BIRKIMER, John Charles, 1940-
SENSORY PRECONDITIONING AND HIGHER ORDER CONDITIONING WITH DISCRIMINATIVE STIMULI IN INSTRUMENTAL REWARD LEARNING.
The Ohio State University, Ph.D., 1966
Psychology, experimental

University Microfilms, Inc., Ann Arbor, Michigan
SENSORY PRECONDITIONING AND HIGHER ORDER CONDITIONING WITH
DISCRIMINATIVE STIMULI IN INSTRUMENTAL REWARD LEARNING

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

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* * * * * * *

The Ohio State University

1966

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ACKNOWLEDGMENTS

The author expresses his appreciation to his adviser, Dr. Reed Lawson, and to the other members of his dissertation committee for their encouragement and guidance. He also expresses his gratitude for financial assistance to the National Science Foundation, the National Institute of Mental Health, and to the Graduate School.
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INTRODUCTION

Higher Order Conditioning

Pavlov (1927) summarized the first studies on higher order conditioning (HOC). In first order, or simple classical conditioning, a neutral stimulus precedes an unconditioned stimulus (UCS), the latter eliciting an unconditioned response (UCR) reliably. After several such pairings the neutral stimulus (now referred to as a conditioned stimulus or CS) begins to elicit a learned response or conditioned response (CR) of the same class as the UCR. In second order conditioning a new neutral stimulus is arranged to precede the CS from successful first order conditioning, but the UCS does not follow the CS. (Often some CS-UCS pairings are interspersed among these neutral stimulus-CS pairings to prevent extinction of the CR the CS elicits.) After several pairings of the neutral stimulus and CS, the neutral stimulus begins to elicit the CR. The neutral stimulus is then referred to as a second order conditioned stimulus or $CS_2$, and the CR which occurs to it is called a second order conditioned response or $CR_2$. Another neutral stimulus could now be selected and third order conditioning attempted. Any order conditioning above the first is referred to as higher order conditioning; such conditioning invariably involves the eliciting of the to-be-conditioned response by a CS, a stimulus which elicits the response as a result of previous conditioning.
Pavlov discussed studies using metronome or buzzer as CS, food as UCS, salivation as UCR, CR, and CR$_2$, and a black square as CS$_2$. He reported an inability to obtain third order conditioning with food as UCS. He did report third order conditioning in classical defense conditioning, however, with shock to the skin on the paw as UCS, mechanical stimulation of the paw as CS, sound of bubbling water as CS$_2$, and a tone as CS$_3$. The UCR and various level CRs were flexion of the leg. Fourth order conditioning was found impossible even with the classical defense conditioning procedure.

Attempts to replicate Pavlov's work were made in America during the decade from 1930 to 1940 by Brogden (1939), Brogden and Culler (1935), and by Finch and Culler (1934). These studies claimed to demonstrate the effect easily through use of an additional motivating stimulus. Their procedure involved discriminated instrumental avoidance learning, rather than classical defense conditioning, in that the "UCS" (shock) was avoidable if the "CR" (leg-flexion) occurred after the CS was presented but before the "UCS" began. Further, the additional motivating stimulus was thoracic shock in the 1934 and 1935 studies, a shock which was avoided if the "CR" occurred to higher-order CSs, and food in the 1939 study, food given only if the "CR" occurred to higher order CSs. These studies found each higher level easier to obtain than the last, a point consistent with the modern interpretation of their results. They were simply training instrumental responses to various stimuli, not demonstrating HOC. Primary reinforcement in the form of thoracic shock or food was available on supposed HOC trials.
Successful American demonstrations of HOC began with that of Eocher and Culler (1941). After cats were trained to avoid shock by foot-withdrawal and thus terminate CS, they could be trained to terminate a CS\textsubscript{2} to avoid CS with no shocks presented after original shock avoidance training. Extinction of the response to either first or second order CSs occurred quickly when the CS was presented with neither the shock nor the preceding higher order CS.

Razran (1955) reported a study using humans as subjects, food as UCS, salivation as UCR, CR, and CR\textsubscript{2}, the sound of a metronome as CS, and the flashing of a green light as CS\textsubscript{2}. Three groups of subjects were run; a "misinformed" group (MI), told that the purpose of first order conditioning was "to study the effects of auditory fatigue upon digestion" and of second order was "to find out which affects digestion more, auditory or visual stimuli," a second group "informed without suggestion" (IWOS) was told about Pavlov's dog studies and told that the experiment was being performed to "find out whether human subjects condition similarly," and a third group "informed with suggestion" (IWS) was told that human subjects do condition like dogs and that the experiment was being performed to gather more data on the matter. First order conditioning was successful in all groups, with MI showing more of an effect than IWS which, in turn, showed more than IWOS. Second order conditioning, however, did not occur in MI, was questionable in IWOS, while definitely occurring in IWS. Razran concluded that the effect was likely the result of a "central cognitive factor." He felt that HOC was likely unobtainable in dogs, while obtainable in
lower species as a result of extinction generated failure of earlier discrimination training. He later (1961) retracted these suggestions and accepted the cross-species generality of the effect.

Murphey and Miller (1957) attempted higher order instrumental avoidance conditioning in 15 rhesus monkeys, using a variety of visual and auditory stimuli. After obtaining first order bar-press avoidance conditioning, they presented second order stimuli alone and tested for generalized responding to them. If such responding occurred they extinguished it and then attempted to get their subjects to avoid the CS from first order conditioning. Only seven of the 15 subjects showed second order conditioning and only one of these showed third order. The authors pointed out that Eccher and Culler had not given generalization tests to their higher order stimuli and may have thus reported only generalized responding. (The Eccher and Culler data showed increasing percent avoidance over higher order trials, so their results appear to be a learning effect, not generalized responding.)

Finally, McAllister and McAllister (1964) reported a third case of higher order avoidance conditioning using a hurdle jumping response, a 1200 cps 90 db tone as CS, an 18.5 ftc illumination increase as CS₂, and shock as the "UCS." After a series of CS-UCS and CS₂-CS pairings, rats in a forward conditioning group (CS preceded UCS, CS₂ preceded CS) did not show significantly greater percent avoidance of CS to CS₂ than did a backward conditioned group and a control group when compared on the training day, but did show significantly more the next day.

The American demonstrations of HOC, then, include three fairly definite examples, though each of these involved an instrumental
avoidance learning procedure, not simple classical conditioning.

