

The effects of horn devaluation on the transfer of conditioned inhibition between horn and shock¹

Los efectos de la devaluación de un ruido intenso sobre la transferencia de inhibición condicionada del ruido a choques eléctricos

by

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ABSTRACT

Two experiment using a conditioned suppression procedure in rats assessed transfer of conditioned inhibition from a loud car horn to electric shock, after postconditioning manipulations designed to habituate or counterconditioning the aversive effects of the horn. Both experiments showed that the inhibitory effects of a stimulus are not restricted to the reinforcer used in its establishment, but that they generalize to other reinforcers with similar characteristics. The experiments were less successful in habituating and counterconditioning the horn despite the use of various parametric variations. The implications of these findings for theories of conditioned inhibition are discussed.

DESCRIPTORS: Conditioned inhibition, Devaluation, Habituation, Counterconditioning, Rats.

RESUMEN

Los experimentos que utilizaron el procedimiento de supresión condicionada en ratas evaluaron los efectos de la devaluación o contracondicionamiento de un sonido fuerte sobre la transferencia de inhibición condicionada del sonido a choques eléctricos. Ambos experimentos indicaron que los efectos inhibitorios de un estímulo no se restringen al reforzador utilizado en su establecimiento, sino que se generalizan a otros reforzadores con características similares. Los experimentos tuvieron menos éxito en conseguir la habituación o el contradondicionamiento del sonido, a pesar de varias manipulaciones. Se discuten las implicaciones de estos resultados para las teorías de condicionamiento inhibitorio.

DESCRIPTORES: Inhibición condicionada, Devaluación, Habitación, Contracondicionamiento, Ratas.

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In the conditioned inhibition paradigm (Pavlov, 1927) two sorts of trials occur in an intermixed fashion: during A + trials one stimulus is presented and its offset is followed by reinforcement, and during AX- trials the stimulus A is compounded with a second stimulus (X) and reinforcement is withheld. As the result of this procedure stimulus A is said to acquire excitatory properties in the sense of being able to elicit a conditioned response, whereas stimulus X becomes a conditioned inhibitor because it is capable of attenuating responding elicited by the exciter, as in summation tests, and also because it is transformed into an exciter slower than control stimuli, as in retardation tests (see Hearst, 1972; Rescorla, 1969).

Following Konorski's (1948) and Rescorla's (1975) theories of Pavlovian conditioning, it is common to assume that the contingencies arranged between the conditioned stimuli and the reinforcer give rise to the formation of associations between the memories of those events. Presentation of the exciter is assumed to reactivate the memory of the reinforcer and that it is this reactivation which determines the consequent elicitation of the conditioned response; presentation of the inhibitor is assumed to prevent such reactivation with the consequent attenuation of responding otherwise elicited by the exciter. One implication of these theories is that any alteration of the memory of the reinforcer should alter the effectiveness of exciter and inhibitor. The logic for testing these predictions was discussed by Rozeboom (1958) and has more recently been developed by Rescorla and collaborators (e.g., Rescorla, 1973 b).

A study by Rescorla (1973 a) illustrates this method and is particularly relevant to the experiments reported here. Rats were exposed to pairings of a light with a loud car horn until conditioned suppression developed to the light; then a group of rats was exposed off-the-baseline to unsignaled presentations of the horn with the aim of habituating its aversive effects. A subsequent savings test showed that the ability of the light to elicit suppression of lever pressing was attenuated, relative to the effects the light had in the control group which did not receive habituation training. Subsequent studies have obtained comparable results in both appetitive and aversive conditioning (e.g., Adams, 1981; Adams & Dickinson, 1981; Colby & Smith, 1977; Holland & Rescorla, 1975; Holman, 1976, Rescorla, 1975; but see Brookshire & Brackbill, 1976; Riley, Jacobs & LoLordo, 1976). Thus, the fact that post-conditioning alterations of the value of the reinforcer retroactively alter responding elicited by the exciter is consistent with the theories which assume that elicitation of the conditioned response results from the reactivation of the memory of the reinforcer.

The present study is an attempt to extend this analysis to conditioned inhibition. However, as altering the value of the reinforcer would alter responding to the exciter and this could make more difficult the assessment of the inhibitory effect, the present experiments assessed the effects of devaluing the reinforcer in a procedure suggested by LoLordo (1967) and more recently developed by Nieto (1984). Nieto trained rats to lever press

with food reinforcement; then a noise was negatively correlated with either shock or horn in different groups with the aim of establishing the noise as a conditioned inhibitor. A subsequent summation test showed that the effect of the inhibitor were not restricted to the aversive reinforcer used in its formation, but transferred to a different aversive reinforcer. Consequently, the present experiments assessed the effects of devaluing the horn's aversive effects on the transfer of inhibition from horn to shock.

EXPERIMENT 1

The aims of this experiment were two. First, it attempted to determine whether habituation of the aversive effects of the horn would affect transfer of conditioned inhibition to a different aversive reinforcer. The rats were first trained to lever press on a variable interval (VI) schedule with food reinforcement. Then, two groups of rats received pairings of stimulus A with horn, B with shock, and the AX compound was not reinforced. For a third group the AX trials were omitted. In the second stage of the experiment the Inhibition-habituation (I-H) group received off-the-baseline un signaled presentations of the horn designed to cause its habituation, whereas the two other groups did not receive such treatment. In subsequent test sessions evidence for the successful devaluation of the horn was sought, followed by summation and retardation tests to assess transfer of inhibition. The second aim of the experiment was to determine the relative independence of the memories of the two reinforcers. Transfer of inhibition between horn and shock could occur simply because both reinforcers share temporal and intensity characteristic, besides their common suppressive effects on lever pressing. Consequently, presentation of shock exciter (or the shock) could reinstate the effects of the devalued horn, in a manner similar in which the effects of an extinguished shock exciter are reinstated by un signaled presentations of the shock (Rescorla, & Heth, 1975). A demonstration of a selective devaluation effect would make the transfer of inhibition less open to an interpretation in terms of a transreinforcer reinstatement effect.

