Surprise and the Attenuation of Blocking

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Three experiments, employing conditioned suppression in rats, examined the extent to which pretraining on one element of a compound stimulus blocked conditioning to the other element when some feature of the reinforcer was changed on compound trials. In Experiment 1, both the addition of an unexpected second shock 8 sec after the end of each trial and the postponement of an expected second shock from 4 to 8 sec attenuated blocking. Experiment 2 established that this latter unblocking effect was due to the surprising postponement of the second shock on trials when the new element was added rather than to any generalization decrement from pretraining to compound training. Experiment 3 showed that blocking was attenuated not only by the addition of an unexpected second shock but also by the omission of an expected shock.

In a series of experiments on conditioned suppression in rats, Kamin (1968, 1969) showed that the amount of conditioning accruing to one element of a compound conditioned stimulus (CS) over a series of reinforced compound trials was affected by the subject's prior experience with the other element. If one element had previously been paired with shock, it might severely attenuate or, in Kamin's words, block conditioning to the other element.

Kamin interpreted his results to mean that conditioning was dependent on the predictability of reinforcement: No conditioning accrued to the added element on compound trials because reinforcement was already fully predicted by the presence of the pretrained element. Only surprising reinforcers are reinforcing. Rescorla and Wagner (1972) have proposed a model of Pavlovian conditioning which is intended to capture at least part of this idea. They assume that a given reinforcer can support only a certain amount of conditioning (represented by a parameter, \( \lambda \)); and increments to the associative strength of one element of a compound CS are proportional to \( \lambda - \bar{V} \), where \( \bar{V} \) represents the current associative strength of all stimuli present, including, of course, other elements of the compound CS. In the blocking experiment, sufficient initial training with one CS will drive its associative strength close to \( \lambda \), with the consequence that on compound trials the quantity \( \lambda - \bar{V} \) will be very small and the added element can gain little or no associative strength.

Kamin (1969) presented further experimental evidence that is entirely consistent with these accounts of blocking. He showed, for example, that significant conditioning would occur to the added element (i.e., blocking would be attenuated) if the compound CS signaled a stronger shock than that paired with the first element during pretraining. The stronger shock was unpredictable or surprising and hence acted as an effective reinforcer. In Rescorla and Wagner's terms the amount of conditioning portable by a strong shock will be greater than that supported by a weak shock, and with an increase in \( \lambda \) the quantity \( \lambda - \bar{V} \) will be sufficiently large to enable the added element to gain a significant amount of conditioning.

A second experiment reported by Kamin, however, although not necessarily creating difficulties for Rescorla and Wagner's model, may at least suggest that their analysis is
not identical to Kamin’s. In this experiment, Kamin produced significant conditioning to the added element, not by increasing the intensity of shock, but by programming a second, surprising shock 5 sec after each compound trial. As this double shock did not produce more rapid initial conditioning than a single shock, Kamin argued that this second case of unblocking could not be attributed to an increase in the strength of reinforcement. Whether or not one accepts this argument (and Rescorla and Wagner, 1972, p. 79, do not), it serves to pinpoint the difference between Kamin’s and Rescorla and Wagner’s analyses. According to Kamin, unblocking may require only that the added element signal some surprising event; according to Rescorla and Wagner, significant excitatory conditioning to the added element appears to require an increase in the magnitude of reinforcement on compound trials. The present experiments sought to distinguish between these two possibilities by scheduling changes in reinforcement on compound trials that could not plausibly be regarded as an increase in magnitude.