Russian demonstrations of HOC continued. After Pavlov's report studies investigating the effect in monkeys and dogs included eight successful cases, 63 cases finding conditioned inhibition (subject learns to give CR only to CS, not to give it to CS₂-CS combination) and even more found no effect (Razran, 1955).

Pure classical conditioning demonstrations of HOC are reviewed in Razran (1961), including a study using rhythmic inflation of the duodenum of a dog as CS, unavoidable shock to the hind paw as UCS, paw withdrawal as UCR, CR, AND CR₂, and the sound of a buzzer as CS₂. A second study again used paw-withdrawal and shock but used a metronome as CS and irrigation of an intestinal loop with room-temperature water as CS₂.

With the possible exception of Russian work not easily accessible to the American investigator, there are no demonstrations of higher order conditioning in instrumental reward conditioning. The Russian work reviewed here confirms the phenomenon in classical defense conditioning, while Pavlov's original work established it in classical reward conditioning and defense conditioning. American studies demonstrated the effect in instrumental avoidance conditioning, but a demonstration of higher order conditioning in instrumental reward learning is lacking.

Sensory Preconditioning

Sensory preconditioning (SPC) is a phenomenon operationally somewhat similar but distinct from HOC. While HOC originated in classical conditioning work, SPC was discovered by Brogden (1939).
in an instrumental avoidance conditioning task (foot-withdrawal). He gave eight dogs 200 pairings of a bell and a light, then trained them to avoid shock by responding to the light alone. When he presented the tone alone, without shocks for failure to avoid, the eight subjects made more avoidance responses than eight control subjects who had not received the pairings of bell and light. Brogden called the apparent association of the two stimuli sensory preconditioning.

It can be seen, then, that SFC demonstrations involve first the pairing of two stimuli ($S_1$ & $S$), then training a response ($R$) to one of them ($S$), and finally testing for the response to the other stimulus ($S_1$). In these terms HOC involves the training of a response to one stimulus (first order conditioning), then the pairing of two stimuli (a neutral stimulus and the CS) and testing for the response to the paired stimulus (the neutral one).

The paradigm Brogden used was:

<table>
<thead>
<tr>
<th>Exp. group</th>
<th>Pairings</th>
<th>Training</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$S_1$--$S$</td>
<td>$S$--$R$</td>
<td>$S_1$--$R$</td>
</tr>
<tr>
<td>Con. group</td>
<td>$S$--$R$</td>
<td>$S_1$--$R$</td>
<td>$S_1$--$R$</td>
</tr>
</tbody>
</table>

Reid (1952) suggested that the above design allowed the possibility that differences between the two groups were due to the novelty of $S_1$ in the test phase for the control subjects. He suggested an alternative paradigm to control for this:

<table>
<thead>
<tr>
<th>Exp. group</th>
<th>Pairings</th>
<th>Training</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$S_1$--$S$</td>
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<td>$S_1$--$R$</td>
</tr>
<tr>
<td>Con. group</td>
<td>$S_1$</td>
<td>$S$--$R$</td>
<td>$S_1$--$R$</td>
</tr>
</tbody>
</table>

In a variation of this paradigm some experimenters (Es) have presented
both stimuli to the control group during the pretraining phase, but unpaired.

Brogden (1942) using the second paradigm attempted to show SPC with humans and the galvanic skin response. His data did not show the effect, and he attributed this to a lack of reliability in his measure of conditioning. In 1947 he used a tone as $S_1$ and a light as $S$ and attempted to show SPC in three different ways. He had three control groups, one having no pretraining, one with as many exposures to $S_1$ as the experimental group, and one with no pretraining and no testing to $S_1$. He believed groups showing greater SPC during the test phase should show fewer responses to extinction to $S$ in an extinction test following the usual SPC test phase. He told his subjects they were to respond to the light ($S$) and would be shocked if they were too slow. (In reality no shocks were given.) The test phase of his study showed SPC, the experimental group responding more often than the control, and the first two control groups showed no difference. (This is a test of the necessity of paradigm 2.) His extinction test, however, showed that the first two control groups and the experimental group did not differ in the amount of extinction they showed to $S$, though they all differed from the third control, the no pretraining or test group. A reaction time test was inconclusive.

Kara (1947), using finger-flexion avoidance as $R$, gave 12 college students 50 simultaneous 2 sec. pairings of light ($S_1$) and buzzer ($S$). He used a paradigm one control (12 subjects) and obtained the SPC effect, a greater number of test responses to $S_1$ by the experimental group.
Chernikoff and Brogden (1949) gave three experimental groups different instructions: \(E_1 \) "Respond only to the light," \(E_2 \) "Do not respond to the tone," and \(E_3 \) "Do what seems natural." In other respects this study was like Brogden's 1947 one, thus the tone was \(S_1\) and the light was \(S\). Only the first \(E\) group, \(E_1\), differed from the control group, and differed only in number of \(R\)'s to \(S_1\), not in reaction time to it.

Wickens and Briggs (1951) argued that SPC in humans was the result of a verbal mediating response. Using ten subjects (\(Ss\)) per group, they paired a tone and a light (\(S_1\) and \(S\)) 15 times for a first experimental group and presented the tone and light 15 times in random order for a second experimental group. The first group was instructed to say "now" to the paired stimuli, the second group was instructed to say "now" aloud to each stimulus. A first control group responded "now" aloud to the tone alone 15 times, and a second control group to the light alone the same number of times. Each group was then given finger-flexion avoidance training to the light. During the test phase the two experimental groups did not differ, the two controls did not differ, and the experimental groups were each significantly greater than each of the controls. These response differences indicate that a mediating response made to each stimulus separately yields the same SPC effect as does such a response made to the paired stimuli. Thus it was argued that regular human SPC \(Ss\) make a response to the two stimuli, a response elicited by one stimulus and conditioned to the other, and that this response mediates the occurrence of \(R\) to \(S_1\) during the test phase.
Animal work continued. Reid (1952) reported a failure to obtain SPC using paradigm two control with pigeons as Ss and an instrumental food rewarded response as R. He mentioned a study by Macpherson using pigeons, the same method, and paradigm one controls and obtaining positive results. He assumed his own failure was the result of differences between the two control procedures and suggested the necessity of the second paradigm.