Method

Subjects

Twenty four male naive hooded rats obtained from the University of Sussex breeding colony were used. Their mean body weight was 300 g (range 281 to 376 g), and they were maintained at 80% of their initial weights by feeding them with appropriate amounts of chow after each session.

Apparatus

Four identical two-lever chambers manufactured by Campden Instruments Ltd. and measuring 23 x 25 x 20 cm were used. Each chamber was enclosed

in a sound attenuating shell provided with an exhaust fan which produced a background noise of 74 db SPL. In each chamber the right-hand lever was permanently removed. All walls were aluminium except for the clear Plexiglas entrance door and the translucent ceiling. A recessed food magazine into which 45-mg pellets could be delivered was centered in the front wall. Each pellet delivery was signaled by a brief flash of a light mounted behind the magazine entrance. Mounted on the midline of the front wall and 16 cm above the floor was a 8-W 24-Vdc houselight; two additional lights were mounted at 10 cm from the floor and 7 cm to each side of the houselight. A 84-db SPL white noise could be presented through a speaker mounted in place of the right-hand lever. An overhead light could be presented by operating a 40-W 240-Vac striplight located behind the ceiling. The floor of the chamber consisted of sixteen 0.5 cm diameter stainless steel rods spaced 1.5 cm apart. Scrambled shocks of 0.7 mA, 0.5 sec duration could be presented through the grid floor. Horn blasts of 110 db SPL, 5 sec duration, generated by a car horn (Wipac, Mixo TR 89) mounted on the front door and mixed with a 10-kHz tone could be delivered to the rats. Controlling and recording equipment was located in an adjacent room.

Procedure

All rats were first trained to lever press. On the first two days they received two 30-min sessions, with the lever removed, in which 50 pellets were delivered at variable times averaging 1 min (VT 1 min). In the next session the lever was inserted and every press produced a pellet. This session ended when 50 pellets were collected or 30 min had elapsed. Any rat failing to collect 50 pellets was given addition training. The rats were then reinforced according to a VI 30-sec schedule for two sessions. All subsequent sessions were 50 min long. The rats then received seven sessions of lever press training on a VI 1-min schedule before Pavlovian conditioning started.

Inhibitory training. During this stage conditioned inhibition training was carried out for ten sessions. The VI 1-min schedule of food reinforcement was operative throughout this stage. In the first two sessions Pavlovian excitatory training was given to all rats with the aim of establishing stimulus A as the signal for horn and stimulus B as the signal for shock. For half of the rats stimulus A was a 1-min steady overhead light and stimulus B was a 1-min flashing (1 sec on, 1 sec off) operation of the two front panel lights. For the other half of the rats the opposite arrangement of stimuli was used. The offset of A was immediately followed by the horn blast and the offset of B by 0.5 mA, 0.5 sec shock. In each session one A and one B trial were presented.

Excitatory training was continued for a further eight sessions with the shock intensity increased to 0.7 mA. The rats were then assigned to one of three groups. The groups Inhibition (I) and Inhibition-habituation (I-H) received discrimination training with the aim of establishing a 1-min white noise (X) as an inhibitor with respect to the horn. For these two groups a

session consisted of one A-horn, one B-shock, and two nonreinforced AX trials. The sequence of trials was altered every session and the trials were presented every six min on average. For the Control group (C) the AX trials were omitted and the sequence was matched to that of the previous groups.

Horn devaluation. This stage lasted for five sessions and attempted to reduce the aversiveness of the horn in the group I-H. During these sessions the lever was removed, the tray entrance blocked, and the grid floor covered by a Plexiglas sheet and sawdust. The group I-H received eight un signaled presentations of the horn each session, the horn was presented every four min on average. The rats in the groups I and C were placed in the chamber for the same amount of time as the group I-H, but never experienced horn during this stage.

Testing. On the next session all subjects received a single leverpress re-training session in preparation to the series of test to follow. The first test session assessed the effects of the horn habituation stage on suppression of lever pressing elicited by A. During this test all groups received four non-reinforced presentations of A.

The following two test sessions assessed transfer of conditioned inhibition across the two aversive reinforcers. In the first summation test all groups received two B and two BX trials, all of them nonreinforced. In the second summation test all rats received the same number and types of trials, but the first B trial was reinforced by the shock. The sequence of trials during the first test was B, BX, B, and BX for half of the subjects in each group and the opposite arrangement was used for the other half. On the second test the sequence was BX, B, BX, and B for the first half and the opposite for the second half.

In the final test session all subjects were given a retardation test: the noise (X) was presented four times and each time its offset was followed by the 0.7 mA, 0.5 sec shock. During all the test sessions the trials were presented every six min on average and the VI 1-min food reinforcement schedule was operative.

In this and the following experiment the index of Pavlovian conditioning was the suppression ratio (Annau & Kamin, 1961) of the form (CS response)/(CS responses + pre-CS responses), where CS responses refers to the number of lever presses during presentation of the conditioned stimuli, and pre-CS responses refers to the number of lever presses during the 1-min interval immediately preceding the conditioned stimuli. This ratio yields a value of 0.50 when responding during the conditioned stimuli is equivalent to that during the interval preceding them, a value of 0.00 indicates complete suppression of lever pressing during the conditioned stimuli. In all statistical comparisons rejection level for Type I error was set at $p < 0.05$.