Experiment 1
That the addition of a second, delayed shock on compound trials produces some conditioning to the added element is not sufficient to decide between Kamin’s and Rescorla and Wagner’s analyses, since an additional shock, even if delayed, presumably constitutes some increase in total aversive stimulation and may be regarded as increasing the overall magnitude of aversive reinforcement. In Experiment 1, therefore, we compared the effects of adding a second, surprising shock on compound trials to those produced by simply delaying by a few seconds the delivery of an already expected second shock. One group of rats was initially trained with a CS signaling a single shock, while a second group received comparable training except that a second shock was delivered 4 sec after the end of each conditioning trial. Both groups then received a series of compound trials on which a second shock was delivered 8 sec after the end of each trial. The first group constitutes, of course, a partial replication of Kamin’s experiment; the second should show whether postponing the delivery of a second shock, an operation unlikely to constitute an increase in the magnitude of effective reinforcement, is sufficient to produce unblocking. A third, control group received a second shock, delayed by 8 sec on all trials during both initial and compound training, while a fourth group was given no initial training with one element in order to provide some assessment of the magnitude of the blocking and unblocking effects observed in the other three groups.

Method
Subjects and apparatus. The subjects were 32 male hooded rats from the colony maintained at the University of Sussex, weighing approximately 300 g at the start of the experiment. They were housed in individual cages with unlimited access to water, and gradually reduced to 80% of their free-feeding weights. They were maintained at this weight for the remainder of the experiment, being fed an appropriate number of pellets immediately after each day’s training session.

The apparatus consisted of four two-lever chambers manufactured by Campden Instruments. The right-hand lever was removed from the chambers, and a white Perspex ceiling substituted for that usually fitted. A 60-W, 240-V strip light was mounted above the Perspex ceiling. The chambers were placed inside sound-attenuating shells, and the experiment was controlled by automatic programming equipment in an adjoining room.

Throughout each session, the chambers were permanently illuminated by a 24-V white jewel light mounted in the center of the front wall, and white masking noise was delivered from a speaker mounted in the center of the rear wall. Two CSs were used, a light and a clicker. The light was produced by switching on the overhead strip light, the clicker by a Campden Instruments audio generator delivering a 10-Hz train of clicks to the speaker. All CSs were 100 sec long. Shocks were delivered by Grason-Stadler shock generators and scramblers.

Procedure. The preliminary phase of the experiment involved magazine training and the establishment of lever pressing. On Day 1, subjects received a 50-min session, with the lever removed, and free food (45-mg pellets) delivered on a variable-time 1-min schedule. On Day 2, the lever was inserted, and lever pressing was consistently reinforced. This session lasted 30 min. Rats failing to eat pellets on Day 1 or to press the lever on Day 2 were given additional training. Throughout the remainder of the experiment, all sessions were 50 min long. On Day 3, lever pressing was reinforced on a variable-interval (VI) 30-sec schedule, and on Days 4 and 5 (and for the remainder of the ex-
ing a 100-sec period immediately prior to CS onset.

On pretest trials the group mean suppression ratios to the light ranged from .40 to .47, \( F < 1 \), and to the clicker from .41 to .53, \( F(3, 28) = 1.55, p > .10 \).

Figure 1 portrays the mean suppression ratios of the different groups to the light during Stage 1, to the clicker–light compound during Stage 2, and to the clicker during the test trials. Inspection of Figure 1 suggests that the groups receiving a double shock (Groups L+8+ and L+4+) during Stage 1 suppressed more rapidly than the group receiving a single shock (Group L+). However, this conclusion was not supported by statistical analysis. Neither the effect of groups \( (F < 1) \) nor the Groups × Days interaction \( (F < 1) \) was significant. An examination of pre-CS response rates, however, suggested that Group L+8+ responded, at least on some days, at a slower rate than the remaining groups. An analysis of variance performed on these pre-CS rates revealed a significant Groups × Days interaction, \( F(10, 105) = 3.36, p < .01 \), and a separate analysis of response rates on each session showed a significant effect of groups on Session 3, \( F(2, 21) = 7.01, p < .01 \), and Session 5, \( F(2, 21) = 11.21, p < .01 \). Individual comparisons using a Newman-Keuls procedure indicated that Group L+8+ responded significantly more slowly than Groups L+ and L+4+ on both these sessions \( (p < .05) \).