Bahrick (1952) gave rats 400 simultaneous pairings of a buzzer (S) and a light (S₁). He then trained them to avoid to the buzzer and examined speed of transfer of this response to the light. During pretraining different groups were under 21, 15, 8, and 1 hour food deprivation, and transfer, under no deprivation, was an increasing function of preconditioning deprivation level. Differences were also found, however, in speed of acquisition of the R to the buzzer, again as a function of preconditioning deprivation level. Evidence from a high deprivation control group suggested that this latter effect reflected residual deprivation, and that this deprivation was eliminated by the time the transfer test was performed. In a second study (1953), in most respects similar to the first, he compared high and low deprivation experimental groups to a high deprivation control group and found the high experimental group to show faster transfer of the avoidance response from S (buzzer) to S₁ (light) than either low deprivation experimental Ss or high deprivation control Ss, who did not differ. Deprivation conditions again existed only during pretraining, suggesting that high food deprivation enhanced the SPC effect.
Silver and Meyer (1954) used rats and avoidance as R, and found a 1.5 sec. interval between onset of \( S_1 \) and of \( S \) to be superior to a 0 sec. or a 1.5 backward (\( S \rightarrow S_1 \)) interval. They also found no difference between paradigm one and two control groups.

Seidel (1958) had rats food-deprived during pretraining and either food-deprived, water-deprived, or satiated during training and testing. He found no difference between any of these treatments, but all showed greater transfer of the avoidance response to \( S_1 \) than did control \( S \)s trained according to paradigm two. Seidel argued that these results indicate no mediating response which is a function of deprivation state can be used to explain SPC.

Coppock (1958) used the galvanic skin response, with tone and light as \( S_1 \) and \( S \) respectively. He used a control group in which both the stimuli were presented separately in pretraining, and four experimental groups with various pretraining procedures: \( E_1 \) was given a one sec. interval between \( S_1 \) and \( S \), \( E_2 \) was given a one sec. interval between \( S \) and \( S_1 \) in that order, \( E_3 \) was given the \( E_1 \) training then the \( E_2 \) training, and \( E_4 \) was given the \( E_1 \) training then single presentations of \( S_1 \). Coppock's mediation theory suggests that \( S_1 \) is a CS, coming to elicit a CR similar to whatever UCR occurs to \( S \), and thus predicts the strengths of SPC for these groups to be functions of: (\( E_1 \)) the response being trained to a UCR then elicited in testing by a CR, (\( E_2 \)) the response being trained to a CR then elicited by a UCR, (\( E_3 \)) the response being trained to both a CR and a UCR then elicited by a UCR and a CR, and (\( E_4 \)) partial extinction of the CR which then elicits the response during extinction. He found: (1) \( E_3 \) greater than
$E_i$, in turn greater than $C$, (2) $E_j$ greater than $C$, and (3) $E_2$ no different than $C$. He made no other comparisons. His explanation handles the results fairly well, as do all the stimulus-response mediation theories.

Hoffeld, Thompson, and Brogden (1958) used cats as $S$s, tone and light as $S_1$ and $S$, and avoidance as $R$. They had five experimental groups, with 0, .5, 1.2, 2, and 4 sec. intervals between onset of $S_1$ and $S$. (Both $S$s ended contiguously.) A control group as in paradigm one was used, a paradigm two control was run erroneously and could not be used in comparisons. Each $E$ group was significantly greater than the control, but only the 4 second group was significantly greater than the other $E$ groups. Thus each interval seems to give SPC, with a four sec. interval between onset of $S_1$ and $S$ being optimum.

Hoffeld, Kendall, Thompson, and Brogden (1960) gave groups of six cats either 0, 1, 2, 4, 8, 10, 20, 40, 80, 200, 400, or 800 pairings of tone and light, then taught an avoidance response to the light. (The 0 pairings group is the paradigm one control.) Each group gave significantly more responses in the test phase than did the 0 pairings group, with only the 4 pairings group being significantly greater than the others. Thus, apparently, one pairing is enough to yield the SPC effect, four pairings are optimum, and a greater number is less than optimum but still effective.

Razran (1961) reviewed a Russian demonstration of SPC with dogs and conditioned paw-withdrawal as the $R$, shock as the reinforcement, and using internal stimulation as $S_1$ and external as $S$, and vice versa.
Wynne and Brogden (1962) then replicated the Hoffeld, Thompson, and Brogden study with a greater range of $S_1-S$ intervals. They found no SPC effect at minus 4, minus 2, or 16 second intervals, borderline significance at minus 1 and 8 seconds, significant differences from control Ss at 0, 1, 2, 4, and 6 seconds, and the 4 second interval again significantly greater than the other successful intervals.

Wickens and Cross (1963) used the galvanic skin response with humans and intervals of 0, .1, .4, and .6 seconds. An analysis of variance on their data showed a significant group difference, with the order of superiority, from low to high, being .6, 0, .1, and .4 seconds. The difference in optimum interval between the Wickens and Cross study and the Hoffeld, Thompson, and Brogden and the Wynne and Brogden studies merits comment. Two possible explanations are apparent. Brogden has not examined intervals between zero and one second, so perhaps SPC is produced by two mechanisms, one optimum at .4 seconds and one at 4 seconds. A single bimodal mechanism is, of course, possible. Alternatively, the difference between the two may lie in the subjects used or the response investigated. Obviously, the Wickens and Briggs verbal mediation notion would apply only to humans.

A second point emerging from this literature review concerns the necessity of the paradigm two control. Reid concluded that his failure after Macpherson's success indicated the need for the second paradigm. Brogden's 1947 study and the Silver and Meyer study suggest no differences between the two control procedures. The latter two studies used threat of shock and avoidance of shock, respectively, while the first two used food reinforcement to train R to S.
food reinforced responses, then, perhaps the paradigm two control is necessary, while not essential with negatively reinforced responses.

A final point involves the fact that only one successful study is reported investigating SPC with food reward for the R trained to S, the study by Macpherson mentioned in Reid's article and using only a paradigm one control. The existence of the phenomenon under food reinforcement for R to S would be better demonstrated if Macpherson's results were replicated, and with a paradigm two control.

On the basis of the reviews of the HOC and SPC literature it was concluded that a study attempting to show HOC with discriminative stimuli in instrumental reward conditioning, and to show SPC under the same conditions, was in order.
METHOD

General Statement of Procedure

The SPC procedure used was straightforward, with the exception that a within-subjects design was used. Rather than have separate groups of $S$s with $S_1$ and $S$ paired for one group and unpaired for a second, all SPC $S$s were given pairings of an auditory stimulus with light, and a second auditory stimulus unpaired. Differences in responses during the test phase to the paired auditory stimulus ($S_1$) and the unpaired one ($S_2$) in favor of the first would be evidence of SPC. Thus $S_1$ was paired with light while $S_2$ was presented an equal number of times but not paired with light. The light ($S^D$) was then established as a discriminative stimulus, a bar-press response was reinforced with food only when the light was on. Finally, the $S_1$ and $S_2$ were presented singly an equal number of times without reinforcement to determine their respective abilities to lead to the response.