Results and Discussion

All rats acquired lever pressing during the first training session and responded consistently during preliminary VI training. On the last of those

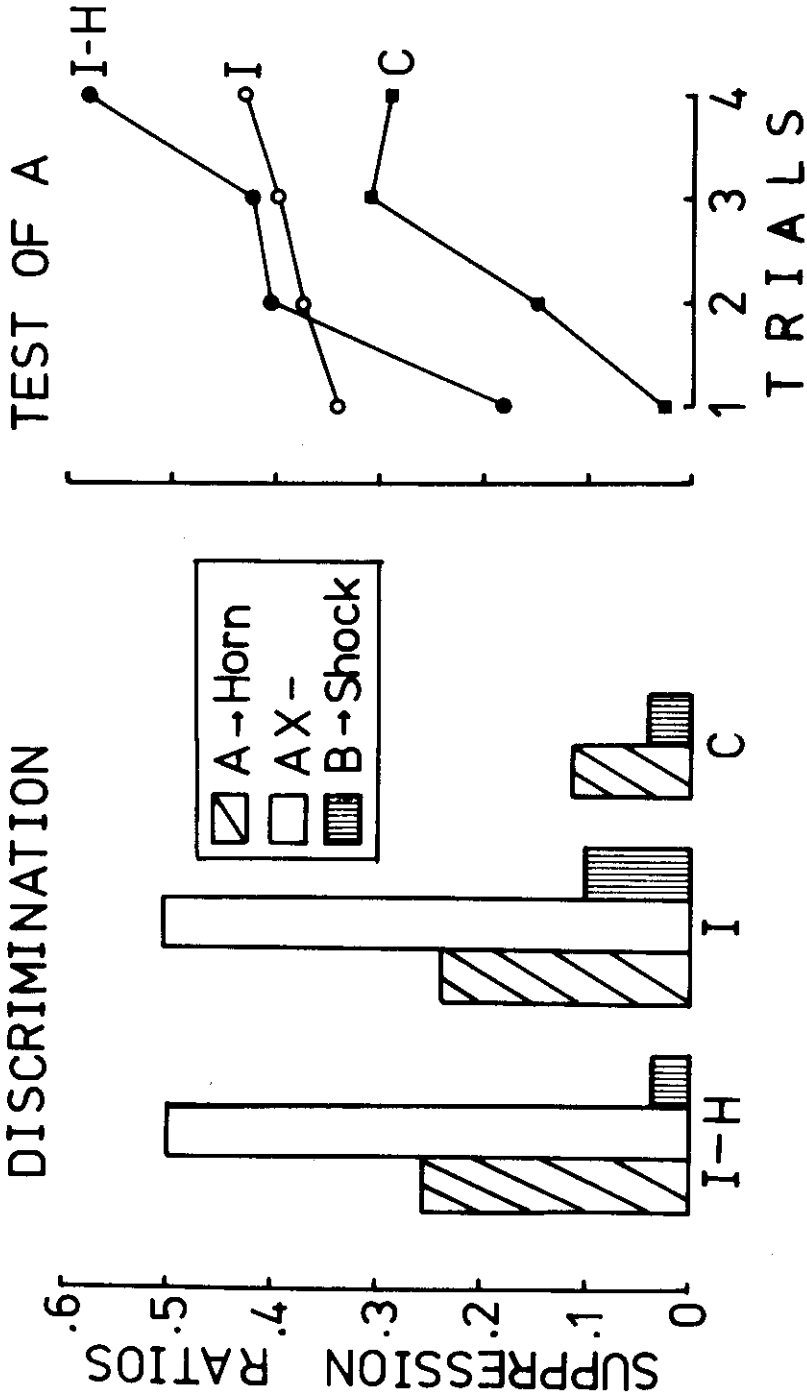


Figure 1. The left-hand side shows the mean suppression ratios on each trial over the last two sessions of inhibitory training. Stimulus A was paired with horn, the AX- compound was not reinforced, and B was paired with shock. The right-hand side shows the mean suppression ratios elicited by A, during this test A was no longer paired with horn. I-H represents the Inhibitory-habituation group, I and C stand for the Inhibition and Control groups respectively.

sessions the mean response rates were 21, 24, and 27 responses per min for the groups I, I-H, and C respectively. These rates did not differ significantly between groups, $F(2, 21) < 1$.

Inhibitory training

During this stage there was little suppression to any stimuli at first, but as training progressed suppression elicited by A and B increased in all groups, with B tending to elicit more suppression than A. This may have reflected the partial reinforcement schedule to which A was subjected by the inclusion of the AX trials. The two inhibitory groups were less suppressed during AX trials than during either of the other trials.

The left-hand side of Figure 1 shows the mean suppression ratios on each trial over the last two inhibitory training sessions for each group. The amount of suppression of lever pressing elicited by A was similar in all groups, $F(2, 21) = 1.39$. On the B trials the groups differed reliably in the magnitude of suppression, $F(2, 21) = 3.54$. A subsequent Newman-Keuls test indicated that the group I was less suppressed than group C but none of the other comparisons were significant. Within-group comparisons of A and B indicated that B suppressed lever pressing more than A in the group I, $t(7) = 2.78$, and in group I-H, $t(7) = 2.52$. The absence of a significant effect in the group C, $t(7) = 1.67$, suggests that both reinforcers were of similar aversiveness.

The two inhibitory groups did not differ reliably in suppression on the AX compound trial, $F(2, 21) < 1$, and in both groups suppression to A was greater than that to AX: group I, $t(7) = 4.59$, and group I-H, $t(7) = 2.83$. Thus inhibitory training succeeded in establishing stimulus X as a conditioned inhibitor. The mean response rates of responding over these two sessions were 27, 25, and 27 responses for the groups, I, I-H, and C respectively; these rates did not differ significantly between groups, $F(2, 21) = 1.49$.

Test of A

The right-hand side of Figure 1 shows the outcome of the test of A after the habituation procedure. Suppression of lever pressing elicited by A decreased in all groups with the number of nonreinforced trials, but the initial trials did not show evidence of attenuation of suppression elicited by A in the I-H group, as would be expected because of the devaluation stage. As the groups extinguished at different speeds separate statistical analyses were carried out for each trial. The groups differed significantly on three trials only: Trial 1, $F(2, 21) = 11.04$; Trial 2, $F(2, 21) = 8.21$; and Trial 4, $F(2, 21) = 10.09$. Subsequent comparisons using the Newman-Keuls test revealed that the I-H group was more suppressed than the group I during the first trial, but that the opposite was true for the fourth trial. The group C was more suppressed than either inhibitory group in all three of these trials. The mean response rates in this session were 23, 19, and 19 for the groups I, I-H, and C respec-

tively. No significant differences due to Groups, Trials and Groups x Trials were detected, $F(2, 21) = 1.4$, $F(3, 63) = 1.06$, and $F(6, 63) < 1$ respectively.