In Stage 2 the three pretrained groups maintained comparable and constant levels of suppression. Group N rapidly developed suppression to the compound CS and after the first session suppressed to a greater extent than the other three groups. An analysis of suppression ratios revealed a significant Groups × Trials interaction, \( F(12, 112) = 11.95, p < .01 \). Separate analyses showed a significant effect of groups on all sessions \( (p < .05 \text{ in all cases}) \), with Group N being significantly less suppressed than the other three groups on the first session and significantly more suppressed than Group L+ on Sessions 3, 4, and 5, than Group L+4+ on Sessions 3 and 5, and than Group L+8+ on Sessions 2 and 3 \( (p < .05 \text{ in all cases}) \).

Results

Response suppression during the CS was expressed as a suppression ratio to attenuate the effects of individual differences in the overall rate of responding. The ratio has the form \( A/(A + B) \) where \( A \) is the rate of responding during the CS and \( B \) the rate during Experiment 1: Mean suppression ratios to the light during Stage 1, to the clicker–light compound during Stage 2, and to the clicker during the test trials. (None = no conditioning trials during Stage 1; L+ = light paired with single shock during Stage 1; L+4+ = light paired with double shock during Stage 1 with 4-sec intershock interval; L+8+ = light paired with double shock during Stage 1 with 8-sec intershock interval.)
There was no significant effect of groups on the pre-CS response rates during Stage 2, \( F(3, 28) = 2.33, p > .05 \).

During the test trials the basic blocking effect was demonstrated by the fact that Group N was more suppressed than Group L+8+. The absence of suppression in Group L+8+ suggests that the blocking of conditioning to the clicker was almost complete. The intermediate levels of suppression maintained by Groups L+ and L+4+ show that both adding and delaying a second shock attenuated blocking to about the same extent without completely abolishing it. An analysis of suppression on the test trials revealed a significant effect of groups, \( F(3, 28) = 17.35, p < .01 \). Individual comparisons showed that Group N was significantly more suppressed than the three remaining groups (\( p < .01 \) in all cases), and that Groups L+ and L+4+ were more suppressed than Group L+8+ (\( p < .05 \) in both cases). The pre-CS response rates of the four groups did not differ on test trials, \( F(3, 28) = 1.53, p > .10 \).

Discussion

The results of Experiment 1 confirm Kamin's (1969) finding that the addition of a second shock during compound training attenuates blocking. More importantly, it appears that simply delaying the second shock produces a comparable degree of unblocking. Although it might be argued that the addition of a second shock could have increased the effective magnitude of the aversive reinforcer and so permit an explanation of unblocking in terms of Rescorla and Wagner's (1972) theory, it is rather less likely that postponing the second shock could have had such an effect. There is good evidence that the longer the delay between CS termination and unconditioned stimulus onset the more slowly conditioning occurs (e.g., Kamin, 1965); it is not entirely plausible, therefore, to argue that a change from a 4- to 8-sec intershock interval could have represented an increase in the total reinforcement magnitude. Moreover, although the comparison is made difficult by a difference in pre-CS response rates, there is no suggestion that Group L+8+ suppressed more rapidly in Stage 1 than Group L+4+.

Even if it is accepted that postponing the second shock from 4 to 8 sec could not have increased the overall magnitude of reinforcement, there is one possible interpretation of these results that makes no appeal to surprise as a cause of unblocking. In an earlier attempt to show that surprise was the important factor, Feldman (1971) studied blocking in appetitive instrumental discrimination learning by rats, changing from a consistent schedule of reinforcement in initial training with one element to a partial schedule of reinforcement during compound training. In spite of the consequent reduction in the overall probability of reinforcement correlated with the addition of the new element, Feldman found that it gained significant control over his rats' behavior, and attributed this unblocking effect to the surprising change in reinforcement. Neely and Wagner (1974), however, suggested an alternative interpretation in terms of generalization decrement. The change in reinforcement schedule, they argued, might have disrupted the conditioning produced by initial training, and thus, in Rescorla and Wagner's (1972) terms, have increased the magnitude of the quantity \( \lambda - \bar{V} \), not by increasing \( \lambda \) but by decreasing \( \bar{V} \). In the context of Feldman's experiment this is a plausible suggestion, for it amounts to saying that at the end of initial training, the subjects' behavior was controlled not only by the experimenter's nominal discriminative stimulus but also by stimuli arising from the schedule of reinforcement, such as traces of the outcomes of previous trials. A change in schedule of reinforcement will alter this latter class of stimuli and therefore, by generalization decrement, reduce \( \bar{V} \).