The HOC procedure involved training of an $S$ (light) as a discriminative stimulus, again by making bar-pressing effective only in its presence, then preceding the light ($S^D$) with an auditory stimulus ($S_1$) while presenting another stimulus of the same modality ($S_2$) an equal number of times. When $S_1$ and $S_2$ were compared, a difference in the effectiveness of the two as discriminative stimuli, a difference in favor of $S_1$, would be evidence of HOC.
The two procedures were combined in a factorial design, half the Ss receiving SPC training and half not. All Ss were given the HOC treatment, with one-third receiving five, one-third receiving 25, and one-third receiving 50 HOC $S_1-S^D$ pairings (See Table 1). Thus Ss either did or did not receive SPC pairings, then received HOC treatment.

**TABLE 1**

**Summary of Procedure**

<table>
<thead>
<tr>
<th>Day</th>
<th>Sensory Preconditioning Group (12 subjects)</th>
<th>Non Sensory Preconditioning Group (12 subjects)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25 $S_1-S$ pairings</td>
<td>No treatment</td>
</tr>
<tr>
<td>2</td>
<td>Magazine training</td>
<td>Same as SPC group</td>
</tr>
<tr>
<td>3</td>
<td>crf for bar-pressing</td>
<td>Same as SPC group</td>
</tr>
<tr>
<td>4</td>
<td>Same as day 3</td>
<td>Same as SPC group</td>
</tr>
<tr>
<td>5</td>
<td>Same as day 3</td>
<td>Same as SPC group</td>
</tr>
<tr>
<td>6</td>
<td>$S$ and crf presented on VI 2 min. for 10 responses</td>
<td>Same as SPC group</td>
</tr>
<tr>
<td>7</td>
<td>Same as day 6</td>
<td>Same as SPC group</td>
</tr>
<tr>
<td>8</td>
<td>15 sec. with no response required after VI 2 min. before $S$ and crf presented</td>
<td>Same as SPC group</td>
</tr>
<tr>
<td>9</td>
<td>$S$ and crf now presented for 30 sec., not for 10 responses</td>
<td>Same as SPC group</td>
</tr>
<tr>
<td>10</td>
<td>$S$ and crf presented for 22 1/2 sec.</td>
<td>Same as SPC group</td>
</tr>
<tr>
<td>11</td>
<td>$S$ and crf presented for 15 sec., now on VI 80 sec.</td>
<td>Same as SPC group</td>
</tr>
<tr>
<td>12</td>
<td>Same as day 11</td>
<td>Same as SPC group</td>
</tr>
<tr>
<td>13</td>
<td>5  25  50 $S_1-S$  $S_1-S$  $S_1-S$ pairings pairings pairings (4 Ss) (4 Ss) (4 Ss)</td>
<td>Same as SPC group</td>
</tr>
<tr>
<td>14</td>
<td>Twelve $S_1$ and 12 $S_2$ presentations made for 17 seconds each in counterbalanced order on the VI 80 second schedule</td>
<td></td>
</tr>
</tbody>
</table>
Subjects and Apparatus

Twenty-four male hooded rats of the Long-Evans strain were used in the study. These Ss were 120-150 days old on the first day of the experiment. The apparatus included a commercially manufactured operant conditioning apparatus (Grason-Stadler E3125A) and the necessary programming equipment. Stimuli used included an increase in illumination (house-light and both stimulus lights turned on), a white noise (Foringer 1291) and a clicker (Foringer 1293). The two auditory stimuli were equated for intensity with a General Radio Co. sound level meter set on C (flat range). Reinforcers used were 45 mg. Noyes food pellets.

Procedure

The procedure involved, successively, preconditioning pairings of $S_1$ and $S$ for half the Ss, discrimination training with $S$ as $S^D$ for all Ss, HOC pairings of $S_1$ and $S$ (now $S^D$) for all Ss, either 5, 25, or 50 such pairings, then testing of $S_1$ against $S_2$ (presented an equal number of times as $S_1$ during SPC pairings and HOC pairings but not paired with $S$). SPC aspects of the study are, then, a within-subject version of paradigm two control.

Preconditioning. After all Ss were reduced to 60% ad-lib weight, half were selected randomly for SPC pairings. They were placed in the apparatus individually. (During preconditioning and higher order conditioning the manipulandum was removed and the recessed food-well covered.) For half of these Ss the noise came on and was followed, in two seconds, by the light, the two then remaining on together for 15 seconds and ending continguously. Twenty-five such
pairings occurred, with the other auditory stimulus, the clicker, being presented alone for 17 seconds an equal number of times. The two events, noise-light pairings and unpaired clicker presentations, were alternated simply with a fixed inter-event interval of thirty seconds. For the other half of these SPC Ss, the clicker was paired with light, the noise presented unpaired, with all other conditions similar.

Discrimination Training. All Ss were then given one day of magazine training with the light stimulus on, and reinforcements provided free on a VI 1 (variable interval one minute) schedule. The presentation of a reinforcement was accompanied by the food magazine click and a brief termination of the light. The manipulandum (the bar) was present and operative; its depression provided reinforcement and accompanying stimulus events on a crf (continuous reinforcement) schedule. Most Ss learned to bar-press on this magazine training day. Those Ss not showing an obvious learning effect were shaped to bar-press on day two. Days two through four involved crf training with the light present. On day five an S^ condition was imposed, so that the light was off, occurred on a VI 2 schedule, remained on for ten bar-presses on crf, then went off again. Responses during S^ were not reinforced. Day six continued this procedure. On day seven a requirement was added that no light (S^D) period would occur for at least 15 seconds after an S^ bar-press. Thus a 15 sec. period of no responding in S^ preceded each S^D period. On day eight the duration of the S^D period became time-based, still occurring on the VI 2 schedule but lasting for 30 seconds instead of for ten responses.
On day nine the $S_D$ period was reduced to $22\frac{1}{2}$ seconds, and on day ten to 15 seconds, occurring on a VI 80 sec. schedule. Day eleven continued the day ten procedure and concluded discrimination training.