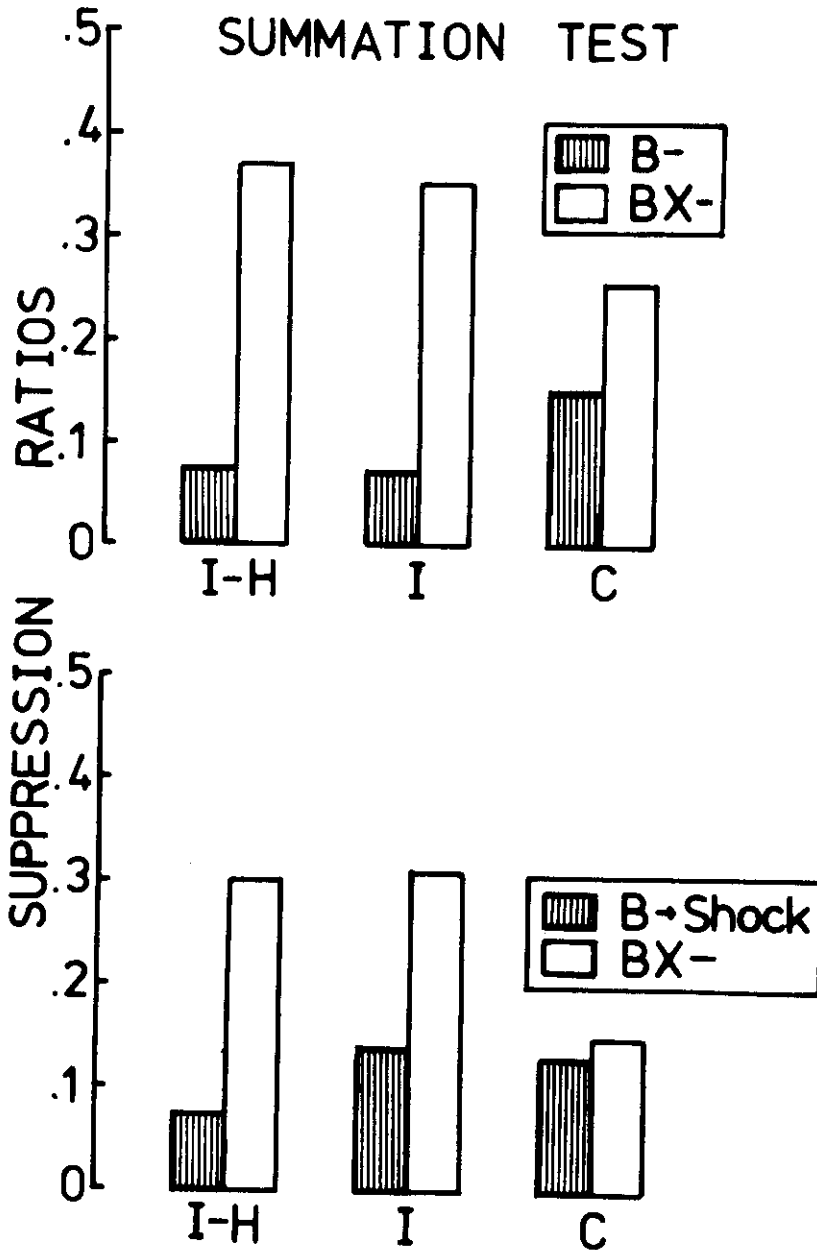


Figure 2. Mean suppression ratios during the two transfer of conditioned inhibitory test. The upper portion shows the results of the summation test in extinction, where both B and BX were not reinforced. The lower portion shows the mean suppression ratios during the reinforced summation test; in this test the first B trial was reinforced by shock. I-H, I, and C stand for the groups Inhibition-habituation, inhibition and Control respectively.

Transfer of conditioned inhibition

The upper portion of Figure 2 shows the mean suppression ratios during the summation test in extinction. Notice that the effects of prior nonreinforced presentations of A did not generalize to B. All groups were equally suppressed during B, $F(2, 21) = 1.39$, and compounding stimulus X with B caused a similar reduction of suppression in all groups, $(F, 2 21) = 1.96$. However, within-group comparisons indicated that only in the group I and I-H was the difference between suppression ratios to the exciter and the compound reliable, $ts(7) = 5.60$ and 4.63 respectively.

In order to compare the differences in the magnitude of the alleviation of suppression, a release score defined as suppression ratio to BX minus suppression to B was computed for each subject. The mean release scores for the groups I, I-H, and C were 0.30, 0.29, and 0.10 respectively. These scores differed reliably between groups, $F(2, 21) = 6.24$. A subsequent Newman-Keuls test indicated that the scores of group C were reliably smaller than those of the groups I and I-H, which did not differ from one another. During this summation test session the mean response rates were 25, 20, and 26 for the above groups respectively. No significant effects of Groups, Trial and Groups \times Trials were detected, $F(2, 21) = 1.49$; $F(3, 63) = 1.16$; and $F(6, 63) = 1.05$ respectively.