It does not, perhaps, seem very probable that in the present experiment a change from a 4-sec to an 8-sec interval between two shocks on one trial should have significantly disrupted conditioning on a subsequent trial occurring not less than 17 min later. Nevertheless, the argument is, in principle, important enough to be taken seriously.

Experiment 2

Neely and Wagner (1974) were able to show that generalization decrement was the
cause of the unblocking observed in Feldman’s (1971) experiment by running additional experiments in which trials to the compound stimulus signaling a changed schedule of reinforcement were interspersed with trials to the pretrained component alone still correlated with its original schedule of reinforcement. By thus maintaining the traces of the initial schedule, this procedure should have prevented significant generalization decrement. It also abolished the unblocking effect.

Experiment 2 was designed first to confirm the finding of Experiment 1 that the shift from a 4-sec to an 8-sec interval between shocks was sufficient to produce unblocking, and secondly, to see whether generalization decrement was in any way responsible for this unblocking effect. After conditioning in Stage 1 to the light alone paired with a double shock, all subjects received two trials per session in Stage 2, the first trial on each day being to the light alone and the second to the clicker–light compound. A factorial design made it possible to assess separately the effects of a shift in intershock interval associated with compound trials and one associated with interspersed trials to the light alone. An analysis in terms of surprise predicts that unblocking would depend on a shift in the intershock interval on compound trials, while the principle of generalization decrement implies that a shift in the intershock interval on each preceding trial to the light alone would produce unblocking.

Method

The subjects were 32 male rats from the same stock as those used in Experiment 1, and the apparatus and general procedure were both exactly the same as before. The magazine and lever-press training was the same as in Experiment 1 except that subjects received only two sessions of training on the VI 1-min schedule. Subsequently four pretest sessions were administered, two with the light and two with the clicker. Each session contained only one stimulus presentation.

The design of the experiment is shown in Table 1. As was the case for Groups L+4+ and L+8+ in Experiment 1, all subjects were conditioned to the light signaling a double shock in Stage 1 (with either a 4-sec or an 8-sec interval between shocks), and in Stage 2 they were all conditioned to the clicker–light compound signaling a double shock with an 8-sec interval between shocks. In an attempt to increase the overall level of conditioning to the clicker, only 6, rather than 12 trials were given to the light in Stage 1. There were 8 compound trials in Stage 2, but these were spread over eight days as the second trial of each day. The first trial of each day in Stage 2 was to the light alone. For Groups S and C (surprise and control), the shock signaled by the light alone was the same in Stage 2 as in Stage 1; for Group C, of course, the compound also signaled the same shock as the light, while for Group S, the compound signaled a longer interval between shocks. For Groups S–GD and C–GD (surprise–generalization decrement, and control–generalization decrement) the light signaled a different interval between shocks in Stage 1 and Stage 2. The intershock interval associated with compound trials was the same as that experienced in Stage 1 for Group C–GD, but longer for Group S–GD. All subjects received four test trials to the clicker alone, one on each of four test days. On each day, the nonreinforced clicker trial was preceded, as in Stage 2, by a trial to the light alone signaling the same pair of shocks as in Stage 2.

Results

On pretest trials the group mean suppression ratios to the light ranged from .33 to .42, $F(3, 28) = 2.05, p > .10$, and to the clicker from .39 to .46, $F < 1$.