Higher Order Conditioning. On the day after discrimination training ended the Ss were divided into three groups of eight Ss each, with the requirement that each group of eight contain four SPC and four non-SPC Ss, and that each group of four SPC and four non-SPC Ss contain two for whom noise was paired with light and two for whom click was paired with light. The first group of eight Ss was then given five presentations of the $S_1$ and $S_D$ paired, with five presentations of $S_2$ alone, with the time relationships and arrangement of events the same as in the SPC pairings procedure. The second group was given 25 pairings of $S_1$ and $S_D$ with 25 unpaired $S_2$ presentations. For SPC Ss the $S_1$ and $S_2$ identities were retained, if $S_1$ was noise in SPC training it was noise in HOC training also. Thus half the SPC Ss in each group had noise as $S_1$ and half had click as $S_1$. For non-SPC Ss the same arrangement was made, half in each HOC pairings group had noise as $S_1$ and half had click.

Testing Procedure. On the day following HOC training all Ss were tested. Each S received 12 seventeen second presentations of $S_1$ and also of $S_2$. Stimuli were presented on the VI 80 sec. schedule in counterbalanced order, as $S_1$ $S_2$ $S_2$ $S_1$, etc. Within each HOC pairings group, each SPC or non-SPC group, as stated above, two Ss had received noise as $S_1$ and two click as $S_1$. From each of these pairs one S received, during testing, the order of S presentations $S_1$ $S_2$ $S_2$ $S_1$ and the other received the order $S_2$ $S_1$ $S_1$ $S_2$. Thus HOC groups were
balanced with respect to SPC or non-SPC, these in turn were each balanced for noise or click as S₁, and these in turn were balanced as to which was presented first in testing, noise or click. During testing the bar was present in the apparatus, and Ss' responses during each stimulus presentation were recorded.
RESULTS

Table 2 shows the data recorded for each $S$, both in terms of difference scores (total responses to $S_1$ minus total responses to $S_2$) and in terms of the percentage of the responses made to the two stimuli which were made to $S_1$. Observation of the scores indicates that, while under five HOC pairings results are ambiguous, under 25 pairings both SPC and non-SPC Ss show a positive effect (with the single exception of one zero score), and under 50 HOC pairings all SPC Ss show a positive effect, all non-SPC Ss a negative one.

TABLE 2

DIFFERENCE SCORES AND PERCENTAGE RESPONSE TO $S_1$ FOR ALL Ss LISTED ACCORDING TO SPC--NON-SPC AND NUMBER OF HOC PAIRINGS TREATMENTS

<table>
<thead>
<tr>
<th>Number of HOC Pairings</th>
<th>SPC</th>
<th>Non-SPC</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>d %</td>
<td>d %</td>
</tr>
<tr>
<td>1</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>-1</td>
<td>48.1</td>
<td>0</td>
</tr>
<tr>
<td>-2</td>
<td>37.5</td>
<td>2</td>
</tr>
<tr>
<td>-5</td>
<td>22.2</td>
<td>1</td>
</tr>
<tr>
<td>25</td>
<td>d %</td>
<td>d %</td>
</tr>
<tr>
<td>1</td>
<td>53.3</td>
<td>53.3</td>
</tr>
<tr>
<td>-1</td>
<td>53.3</td>
<td>53.3</td>
</tr>
<tr>
<td>-2</td>
<td>38.9</td>
<td>38.9</td>
</tr>
<tr>
<td>-5</td>
<td>59.4</td>
<td>59.4</td>
</tr>
<tr>
<td>50</td>
<td>d %</td>
<td>d %</td>
</tr>
<tr>
<td>1</td>
<td>33.3</td>
<td>33.3</td>
</tr>
<tr>
<td>-1</td>
<td>49.0</td>
<td>49.0</td>
</tr>
<tr>
<td>-2</td>
<td>38.9</td>
<td>38.9</td>
</tr>
<tr>
<td>-5</td>
<td>59.4</td>
<td>59.4</td>
</tr>
</tbody>
</table>
Analysis of variance was run on the difference scores (See Table 3). The analysis was performed by transforming difference scores (transformed score = observed score plus 20) so that no scores were negative. Neither of the main effects (SPC or Non-SPC, and Number of HOC Pairings) reached acceptable probability levels, but the interaction term yielded a p < .01. This indicates that the effect of one treatment depends on the level of the other treatment, and can be interpreted as indicating that the effect of SPC pairings is a function of the number of HOC pairings given. Observation of scores, of course, suggested that, while SPC and non-SPC Ss were similar at five and 25 HOC pairings, SPC Ss were positive and non-SPC Ss negative under 50 HOC pairings.

**TABLE 3**

**ANALYSIS OF VARIANCE SUMMARY TABLE ON DIFFERENCE SCORES**

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (SPC)</td>
<td>32.7</td>
<td>1</td>
<td>32.7</td>
<td>1.97</td>
</tr>
<tr>
<td>B (HOC)</td>
<td>54.7</td>
<td>2</td>
<td>27.3</td>
<td>1.64</td>
</tr>
<tr>
<td>AB</td>
<td>256.1</td>
<td>2</td>
<td>128.0</td>
<td>7.71 *</td>
</tr>
<tr>
<td>S's/G's</td>
<td>299.0</td>
<td>18</td>
<td>16.6</td>
<td></td>
</tr>
</tbody>
</table>

* F .99(2,18)=6.01

The results of t tests comparing mean difference scores to zero agreed essentially with visual analysis, the SPC and non-SPC groups combined under 25 HOC pairings differed significantly from zero, yielding a \( t = 3.19(7\text{df}) \) \( t_{0.02}(7) = 3.00 \). Comparing SPC, 50 HOC Ss
mean difference score with zero yielded a $t = 10.94$ (3) [$t_{0.01}(3) = 5.84$]. Finally, a $t$ comparing non-SPC, 50 HOC Ss with zero was equal to $3.31$ (3) [$t_{0.05}(3) = 3.18$]. Thus the HOC pairings appear to have the effect of increasing difference scores at 25 HOC pairings for all Ss, but at 50 HOC pairings only SPC Ss are positive, non-SPC Ss are negative (Figure 1).