The results of the reinforced summation test are shown in the bottom part of Figure 2. This figure shows that the groups again did not differ in the amount of suppression elicited by B, $F(2, 21) < 1$; nor did they differ in suppression during the BX compound, $F(2, 21) = 1.80$. Nevertheless, suppression of lever pressing elicited by B was attenuated by presentation of X, and within-group comparisons again indicated that only in the groups I and I-H was the alleviation from suppression reliable, $ts(7) = 3.15$ and 2.82 respectively. The mean release scores during this test were 0.17, 0.23, and 0.05 for the groups I, I-H, and C respectively. These scores did not differ reliably between groups, $F(2, 21) = 2.18$. On this test session the mean responses per min were, 21, 17, and 16 for the above groups respectively. No effects of Groups, $F(2, 21) = 1$; Trials, $F(3, 63) = 1$; and Trials \times Groups, $F(6, 63) = 1.24$ were detected.

Retardation test

Figure 3 shows the outcome of the retardation test when stimulus X was paired with shock four times. During the first trial the amount of suppression elicited by X was little for all groups, as training progressed responding was more suppressed in the group C than in either of the other groups. An analysis of variance over blocks of two trials each confirmed that the groups differed in both blocks: Block 1, $F(2, 21) = 5.85$; and Block 2, $F(2, 21) = 3.47$. A subsequent Newman-Keuls test revealed that the group C differed

RETARDATION TEST :

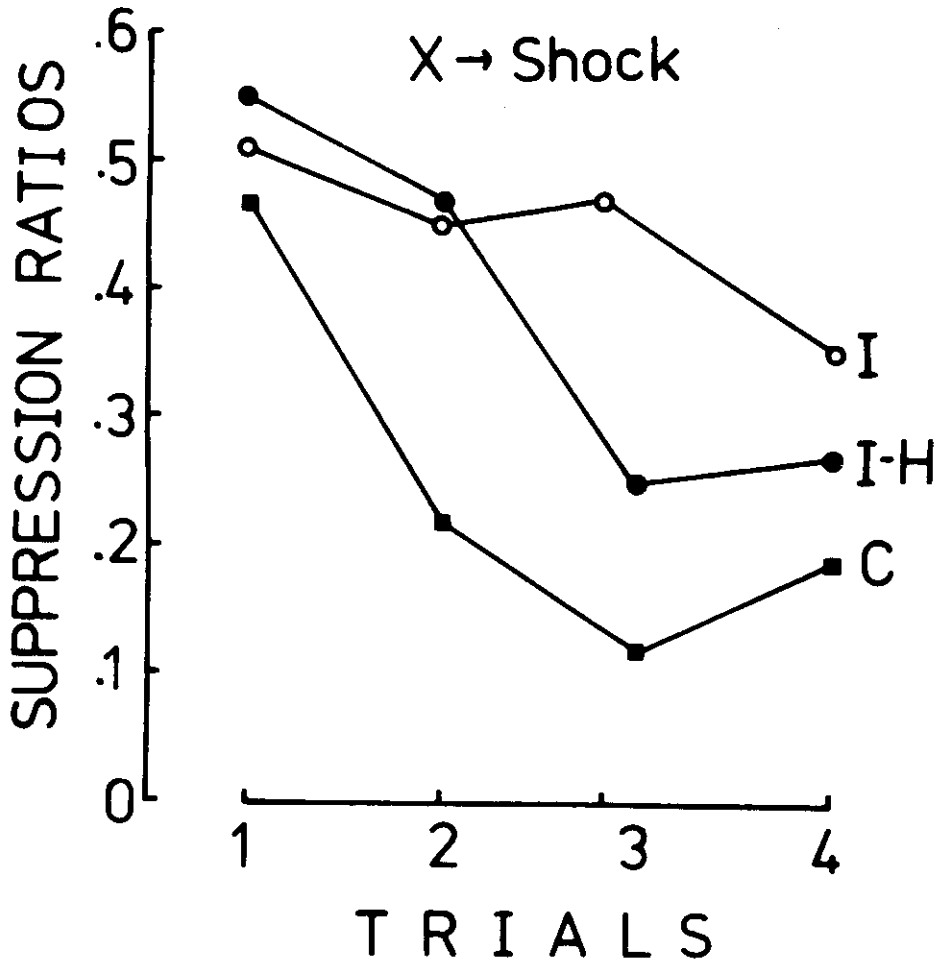


Figure 3. Mean suppression ratios during the retardation test, where stimulus X was paired with shock. Other details as for Figure 1.

from the two inhibitory groups which did not differ between them in Block 1. During Block 2 the group I differed from group C and none of the other comparisons were significant. During this session mean response rates varied from 10 to 55 responses per min. Their analysis showed nonsignificant effects of Groups, $F(2, 21) < 1$; Groups \times Trials, $F(6, 63) = 1.05$; but the Trials effect was significant, $F(3, 63) = 4.05$.

The results of this experiment indicate that the conditioned inhibition procedure used in stage 1 successfully established stimulus X as a conditioned

inhibitor. In addition, the results of the group inhibition showed that an inhibitor based on the horn can effectively attenuate suppression elicited by B, the shock exciter. Both these findings are consistent with the transfer effect reported by Nieto (1984).

One surprising finding of this experiment was that unsignaled exposures to the horn did not attenuate the magnitude of suppression elicited by A, in a way that was expected from Rescorla's (1973 a) results. Two points should be raised about this result. First, Rescorla (1973 a) used a greater number and rate of horn exposure; therefore the present result may reflect incomplete horn habituation. Second, the number of horn exposures used in this experiment was based on previous evidence (Nieto, 1984, Experiment 1) indicating that after 40 horn exposures, pairings of stimulus A with horn resulted in very little conditioning. It may be that an acquisition test and a savings test are differentially sensitive to devaluation of the reinforcer in a situation where more than one reinforcer is presented.

Given the present lack of evidence for habituation of the horn, it is not surprising that the summation test failed to find a difference between the Inhibition and the Inhibition-habituation groups. However, the outcome of the retardation test suggests that the habituation procedure did not go without effect. The analysis of the retardation test in blocks of two trials indicated that only in the first block were the inhibitory groups equally suppressed, while in the second block the Inhibition-habituation was more suppressed than the Inhibition group. Although this difference can only be suggestive, it points towards the weakening of inhibitory learning by habituation. The next experiment attempted to confirm this suggestion.