Figure 2 illustrates the acquisition of suppression to the light in Stage 1, suppression to the clicker–light compound in Stage 2, and the suppression controlled by the clicker alone on test trials. During Stage 1, Group S–GD appeared to condition more slowly to the light than the remaining three groups. This difference cannot be due to the training conditions in effect during Stage 1, since Group S–GD was treated in exactly the same way as Group S (both receiving a 4-sec intershock interval). It presumably reflects a sampling error. By the end of Stage 1, all

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**Table 1**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Stage 1, 3 sessions</th>
<th>Stage 2, 8 sessions</th>
<th>Test, 4 sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>2L+4+</td>
<td>L+4+, CL+8+</td>
<td>L+4+, C</td>
</tr>
<tr>
<td>C</td>
<td>2L+8+</td>
<td>L+8+, CL+8+</td>
<td>L+8+, C</td>
</tr>
<tr>
<td>S–GD</td>
<td>2L+4+</td>
<td>L+4+, CL+8+</td>
<td>L+4+, C</td>
</tr>
<tr>
<td>C–GD</td>
<td>2L+8+</td>
<td>L+4+, CL+8+</td>
<td>L+4+, C</td>
</tr>
</tbody>
</table>

Note. Abbreviations: S = surprise, C = control, GD = generalization decrement; L = light, C = clicker. +4+ = double shock with 4-sec intershock interval, +8+ = double shock with 8-sec intershock interval.
groups showed nearly complete suppression to the light. An analysis over all three days showed a significant effect of groups, $F(3, 28) = 4.12$, $p < .025$, but no significant Groups × Days interaction, $F(6, 56) = 1.93$, $p > .05$. Individual comparisons (Newman-Keuls test) showed that Group S-GD was less suppressed than Groups S and C-GD, $p < .05$ in each case, while Groups C, C-GD, and S could not be differentiated. Pre-CS response rates did not differ between groups; for both the main effect of groups and the Groups × Days interaction, $F < 1$.

All groups maintained virtually complete suppression both to the light alone and to the clicker–light compound throughout Stage 2. Suppression on trials to the light alone was affected neither by whether the intershock interval was 4 or 8 sec, nor by whether the interval had been changed from Stage 1 to Stage 2, nor by the interaction of these factors, $F < 1$ in all cases. Suppression to the clicker–light compound was similarly unaffected by changing the intershock interval associated with the compound (surprise factor), or that associated with the light alone (generalization decrement), or by their interaction, $F < 1$ in all cases. Finally, there were no differences between the four groups in their pre-CS response rates, $F(3, 28) = 1.33$, $p > .10$.

Inspection of Figure 2 shows that the two surprised groups exhibited greater suppression to the clicker than their respective controls throughout the test trials. By contrast, the effect of generalization decrement interacted with test trials. On Trials 1 and 2 the groups experiencing generalization decrement showed less suppression than their respective controls. Although this difference was preserved on Trials 3 and 4 for Groups S–GD and S, it was reversed for the two nonsurprised groups, with Group C exhibiting less suppression than Group C–GD. There was no difference between the four groups in the level of suppression maintained on retraining trials to the light on these test days.

These conclusions were confirmed by statistical analysis. An overall analysis of suppression to the clicker revealed a significant effect of surprise, $F(1, 28) = 12.91$, $p < .01$, and a significant Generalization Decrement × Trials interaction, $F(3, 84) = 3.19$, $p < .05$. Neither the main effect of generalization decrement, $F(1, 28) = 3.58$, $p > .05$, nor the Surprise × Generalization Decrement interaction, $F(1, 28) = 2.44$, $p > .10$, reached significance. An analysis of performance on individual test trials revealed a significant effect of generalization decrement on Trial 2, $F(1, 28) = 6.34$, $p < .025$, and a significant Surprise × Generalization Decrement interaction on Trial 3, $F(1, 28) = 10.28$, $p < .01$. An analysis of suppression on trials to the light alone showed that performance was affected neither by the intershock interval associated with the light, nor by whether this interval had been shifted from Stage 1 to Stage 2, nor by their interaction, $F < 1$ in all cases. The four groups showed similar pre-CS response rates throughout testing, $F < 1$.