A second analysis of variance was run, on the percentage responses to $S_1$ data (Table 4). The analysis indicated both the SPC main effect and the interaction term to be below the $p = .10$ but above the $p = .05$ levels. The HOC main effect did not approach significance. A subsequent simple main effects analysis showed no significant SPC effect at zero ($F < 1.0$) or at 25 ($F < 1.0$) HOC pairings, but a significant SPC effect at 50 HOC pairings [$F = 10.483 (1, 18) p < .01$]. Simple $t$ tests again indicated 25 HOC Ss (SPC and non-SPC combined) to be

### Table 4

ANALYSIS OF VARIANCE SUMMARY TABLE ON PERCENTAGE RESPONSES TO $S_1$

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (SPC)</td>
<td>1,089.40</td>
<td>1</td>
<td>1,089.40</td>
<td>4.382&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>B (HOC)</td>
<td>1,180.23</td>
<td>2</td>
<td>590.11</td>
<td>2.37&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>AB</td>
<td>1,554.38</td>
<td>2</td>
<td>777.19</td>
<td>3.12&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>S's/G's</td>
<td>4,475.08</td>
<td>18</td>
<td>248.62</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> $F_{90}(1,18) = 3.01$  $F_{95}(1,18) = 4.41$

<sup>b</sup> $F_{90}(2,18) = 2.62$  $F_{95}(2,18) = 3.55$
Fig. 1.—Mean difference scores for groups of four subjects defined by SPC or Non-SPC, and by number of HOC pairings.
greater than 50% (p < .02), SPC, 50 HOC Ss greater than 50% (p < .03) and Non-SPC, 50 HOC Ss less than 50% (p < .01) (Figure 2). The percentage of responses to $S_1$ analysis, then, again shows the SPC treatment holding scores high at 50 HOC pairings and the non-SPC treatment permitting scores to drop.

Finally, extreme non-homogeneity of interaction cell variance was found in both analyses (See Table 5), but the high significance levels found for the interaction term in the difference score analysis and the simple main effect test in the percentage responses to $S_1$ analysis, along with the essential agreement shown by the $t$ test results and observation of the scores, suggest that conclusions are relatively safe from alpha error.

**TABLE 5**

VARIANCES UNDER TWO SPC AND THREE HOC LEVELS FOR DIFFERENCE SCORES (d) AND PERCENTAGE RESPONSES TO $S_1$ (%)

<table>
<thead>
<tr>
<th>Number of HOC Pairings</th>
<th>5</th>
<th>25</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPC</td>
<td>d %</td>
<td>d %</td>
<td>d %</td>
</tr>
<tr>
<td>Non-SPC</td>
<td>6.25</td>
<td>1.139.1</td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td>64.33</td>
<td>107.7</td>
<td>7.0</td>
</tr>
</tbody>
</table>
Fig. 2.—Mean percentage responses made by groups of four subjects defined by SPC or Non-SPC, and by number of HOC pairings.
DISCUSSION

The results indicate an interaction between SPC and HOC, such that performance after 25 HOC pairings is positive, but performance after 50 HOC pairings is positive only after SPC treatment, negative after the non-SPC treatment. The HOC treatment, then, appears to have an effect, to yield HOC after 25 such pairings. The SPC treatment has the effect of preventing a decrease in the positive performance of SPC, 50 HOC Ss, a decrease shown by the Non-SPC 50 HOC Ss. Two questions occur immediately: "How can HOC, a classical conditioning phenomenon, affect instrumental discrimination performance?" and "How can SPC interact with the HOC effect to yield the results found here?" This study, of course, only demonstrates the interaction, it does not answer these questions. Speculation on them seems reasonable.

Possible Explanation of HOC Effect on Instrumental Performance

Demonstrations of HOC in instrumental avoidance learning, as reviewed above, are not surprising; Mowrer's (1939) two-factor theory of instrumental avoidance conditioning suggests that an aversive classically conditioned response (he calls it "fear") develops to the CS or warning signal and that the instrumental response is reinforcing because it terminates the CS and thus the aversive CR. HOC in instrumental avoidance learning may involve only the classically conditioned component, permitting a higher order aversive CR to develop to higher
order CSs, with the instrumental avoidance response still reinforced by the termination of these higher order CSs and thus their aversive higher order CR. Perhaps, then, a classically conditioned component is involved in the instrumental reward training situation, and the HOC treatment acts upon it.

Several studies have been published recently on this matter. Two of these demonstrated a correlation between classically conditioned responses and instrumental responses. Sheffield (1965) reports that a dog classically conditioned to salivate to a tone was then trained to panel-press when a buzzer sounded, with pressing reinforced by the tone and food. Instrumental responses made during acquisition but in the absence of the buzzer were always accompanied by salivation, sometimes before the panel-press but more often contiguous with it or just afterward. Miller and Debold (1965) report that in rats learning a discrimination, classically conditioned tongue licking responses were distributed temporally around bar-presses made during the S condition, occurring most often with the press but often just before or just after.

A third study showed a possible control of instrumental responding by classically conditioned responses. Shapiro and Miller (1965) trained dogs to lever-press for food on a drl (differential reinforcement of low rate) schedule. Thus responses produced food only if the animals had waited a given period of time before pressing, and a premature response reset the timing interval to its original length. They then gave their Ss classical reward training, following a 1600 cps tone of five seconds duration with food. Returning the animals to the drl schedule, they presented the tone CS a number of times, noting
whether or not it was followed by an increase in salivation and whether or not it was followed closely by a premature lever-press. They found a positive correlation such that salivation to the tone was more likely followed by a premature lever-press and no salivation by no such lever-press, in four Ss. A fifth dog, who inhibited salivation to the tone, inhibited lever-pressing under the drl when the tone was sounded.

It is possible, then, that classically conditioned responses established through classical reward conditioning may control the occurrence of instrumental responses. The Shapiro and Miller data may indicate this; alternatively, their data may simply indicate that the two responses are correlated but independent, both a function of the tone, or that tone and CR control lever-pressing, not CR alone. The fact that probability of response was greater following the CR is at least suggestive of a possible controlling relationship.

A final study demonstrates that classically conditioned salivary responses do not necessarily precede the occurrence of instrumental food-rewarded behavior. Ellison and Konorski (1964) showed that dogs on a fixed-ratio nine schedule in the presence of a light S_D (thus nine responses were required to obtain the reward, and were successful only when the light was present) would respond to obtain a buzzer followed eight seconds later by the food reward. Under these conditions, bar-pressing occurred to the light while no salivation occurred, and salivation did occur to the buzzer while bar-pressing did not.

The literature indicates, then, that CRs and instrumental responses often occur together in instrumental response tasks, that CRs might be a controlling contingency for instrumental responses, and that
some schedules of reinforcement for instrumental responses can lead to temporal independence of CRs and instrumental responses.