EXPERIMENT 2

The aims of this experiment were similar to those of Experiment 1. In addition, it attempted to provide reliable evidence for the devaluation of the horn. Given that 40 postconditioning exposures to the horn did not produce good evidence of reduction in suppression elicited by the horn exciter during the savings test, the present experiment used 84 horn exposures. This number is greater than Rescorla's (1973 a) study where a horn of similar intensity was habituated after only 72 exposures.

Since the previous results raised the possibility that a conditioned inhibitor may continue to be effective even after the reinforcer on which it was established has been habituated, the present experiment enquires whether this could occur when a more powerful devaluation procedure was used. Consequently, one group experienced pairings of the horn with food with the purpose of counterconditioning the horn's aversive effects. It was expected that such a training would not only habituate the aversive effects of the horn, but that such procedure would possibly transform it into an appetitive exciter (see Pearce, 1975; Konorski, 1967).

Method

Subjects and Apparatus

Thirty-two male naive hooded rats obtained and maintained as for Experiment 1 were used. The apparatus was as in the previous experiment.

Procedure

The procedure of this experiment is largely similar to that used in Experiment 1 with the following exceptions. During inhibitory training one instead of two AX trials was presented each session. Also, the devaluation procedure was longer and included the manipulations described below. The rats were trained to lever press and then given seven sessions on a VI 1-min food reinforcement schedule before Pavlovian conditioning started. All sessions were 50 min long.

Inhibitory training. During the first two sessions stimulus A was paired with the horn and stimulus B with shock. For half of the rats A was the flashing light, for the other it was the ceiling light. Each stimulus lasted for 1 min, and two such pairings occurred each session. Horn blasts were 5 sec, and shocks were 0.7 mA, 0.5 sec. The rats were assigned to four groups on the basis of their levels of suppression to both stimuli, and three of these groups were exposed to the conditioned inhibition procedure for a further twelve sessions. In each session these groups received one A-horn, one B-shock, and one AX nonreinforced compound trial. The fourth group did not receive the AX trials.

Devaluation training. The stage, lasting seven sessions, was intended to decrease the aversiveness of the horn in two of the groups. For the group Inhibition-Habituation (I-H) in each session twelve unsignaled horn blasts were presented. For the group Inhibition-counterconditioning (I-CC) in each session twelve unsignaled horn blasts occurred, but the offset of each was followed by the delivery of 5 pellets. The groups Inhibition (I) and Control (C) were placed in the chambers for the same number of sessions, but no scheduled events occurred. During this stage, the lever was removed and the floor was covered by a Plexiglas sheet and sawdust.

Testing. In the next two sessions the rats received lever-press retraining under the VI 1-min schedule in preparation for the tests to follow. In the first test session four A only trials were presented to all rats. In the next session a summation test in extinction consisting of two B and to BX trials was given. The reinforced summation test was omitted in order to avoid the possible confounding effect of shock presentation in the same session with stimulus X. The sequence of trials was as in Experiment 1. In the following session four noise-shock pairings were given as a retardation test. Throughout the experiment intertrial intervals were variable, with a mean of 10 min.

Results and Discussion

During the first stage of the experiment three rats were discarded because they ceased responding, and a fourth was also discarded because it showed signs of horn-induced seizures (Bures, Buresova & Houston, 1976). All other rats learned to lever press, although their response rates were more variable than those of the subjects in Experiment 1. On the last lever press training session the mean response rates were 21, 27, 19, and 21 response per min for the groups I, C, I-H, and I-CC respectively. These rates did not differ reliably between groups, $F(3, 24) < 1$.

Inhibitory training

The left-hand side of Figure 4 shows the mean suppression ratios on each trial over the last two session of inhibitory training. The three different types of trials generated rather different suppression levels. On B trials suppression was near maximal, on A trials it was intermediate, and during the AX trials there was no suppression at all. Considering suppression of lever pressing elicited by the exciters first, it seemed that the group C was more suppressed to A than all other groups; however, this was not confirmed by a statistical test, $F(3, 24) = 1.32$. The groups did not differ significantly with respect to suppression to B, $F(3, 24) < 1$. In order to compare the magnitude of suppression to the exciters the suppression ratios were analysed using Groups and Exciters as factors. This analysis indicated a highly significant Exciters effect, $F(1, 24) = 60.06$. Neither the Groups effect, $F(3, 24) = 1.09$, nor the Groups x Exciter interaction was significant, $F(3, 24) = 2.62$.

The groups exposed to the conditioned inhibition procedure were equally suppressed to AX, $F(3, 24) < 1$. Furthermore, a comparison of suppression on A and AX trials revealed a significant Trials effect, $F(1, 18) = 17.75$; but nonsignificant effects of Groups, $F(3, 24) < 1$; and Groups X Trials, $F(9, 72) < 1$.

Test of A

The right-hand side of Figure 4 shows the mean suppression ratios after the devaluation stage. During the first trial the group C was more suppressed than all other groups, and the group I also seemed more suppressed than both I-H and I-C groups. Interestingly, the least suppressed group seemed to be the I-CC group. However, the analysis of this data with the factors of Groups and Trials revealed a highly significant Trials effect, $F(3, 72) = 20.99$; but only marginally reliably Groups effect, $F(3, 24) = 2.56$; the Group x Trials interaction was not significant, $f(99, 72) = 1.23$. The mean response rates on this session were 18, 16, 19, and 19 response per min for the groups