Discussion

The results of Experiment 2 agree with those of Experiment 1 in showing that the postponement of a second shock on compound trials may attenuate blocking. They also demonstrate that generalization decrement in no way contributes to this result. If the attenuation of blocking were entirely attributable to generalization decrement, then
Group S would have shown no more suppression to the added element than Group C. This was clearly not so. If generalization decrement were even partially responsible for the attenuation of blocking, then Groups S–GD and C–GD would have shown more suppression to the clicker than Groups S and C, respectively. There was, however, no consistent difference between Groups C–GD and C, while Group S–GD was reliably less suppressed than Group S.

This latter difference is consistent with the suggestion that the unblocking observed here is entirely a consequence of correlating clicker-light trials and light-only trials with different intershock intervals. The explicit method of producing surprise in this experiment was to change the intershock interval correlated with compound trials in Stage 2 from that correlated with light trials in Stage 1. Blocking should also be attenuated, however, by a difference between the intershock intervals correlated with light and clicker-light trials within Stage 2 itself. Since Group S was exposed to such a difference while Group S–GD was not, the greater suppression to the clicker shown by Group S is further evidence of the importance of surprise.

Groups C and C–GD both received the same intershock interval on compound trials as they had on light trials in Stage 1, but for Group C–GD the intershock interval on light trials was changed in Stage 2. There is no obvious reason why Group C should have shown more suppression on early test trials but less on later trials, and it does not seem worth speculating further on this pattern of results.

There were no reliable differences between the various groups in suppression to the light in Stage 1, and no suggestion of any difference between groups receiving the 4-sec intershock interval and those receiving the 8-sec interval. This again suggests that the attenuation of blocking we have observed cannot be a consequence of any increase in the effective magnitude of reinforcement. Even if this is accepted, however, it remains true that the surprising postponement of a second shock must involve the presentation of an unexpected shock. It might be possible, therefore, for Rescorla and Wagner’s (1972) model to explain the unblocking observed in Experiments 1 and 2, not by arguing that a longer delay between two shocks was generally more reinforcing than a shorter delay but rather by supposing that the second shock would be more reinforcing if it occurred at an unexpected time rather than at an expected time. It could be assumed that temporal cues dating from the termination of the CS would come to signal the occurrence of the second shock and serve to block further conditioning to that shock, provided that it continued to occur at the same interval after the CS. Any change in the time of the second shock, however, would mean that its occurrence was not fully predicted and would enable it to reinforce further conditioning.

**Experiment 3**

Although these arguments are somewhat speculative, the point they raise is sufficiently important to justify further experimental analysis. The one condition that could be construed neither as increasing the overall magnitude of reinforcement nor as involving the presentation of an unexpected second shock would be the omission of an otherwise expected second shock. Experiment 3 employed a simple factorial design in which the CS signaled either a single shock or a pair of shocks in Stage 1, and each of these groups was divided in Stage 2 for compound training, with half receiving a single shock following each compound trial and half receiving a double shock. For one group, therefore, the new element added on compound trials signaled the addition of a second shock, and for another it signaled the omission of a second shock. The two control groups received the same number of shocks, either one or two, in both stages of the experiment. To add further generality to our results, the stimulus used in Stage 1 was the clicker, and the stimulus added in Stage 2 was the light.