In the procedure used for the present study, the first bar-press after the light came on was reinforced immediately, as was each succeeding bar-press, so time relationships and training conditions were such as to more likely permit a food-reinforced CR to occur to the light onset. If such CRs occurred reliably, their stimulus consequences would be a part of the stimulus complex present during reinforced responding, and might come to exert at least some control over the instrumental response. Thus the possibility that a CR was established to the light, as a result of its being followed quickly by an instrumental response and food, and that this CR developed some control over the occurrence of the instrumental response, offers a plausible explanation of the HOC effect suggested by the data from this study. During HOC pairings a higher order CR would be conditioned to the auditory stimulus paired with the light while none would develop to the other, unpaired, auditory stimulus and, during testing, the occurrence of the higher order CR to the paired stimulus would lead to more responding to it than to the unpaired stimulus. Thus a possible explanation of the HOC effect involves the notion that classically conditioned components develop in instrumental reward learning, are capable of being conditioned through HOC procedures, and do have some control over the instrumental response learned.

Spence has, of course, argued this point frequently (1965). He suggests that those components of the goal response (receipt and ingestion of food) which can occur in the absence of food (salivation
chewing, perhaps others) do become established as CRs to stimuli preceding the goal response consistently. He calls these CRs "rg's," suggesting that they have proprioceptive stimulus consequences "sg's," and that these sg's, as part of the stimulus context in which reinforced instrumental responses are made, come to gain control over the response.

Work testing predictions made by Spence's theory has been reported; other work of a similar sort, developing from an atheoretical position, has been published. Morse and Skinner (1958) showed that pigeons given free food on a variable-interval one-minute schedule in the presence of a light of one hue and no food to a light of another hue will, after being trained to key-peck on the VI 1 for food, give many more responses in extinction, and at a greater rate, to the previously reinforced hue than to the previously non-reinforced one. Since the two hues were not present during key-peck training, their differential effectiveness as S^D's during extinction must be a function of the receipt of food to one hue and not the other during the initial training.

Bower and Grusec (1964) showed that if rats are given water in the presence of S_1 and no water in S_2, then given discrimination training with responses reinforced by water to S_1 and not to S_2, they learn the discrimination faster and perform it consistently better than S_s given water for responses to S_2 and not to S_1.

Trapold, Carlson, and Myers (1965) showed that, of rats given extensive non-contingent VI 2 or FI 2 reinforcement, the FI S_s develop: (1) FI scallops, (2) low post-reinforcement rates of response, and (3)
High pre-reinforcement rates of response faster than the VI Ss when all are placed on an FI 2 schedule of reinforcement for bar-pressing.

Finally, Trapold and Winokur (1966) showed that pairings of stimuli and non-contingent reinforcement facilitate acquisition of a discriminated response to the stimulus, that presentations of the stimulus and no reinforcement with the bar removed facilitate extinction, and that generalization of a response to a different stimulus is increased if that stimulus has been paired with reinforcement and is decreased if it has been paired with non-reinforcement.

These studies all demonstrate effects of classical conditioning operations (pairing of stimuli and reinforcers or of stimuli and non-reinforcement) on later instrumental reward learning or performance, as Spence's theoretical notions suggest. Regardless of the accuracy of Spence's formulation, the manipulations have demonstrable effects on instrumental learning, and are of interest here primarily for this reason. The present study is similar to these, in demonstrating such effects, and the underlying CR approach is simply a plausible theoretical explanation for the results of these studies.

A final point that should be made with respect to the HDC procedure is that it is likely a combined learning-extinction situation. Given that some tendency to attempt a bar-press has been conditioned to the light (SD) and that, through pairings of the light with S1 this auditory stimulus may acquire the ability to generate the tendency, continued presentations of the light with bar-press impossible (the bar is removed) and no reinforcement given should eventually lead to extinction of the SD properties of the light, and thus, likely,
of any such properties of $S_1$. Within the context of the CR explanation of our results, during early HOC trials a food-based CR ($CR_f$) should be occurring to the $SD$ and, through pairings of $S_1$ and $SD$, developing as a higher order $CR_f$ to the $S_1$. However, the HOC procedure does not involve food reinforcement, so the UCS on which $CR_f$ is based is not present, thus extinction of $CR_f$ should occur with continued trials. A small number of pairings would likely lead to no consistent effect, be too few trials for higher order conditioning to have occurred. An intermediate number of pairings should yield a greater number of bar-presses to $S_1$ than to $S_2$, responses controlled by $CR_f$ occurring to $S_1$ as a result of higher order conditioning. A greater number of pairings would be expected to yield little or no responding to $S_1$, since $CR_f$ should extinguish to $S_1$ and $S$ through their continued presentation without reinforcement. (Indeed, results of this study show the Non-SPC 50 HOC procedure to have led to fewer responses to $S_1$ than to $S_2$ suggesting, perhaps, inhibition of $CR_f$ to $S_1$ as a result of continued non-reinforced pairings of $S_1$ and $S$.)

Possible Explanations of Observed Interaction Between SPC and HOC

The general notion, then, of underlying classically conditioned responses occurring to stimuli in instrumental reward conditioning and having some control over the instrumental response involved has historical precedent and is a reasonable explanation of the HOC effect obtained in this study. The remaining question, how SPC and HOC treatments could interact to yield the results obtained here, requires consideration of existing theories of SPC.
Traditional stimulus-response theories proposed to explain SPC data include those of Brogden, of Wickens and Briggs, of Silver and Meyer, of Coppock, and of Seidel.

Brogden views the first stimulus \( (S^1) \) as a CS, the second \( (S) \) as a UCS. The pairing of these two allows the CS to come to elicit a CR similar to the UCR elicited by the UCS. Training of a response to \( S \), then, establishes the response to UCR, and the test phase presentations of the CS \( (S^1) \) elicit a CR similar enough to the UCR to cause the response to occur.

Wickens and Briggs, and Silver and Meyer, take a cross-conditioning approach. They feel that \( S^1 \) comes to elicit a CR similar to the UCR to \( S \), and that \( S \) comes to elicit a \( CR_1 \) similar to the \( UCR_1 \) to \( S^1 \). The training phase would include \( R \) being conditioned to the UCR to \( S \), and also being conditioned to the \( CR_1 \) preconditioned to \( S \). The test phase, then, would have \( S^1 \) elicit the CR conditioned to it in pretraining, and this CR is similar enough to UCR to cause \( R \). Also, \( S^1 \) would elicit its own \( UCR_1 \), similar to the \( CR_1 \) which \( S \) elicited during training and which \( R \) was conditioned to, so \( R \) occurs. (This source of strength for \( R \) would seem to depend on training trials being few enough to prevent \( CR_1 \) to \( S \) from extinguishing. Note also that Wynne and Brogden found backward SPC with a -1 second \( S^1--S \) interval but not with a -2 second one.) Further, Wickens and Briggs include previously learned \( R \)'s to \( S \) or \( S^1 \) as possible "UCR's" and thus mediators.