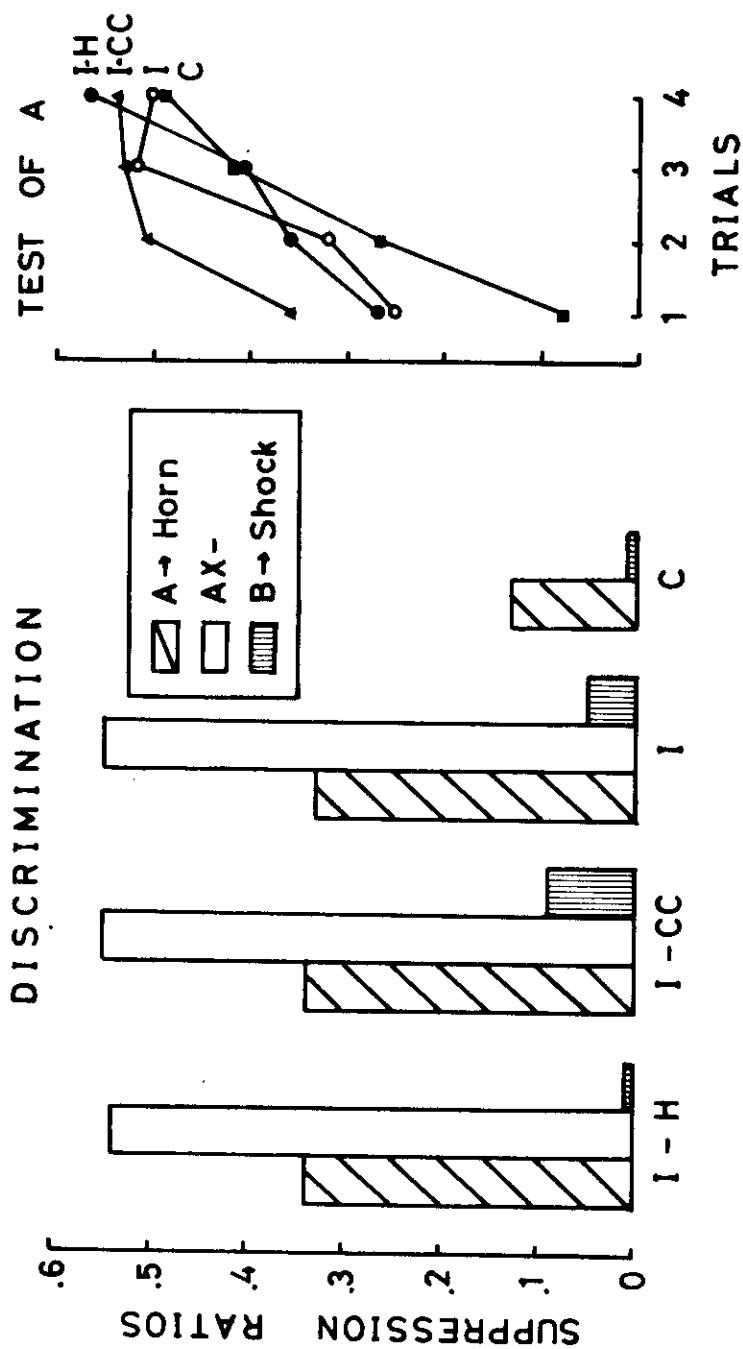


Figure 4. The left-hand side shows the mean suppression ratios on each trial over the last two sessions of inhibitory training of Experiment 2. The right-hand side shows the mean suppression ratios elicited by A, when A was no longer reinforced. I-H, I-CC, 1, and C stand for the groups Inhibition-habituation, Inhibition-counterconditioning, Inhibition, and Control respectively. Other details as described for Experiment 1.

I-H, I-CC, I, and C respectively. They did not differ significantly between groups and trials. Groups, $F(3,72) = 1.51$; Trials, $F(3,72) < 1$; Groups Trials, $F(9, 72) = 1.49$.

Transfer of conditioned inhibition

The upper portion of Figure 5 shows the mean suppression ratios during the summation test. Suppression ratios to B varied between groups to some extent, but the differences never reached significant levels, $F(3, 24) < 1$. Presentation of X reduced suppression to B in the three inhibitory groups, but not in the group C. However, the comparison of suppression during BX revealed that the groups did not differ reliably, $F(3, 24) = 2.15$. As the groups did not differ significantly with respect to B, the release score was computed for each subject. The mean scores were .07, .13, .16, and .00 for the groups I-H, I-CC, I, and C respectively. These scores did not differ between groups, $F(3, 24) < 1$. Mean response rates in this session were 17, 19, 20, and 22 for the above groups respectively. These rates did not differ significantly, Groups, $F(3,24) < 1$; Trials, $F(3,72) < 1$; and Groups x Trials, $F(9, 72) < 1$.

Retardation test

The lower portion of Figure 5 shows the outcome of the retardation test session. Although pairing of X with shock resulted in suppression in all groups, the group C was more suppressed than any of the other groups. An analysis of these data with the factors of Groups and Trials indicated a reliable Groups effect, $F(3, 24) = 3.51$; and a reliable Trials effect, $F(3, 72) = 13.49$; the Groups x Trials effect was not significant, $F(9, 72) = 1.78$.

As X acquired suppression of lever pressing at different speeds in the different groups, the data were analysed in blocks of two trials each. This analysis revealed that the groups differed in both blocks: Block 1, $F(3, 24) = 3.92$; Block 2, $F(3, 24) = 3.39$. Subsequent Newman-Keuls tests showed that the group C was more suppressed than the three inhibitory groups, and that the latter groups did not differ from one another in the first block. In the second block, group C was again more suppressed than the groups I-CC and I, but none of the other comparisons was significant. On this session response rates varied from 2 to 75 responses per min. Their analysis with the factors of Groups and Trials did not reveal a single significant effect: Groups, $F(3, 24) < 1$; Trials, $F(3,72) = 1.50$; Group x Trials, $F(9,72) < 1$.

