla, 1966; Weisman & Litner, 1969a, 1969b; Hammond, 1966, 1967, 1968; Miyashita & Imada, 1971), in Group P, "excitation" (fear) and in Group UP "inhibition" (relaxation) to have been conditioned, which are shown by the positive and negative SR values, respectively. In Group TRC, the CS seems to have acquired no "meaning", which is indicated by the curve of this Group fluctuating around SR = 0. The two-tailed t-tests were conducted for the last four blocks of Fig. 2 for each group separately between the number of licks during pre-CS-5 sec and those during-CS-5 sec. In Group P, there was significantly more licking during pre-CS-5 sec than during-CS-5 sec ($t = 5.19, df = 9, p < .001$). In Group TRC, the $t$ value was 0.24 ($df = 9$) and hence there was no significant difference in licking between pre-CS-5 sec and CS-5 sec periods. In Group UP, the rats tended to drink more during the CS presentation than before it ($t = 1.91, p < .10$).

**Experiment II**

The results of Experiment I clearly indicated that neither the procedures for Group UP nor Group TRC were proper control procedures for the "on-the-base-line" type of CER experiment. What, then, should the proper control procedure be in such a situation? In Experiment II, the validity of the control procedure employed by Hammond (1967, 1968) known as "random control" procedure was tested. In this design, in one group of Ss, one CS (e.g. tone) is always paired with the US (shock) and the other (e.g. light) is presented randomly with both tone and shock. In the other group, tone and light are reversed, i.e., the light is always presented immediately preceding the shock and the tone comes randomly with light and shock. It should be noticed, in both of these groups, shock is made always predictable and hence the BEL of both groups is assumed to be the same. Moreover, an extent to which fear or excitation is conditioned can be legitimately assessed by comparing responses to the CS of the same modality of the two groups, because in one group the CS of one
modality is systematically paired with the US while in the other, it had no contingency with the US or the absence of US. As may be realized, the two groups are mutually experimental and control groups.

METHODS

Subjects and Apparatus

Subjects were 29 experimentally naive male albino rats. Mean body weight was 205 g at the start of the experiment. Apparatus was identical to that used in Experiment I.

Procedure

After 16 days of training of drinking behavior in a manner described in Experiment I, Pavlovian conditioning took place in a drinking box. All rats were divided into three groups, or Group T⁺—L⁻, Group T⁻—L⁺, and Group T⁰—L⁺, being matched in the drinking behavior during preliminary training. The T and L indicate tone and light, respectively, and superscripts mean whether excitation (+), inhibition (−) or none (0) were to be conditioned to the CS's. All groups received the tone and light of 5.7 sec duration three times each and the US (electric shock of 90 V ac) of 0.7 sec duration three times in daily session of 5 min. The tone was 80 db, 1000 Hz and the light was 88 lux. In the present experiment, three different kinds of Pavlovian conditioning were tested with respect to tone. In Group T⁺—L⁻(N=10), tone came invariably 5 sec preceding US while the presentation of light guarantees a safety-period of at least 20 sec. In Group T⁻—L⁺(N=10), quite in contrast with above group, light was paired with the US and the tone was made explicitly unpaired with the US. In Group T⁰—L⁺(N = 9), the light was paired with the US but the tone was presented randomly during the session, provided that the tone was never presented in the first and the last 5 sec periods of each session and during 5 sec periods immediately before the CS⁺ presentation and immediately after the US presentation. The three groups were matched with respect to the temporal positions at which CS⁺ and US were presented. The temporal positions at which CS— was given were matched in Groups T⁺—L⁻ and T⁻—L⁺. The CS—CS interval ranged from 20 to 70 sec, with an mean interval of 40 sec.

RESULTS AND DISCUSSION

Fig. 3 shows the mean total number of licks per session in blocks of two days. On the day immediately preceding the Pavlovian conditioning took place (or at B of Fig. 3), there was no significant difference between groups. The results of a mixed analysis of variance (Lindquist’s Type I, Lindquist, 1953) revealed that only the blocks effect was significant \(F=5.82, df=7, 182, p<.001\). This indicates that the three groups did not differ with respect to BEL and the BEL became lower as the Pavlovian conditioning progressed. This was exactly what the safety-signal hypothesis had predicted and satisfied at least one condition for the different contingencies of the CS with the US can be legitimately compared.

Regarding CER

The SRs were calculated in a manner exactly same as described in Experiment I.
Fig. 4. The SR’s to the tone CS in three groups.

Fig. 4 presents mean SR to the tone CS for each group separately. In Group T\(^{+}\)−L\(^{-}\), fear (excitation) was conditioned, but in Group T\(^{0}\)−L\(^{+}\) and T\(^{-}\)−L\(^{+}\), there was no evidence of conditioning of fear at least at the stable level of conditioning. The \(F\) test conducted over the entire period of conditioning showed that the groups effect to be significant (\(F = 32.11, df = 2, 26, p < .001\)). Paired comparisons indicated that the differences between Group T\(^{+}\)−L\(^{-}\) and two others groups were significant.

In contrast with the result of Experiment I, in Group T\(^{-}\)−L\(^{+}\), there was no clear evidence of conditioning of inhibition to the tone. As pointed out by Hammond (1966, p. 338), however, an extent to which conditioned inhibition reveals itself in the on-the-base-line type of CER experiment may be greatly influenced by BEL. More specifically, when an animal is licking at its fastest rate during the 5 sec period preceding the CS presentation (because of low BEL), presentation of a “safety-signal” (or CS−) could have no effect in a way of lessening suppression, since no suppression existed. By comparing BEL’s of Experiment I and II, it becomes immediately apparent that the BEL of Group T\(^{-}\)−L\(^{+}\) is much lower than that of Group UP. And this could account for the fact that in Group T\(^{-}\)−L\(^{+}\), the SR value was not consistently negative as hypothesized.

Taking the results of Experiment I and II as a whole, one could draw following conclusions with regard to the proper control procedure for the on-the-base-line type of CER experiments: 1) The US should not be given in an unpredictable manner, and 2) The CS should have no systematic contingencies with the presence or absence of the US.

REFERENCES


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(Received Nov. 19, 1971)