Coppock's analysis seems essentially similar to that of Brogden, although he specifically mentions that it is the stimulus consequences
of UCR to S which are conditioned to R during training, and that when, in testing, $S_1$ elicits CR, it is by virtue of the similarity between CR and UCR's stimulus consequences that R occurs.

Each of these theories, then, relies on the occurrence on the test stage of a CR elicited by $S_1$, similar to the UCR to S, and the elicitation of R by that CR. They are referred to as mediation theories, for they argue that the CR mediates the occurrence of the R.

The second general approach, suggested by Seidel (1959) is basically a mediation one, but suggests that the response is a Hebbian perceptual response and can be performed independently of ongoing instrumental behavior. Eye-movements, for example, previously learned to one of the stimuli, become conditioned to the other. The theory, then, explains SPC by the conditioning of a previously learned response to S to $S_1$ and its elicitation by $S_1$ and mediation of R during the test phase.

Thus theories of SPC include mediational explanations of the effect, explanations positing unobserved responses, classical or instrumental, mediating the occurrence of R to $S_1$. We have, then, theoretical justification for assuming that the R is made to unobserved responses conditioned to $S_1$ and originally elicited by the light, or S. We can refer to these as $CR_{1_{ll}}$ ($CR_{light}$). In HOC we assumed that R is made to another CR, a higher order CR based on a UCR of food, one we referred to as $CR_{f}$ ($CR_{food}$). An interaction between SPC and HOC would thus be viewed as an interaction between the two CRs, $CR_{1_{ll}}$ and $CR_{f}$.

The interaction obtained here was such that both SPC and Non-SPC groups show approximately no effect at five HOC pairings, about the
same positive effect (more Rs to $S_1$ than to $S_2$) at 25 HOC pairings, but the SPC group at 50 HOC pairings remains positive while the Non-SPC group shows a negative effect. Considering underlying CRs as the mechanism producing this effect, there are at least two ways that the interaction found here could occur.

A study by Hull (1934) showed, with an instrumental reward conditioning procedure, that rats first taught to run 20 feet down a runway for food, then taught to run 40 feet down the same runway for the food reward, often "regressed" or returned to the older response, running 20 feet and slowing down or stopping, during experimental extinction. In the instrumental reward situation, then, it appears that extinction of the later-learned response may lead to a reappearance of the earlier-learned one. If this interpretation of Hull's findings is correct, and if the same is true of classically conditioned responses, then in the present study the 50 HOC SPC Ss could have "regressed" to making $CR_{1+}$ responses to $S_1$, $CR_F$ having been extinguished by 50 HOC pairings (and thus the negative performance of Non-SPC 50 HOC Ss). Since R, the bar-press response, was learned to the light, it would have occurred to $CR_{1+}$, as this CR is simply a conditioned form of the UCR to light. The similarity of SPC and non-SPC Ss at 25 HOC pairings is consistent with this explanation, all Ss were responding to the stimulus consequences of $CR_F$ made to $S_1$. The lack of an effect at 5 HOC pairings can be interpreted as indicating that five HOC pairings, while not enough to produce a consistent $CR_F$ response to $S_1$, were enough to cause indiscriminate responding to the
two auditory stimuli, $S_1$ and $S_2$, and thus damp out any effect that should have occurred to $CR_{\downarrow}$ to $S_1$ in SPC Ss.

A study somewhat similar to Hull's was performed by Perkins and Tilton (1954). These investigators found that a change in stimulus conditions at the choice point in a "T" maze led rats to regress to an earlier learned response (turning one way as opposed to the other). If these results generalize to include extinction of the later learned response as a change in stimulus conditions, as Hull's study suggests they do, again the possibility arises that $CR_{\uparrow}$ to $S_1$ must be extinguished for SPC Ss before $CR_{\downarrow}$ occurs and has an effect.

A second possible explanation of the results of this study, a second way in which the effects of $CR_{\downarrow}$ could be delayed until $CR_{\uparrow}$ has been extinguished, involves the notion of differential cooss-modal stimulus intensities and early work on conditioning of salivation to cross-modal stimulus compounds (Pavlov, 1927, see also Razran's review, 1965).

Pavlov's students found that, after conditioning salivation to a cross-modal stimulus compound (e.g., a light and a tone), one stimulus was exerting most or all of the control of the CR, while the other exerted little or none. With two stimuli of the same modality, the two controlled the CR about equally only when they were of approximately equal intensity. Pavlov concluded that the cross-modal situation likely involved differences in intensity also. Since conditioning to a compound of two stimuli occurs primarily to the more intense, perhaps extinction to a compound stimulus occurs primarily to the more intense, at least until the response is nearly extinguished.
to that stimulus, then occurs to the weaker one. In terms of the notion of attention, perhaps in Pavlov's situation Ss condition to the stronger stimulus because they attend to it, and perhaps in the test situation used in this study SPC Ss attend to stimulus consequences of CR f made to S 1 and then, as CR f extinguishes, begin to attend to the stimulus consequences of CR 11 made to S 1. Specifically, 5 HOC pairings Ss are supposedly attending to CR f, but this has not been reliably conditioned to S 1 by only 5 pairings, so these Ss show no effect. Twenty-five HOC pairings Ss attend to CR f, reliably conditioned to S 1 by 25 pairings, so these Ss show greater responding to S 1. Finally, 50 HOC pairings Ss differ, those with SPC training attend to CR 11, since CR f is extinguished, and thus make the response more often to S 1, while those with no SPC training make no CR 11 response and thus do not show more responses to S 1. That CR f should have more intense stimulus consequences than CR 11 is likely: SPC Ss had only 25 S 1--S pairings in SPC training, while all Ss had well over 500 food rewards in the presence of light, and all were run at 80% ad-lib body weight.

Both of these theoretical attempts to explain the observed result specify conditions supposedly existing at the beginning of testing, conditions involving differences in the probability or in the intensity of unobserved CRs. Perhaps such approaches to explaining results of the type found here, effects on instrumental learning or performance of classical conditioning manipulations of stimuli, or of SPC manipulations, will be verified and proven useful by future research. Obviously, many of the suggestions made here in attempting to account for the results could be examined experimentally. Perhaps,
alternatively, attempts to explain such results through the mediation of classically conditioned responses will prove unwieldy, ineffective, or incorrect. Under such conditions the results would likely tend to be accepted as independent phenomena. Either way, such studies contribute to the understanding, prediction, and control of behavior.
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