As in Experiment 1, the present experiment failed to detect an effect of postconditioning manipulation of the horn. It was expected that extended exposure to unsignaled horn would attenuate suppression to A in the group I-H, and that this effect would be magnified by pairings of horn-food in the I-CC group. The lack of devaluation effect in the group I-H is quite surprising

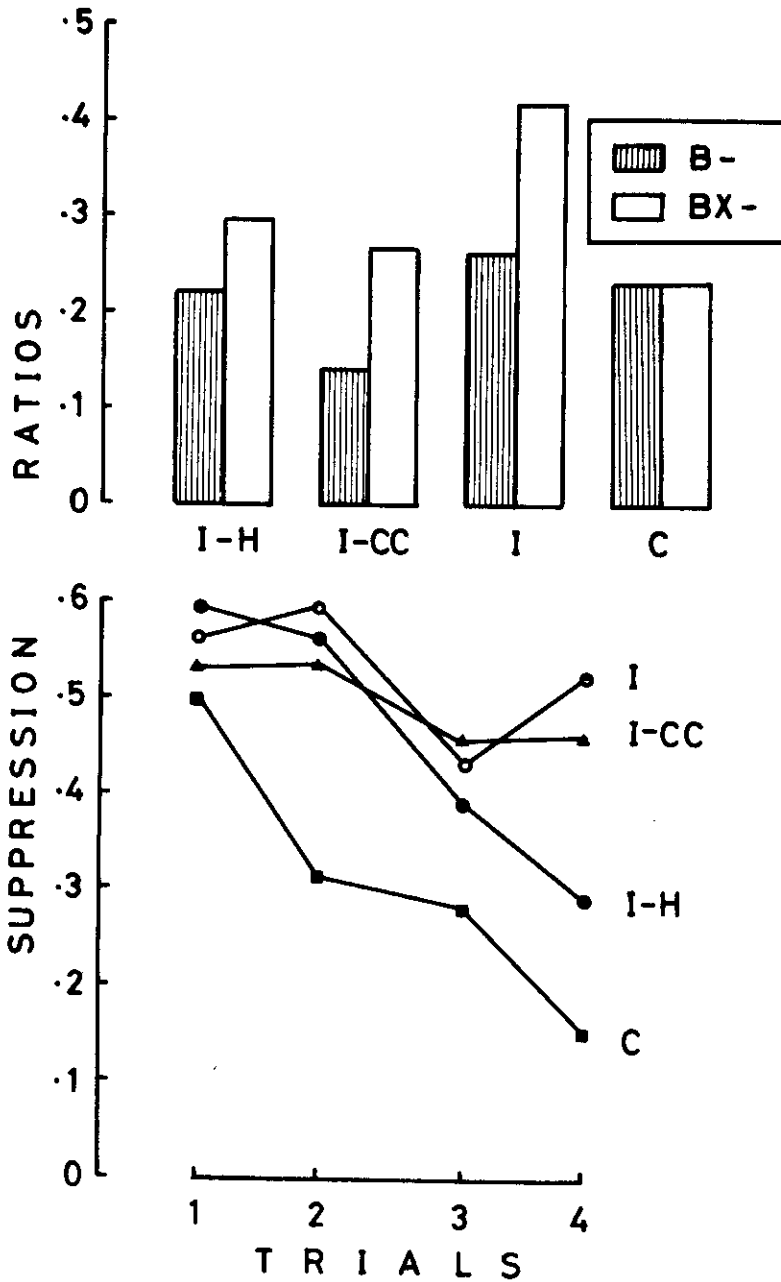


Figure 5. The upper portion shows the mean suppression ratios during the nonreinforced summation test of Experiment 2. The lower portion shows the results of the retardation test, where the conditioned inhibitor (X) was paired with shock. Other details as for Figure 4.

since Rescorla (1973 a) obtained such an effect with only 72 exposure to the horn, but in the present experiment 82 exposures were not enough to produce that effect.

There are several procedural differences between these two experiments and any of these could be responsible for the present failure in replicating. For instance, in Rescorla's study the 72 horn presentations were massed in the 2-hr session while in the present experiment the 82 horn presentations were given in seven 50-min sessions. It may be that massed presentation of the reinforcer is required in order to obtain a devaluation effect with the savings test employed in Rescorla's (1973 a) and the present study. An obvious alternative is that despite the similarity in the magnitude of suppression elicited by the horn in Rescorla's and the present study, the horn blast used in the present experiments was more aversive and therefore required more exposure to habituate.

Equally surprising was the lack of effect observed in the group exposed to horn-food pairings, since it was expected that this procedure would not only habituate the horn but establish it as an appetitive exciter. As no additional measure of appetitive conditioning such as tray entries, nor the ability of the horn to participate in new excitatory learning was obtained it was not possible to ascertain whether the horn ever gained appetitive excitatory control.

GENERAL DISCUSSION

The results of the present experiments clearly demonstrate that the effects of a conditioned inhibitor are not specific to the reinforcer used in its formation, but extend to a different reinforcer. Although these data do not provide evidence which could allow us to identify the facts which permit such transfer effect to occur, other experiments suggest that transfer of inhibitory only occurs between reinforcers belonging to the same hedonic dimension (e. g., Bull, 1970; Konorski, 1967).

The present experiments attempted to determine the relative independence of memorial aspects of the two reinforcers by devaluing one of them. However, the lack of effect of the devaluation procedures does not allow a firm conclusion on this issue. They however suggest that some alternative accounts of the transfer effect can be ruled out. It has been suggested (Nieto, 1984) that the inhibitor for horn could have produced increased lever pressing during the summation test because it acted on the background stimuli-horn association established during inhibitory training, not because it acted on the B-shock association. However, the notion of mediation by background stimuli suggests that there should be a difference in the magnitude of the transfer effect between the Inhibition and Inhibition-habituation groups, since unsignaled presentation of the horn during the devaluation stage should have made background stimuli more excitatory in the latter than in the former group, and therefore the greater the transfer effect should have

been in that group. This was clearly not the case, since these two groups were virtually identical in both experiments. Furthermore, if the background stimuli had been more excitatory in the Inhibition-habituation group than in the other groups, different response rates could be expected between the groups but these differences never were detected. Thus, these data is inconsistent with an interpretation based on mediation by excitatory background stimuli.

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