**Method**

The subjects were 32 male rats from the same stock as those used in Experiments 1 and 2. The apparatus and general procedure were the same as before.
In Stage 1, all subjects received two conditioning trials to the clicker (C) on each day for 6 days. For Group C+ each trial terminated with a single shock; for Group C++, a second shock was delivered 8 sec after the first. In Stage 2 there were two reinforced trials each day to the clicker-light compound (CL) for four days. Groups C+ and C++ were each subdivided, and Groups C+ CL+ and C++ CL+ received a single shock on each trial, while Groups C++ CL++ and C+ CL++ received a second shock on each trial 8 sec after the first. On the final day of the experiment there were two nonreinforced test trials to the light.

Results

On pretest trials the group mean suppression ratios to the light ranged from .40 to .44, \(F < 1\), and to the clicker from .44 to .48, \(F < 1\).

During Stage 1 the groups receiving two shocks developed suppression more rapidly to the clicker than the groups receiving a single shock. This difference is illustrated in Figure 3, which portrays the suppression to the clicker during Stage 1, to the clicker-light compound during Stage 2, and to the light on test trials. Although there was no overall significant effect of the number of shocks during Stage 1, \(F(1, 30) = 2.44, p > .10\), the Number of Shocks \(\times\) Days interaction was significant, \(F(5, 150) = 5.84, p < .01\).

Separate analyses of suppression on each day of Stage 1 showed that Groups C++ CL+ and C++ and CL++ were significantly more suppressed than Groups C+ CL+ and C+ CL++ on Day 2, \(F(1, 30) = 20.20, p < .01\). An analysis of pre-CS response rates showed that neither the main effect of number of shocks, \(F < 1\), nor the Number of Shocks \(\times\) Days interaction, \(F(5, 150) = 1.26, p > .25\), reached significance.

In Stage 2 Groups C+ CL+ and C++ CL++, which were not surprised by either the addition or omission of a shock, maintained comparable levels of suppression to the compound CS. During Days 2 and 3 the group surprised by the addition of a shock, Group C+ CL++, tended to be slightly more suppressed than the nonsurprised groups, while Group C++ CL+, surprised by the omission of a shock, was slightly less suppressed. However, by the end of Stage 2 these small differences had completely disappeared. Although neither the main effect of surprise, \(F < 1\), nor the effect of number of shocks in Stage 2, \(F(1, 28) = 3.09, p > .05\), significantly affected suppression, the Surprise \(\times\) Number of Shocks interaction, \(F(1, 28) = 4.45, p < .05\), was significant. There was no evidence that the pre-CS response rate varied as a function of surprise or shock number. The \(F\) ratios for both these effects and for the Surprise \(\times\) Number of Shocks interaction were all less than 1.

The two groups surprised during Stage 2, Groups C+ CL++ and C++ CL+, both exhibited more suppression to the light on test trials than the nonsurprised groups, Groups C+ CL+ and C++ CL++. However, the level of suppression did not vary as a function of the number of shocks received during Stage 2. There was a significant effect of surprise, \(F(1, 28) = 16.16, p < .01\), but the \(F\) ratios for the effect of number of shocks and the Surprise \(\times\) Number of Shocks interaction were both less than 1. An analysis of the pre-CS response rates revealed no significant effects with all \(F\) ratios less than 1.

Discussion

The results of this experiment provide no support for the suggestion that attenuation
of blocking requires an increase in the effective magnitude of reinforcement from Stage 1 to Stage 2. The differences observed in the acquisition of suppression in Stage 1 suggested that, if anything, a single shock acted as a less effective reinforcer than a double shock. Nevertheless, the change from a double shock in Stage 1 to a single shock in Stage 2 produced just as much unblocking as the addition of a second shock.

**General Discussion**

In Kamin's (1968, 1969) blocking experiments, little or no conditioning accrued to one element of a compound CS, if its addition to the compound signaled no change in reinforcement from that already predicted by the first element. If the new element signaled an increase in shock intensity, or the addition of a second shock shortly after the first, then it would acquire significant associative strength. The present results suggest that it is not necessary that the new element should signal any increase in shock, for either the temporary postponement of an expected second shock or its complete omission was as effective as the addition of an unexpected shock in producing conditioning to the new element. Rescorla and Wagner (1972) predict that any excitatory conditioning to the new element beyond the level found in control groups must depend either on a significant increase in the overall magnitude of reinforcement on compound trials or on the occurrence of an otherwise unpredicted shock. The results of Experiment 3 are particularly hard to reconcile with this analysis. The omission of an expected second shock can hardly be regarded either as constituting an increase in the magnitude of reinforcement or as equivalent to the presentation of an unpredicted shock. The critical finding of Experiment 3 appears sufficiently reliable, since we have been able to replicate it in a somewhat different experimental situation (Mackintosh, Bygrave, & Pickton, Note 1). Although Rescorla and Wagner's model may explain part of the unblocking observed when shock intensity is increased on compound trials, it does not appear that it provides a complete account of unblocking.

This suggests that we should consider more favorably Kamin's (1969) original suggestion that any change in reinforcement sufficient to surprise the subject on compound trials may produce significant conditioning to the added element. There is, however, a certain ambiguity to this suggestion, which may be brought out by considering Kamin's original experiment in which a second, surprising shock is added on compound trials. What is the precise role of this second shock? One possibility is that, because it is expected, it can act as a reinforcer in its own right: In spite of the trace interval separating it from the termination of the compound CS, it is able to support a significant level of conditioning to the newly added element. An alternative possibility, however, is that the second shock does not itself support conditioning, but that, again by virtue of its unexpectedness, its presence somehow ensures that the first shock, which would not by itself have acted as an effective reinforcer, is now able to play a normal reinforcing role. Kamin's suggestion that the surprising shock alerts the subject or causes it to engage in retrospective contemplation (Kamin, 1969) is consistent with this latter possibility.

The present results, especially those of Experiment 3, seem to require us to accept the second possibility. In that experiment, the surprising omission of a second shock on compound trials resulted in significant excitatory conditioning to the added element. The omission of shock may support inhibitory conditioning, but it can hardly act as a reinforcing event to produce excitatory conditioning. We must suppose that the role of the surprising event in this case was not itself to reinforce conditioning but to enable conditioning to proceed normally to the otherwise ineffective first shock. This implication is consistent with the analysis of blocking suggested by Mackintosh (1975). On this account, blocking is a consequence of the fact that subjects learn to ignore stimuli that signal no change of consequence. In a typical blocking experiment, conditioning may proceed normally to the new element on the first compound trial, but because it signals no change in reinforcement from that already predicted by the pretrained
element, there will be a sharp decline in the value of a stimulus-specific learning-rate parameter, $\alpha$, associated with the new element. For significant conditioning to occur to the new element, it is only necessary to prevent this decline in $\alpha$. Provided that it signals some event not already predicted by the pretrained element, whether this be the addition, postponement, or omission of a second shock, the value of $\alpha$ associated with the new element may be maintained at a level sufficient to produce significant conditioning. The surprising event does not itself reinforce that conditioning; it serves to maintain attention to a stimulus that would otherwise be ignored and thus enables the reinforcer actually paired with that stimulus (i.e., the first shock) to have its normal effect. This viewpoint can then explain why Gray and Appignanesi (1973) were able to produce unblocking by presenting a flash of the compound trial stimuli following each compound trial. Such an unpredicted stimulus maintained attention to the added element and thus allowed it to be associated with the reinforcing shock.

The present results have a wider significance than their relevance to theories of blocking. Whether or not one accepts the particular account suggested here, there seems no way of escaping the conclusion that an event of motivational significance such as the addition or omission of the second shock is somehow able to affect the level of conditioning to a particular CS without itself directly reinforcing that conditioning. If we assume that the effect of the surprising event is associative, rather than generally arousing, we must suppose that it is associated with the new element on compound trials, even though it is too far removed in time from the termination of that element to support any change in performance. This implies a rather sharp distinction between the associations that a reinforcer may enter into and the change in the strength of the conditioned response that it may support.

REFERENCE NOTE

REFERENCES

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