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Journal

International Journal of Comparative Psychology, 17(2)

ISSN

0889-3675

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Publication Date

2004-12-31

DOI

10.46867/ijcp.2004.17.02.09

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Peer reviewed

Latent Inhibition of US Signal Value Following CS-US Training

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Two experiments with rats examined latent inhibition of unconditioned stimulus (US) signal value. In Experiment 1, latent inhibition (LI) rats showed attenuated conditioning, compared to control (C) rats, when a single food pellet, delivered 10 min into a session, was followed by three additional pellets. In preexposure, one pellet had been delivered 10 min into the session (in Group LI), or placed into the magazine at the beginning of the session (in Group C). Experiment 2 replicated Experiment 1 and also showed that latent inhibition of US signal value resulted after conditioned stimulus (CS) - US training. Results from Experiment 2 suggest that, in Pavlovian conditioning, subjects learn a CS-US association and also learn that a US signals a subsequent US-free period. Implications for theories of latent inhibition are considered.

Historically, studies of Pavlovian conditioning have investigated the conditions that affect CS signal value and latent inhibition has been a rich source of experimentation and theory (Lubow, 1989). Latent inhibition is shown when preexposure to a conditioned stimulus (CS), such as a light or tone, retards the acquisition of conditioned responding when the CS is subsequently paired with an unconditioned stimulus (US), such as food or electric shock.

There is evidence, however, that a US can also serve as a signal, or cue, for the delivery of another US (Goddard, 1996, 1999a, 1999b; Skinner, Goddard, & Holland, 1998). For example, in Goddard (1999b), a single food pellet was delivered to a group of rats and then, 10 s later, three additional food pellets followed. Subjects rapidly learned this single food-triple food association and evidenced this learning by a significant increase in food cup, or magazine, entries following the delivery of the single food pellet.

In a recent series of experiments (Goddard, 2003), latent inhibition of US signal value was shown. In Goddard (2003, Experiment 1), latent inhibition (LI) subjects first received preexposure in which a food pellet was delivered 10 min into a 14-min session. No other events were presented and subjects received 20 preexposure sessions. Following preexposure, subjects received 5 conditioning sessions in which a single food pellet was again delivered 10 min into the session but was now followed, after 20 s, by three additional pellets. Magazine entries after the single food pellet constituted the dependent variable of interest. Control (C) subjects received identical conditioning but, in preexposure, a food pellet was placed into the magazine (prior to subject placement) and subjects were simply left undisturbed for 14 min. Results showed latent inhibition of US signal value in Group LI compared to Group C. In addition, response deficits in Group LI persisted even with a final test 28 days later. This suggested that latent inhibition of US signal value was a learning, rather than

This research was supported by a grant from the Natural Sciences and Engineering Research Council of Canada. I thank Mathew Lockhart for his technical assistance and Marilyn MacLeod for helping score behavior. Address correspondence and reprint requests to: Murray J. Goddard, Department of Psychology, University of New Brunswick, Saint John, New Brunswick, Canada E2L 4L5 (goddard@unbsj.ca).

performance, deficit (Bouton, 1993; Miller, Kaspro, & Schachtman, 1986).

In Goddard (2003), Groups LI and C were carefully equated on the number of food pellets delivered in sessions of identical duration. This procedural control reduced the possibility that response differences between Groups LI and C were importantly the result of habituation or context conditioning. Of more importance, however, was that latent inhibition of US signal value challenged three prominent theories of latent inhibition: conditioned attention theory (CAT; Lubow, 1989), rate estimation theory (RET; Gallistel & Gibbon, 2000; see also Gibbon & Balsam, 1981; Jenkins, Barnes, & Barrera, 1981), and motivational state theory (Killcross & Balleine, 1996).

According to CAT, stimulus preexposure retards subsequent conditioning because, in preexposure, an organism learns not to attend to it (Lubow, 1989). Note that in Goddard (2003), all rats were hungry (maintained at 80% of their free-feeding weight), and received only one food pellet in each daily preexposure session. It seems strained to suggest that the subjects in Group LI rapidly approached and consumed the food pellet delivered in each daily preexposure session but were failing to attend to that stimulus. Therefore, in its current form, CAT was unable to predict differences in conditioning between Groups LI and C.

According to RET, conditioned responding is a function of the average inter-trial interval between USs (abbreviated I) and the average wait for a US in a trial (abbreviated T). Responding is a function of the I/T ratio, with higher ratios corresponding to greater responding. Note that in Goddard (2003), Groups LI and C first received one food pellet in each 14-min preexposure session, or an I value of 840 s. Later, in conditioning, there was no CS presented but the trial may be conceived of as the 20-s gap between the single food pellet and the three additional pellets. Therefore, during conditioning, both Groups LI and C received I/T values of 210 s/20 s (10.5/1), which should lead to reliable and equivalent responding. In fact, since the I value in preexposure was greater than the I value in conditioning (840 s versus 210 s), RET predicts that if preexposure were to affect subsequent conditioning at all, preexposure would facilitate (not impair) subsequent responding and would do so to an equivalent degree in Groups LI and C.

Finally, according to motivational state theory (Killcross & Balleine, 1996), latent inhibition results because subjects learn that a CS is unrelated to events that are relevant to their current motivational state. For example, rats preexposed to a CS when hungry (or thirsty) showed attenuated responding but only when the CS was paired with food (or fluids) that was directly relevant to the rat's motivational state in preexposure. Note that in Goddard (2003), the stimulus delivered in preexposure was not a CS but a US (food). Since food was directly relevant to the rat's motivational state (hunger), motivational state theory was unable to predict differences in conditioning between Groups LI and C.

In Goddard (2003), latent inhibition of US signal value may have resulted because post-US inhibition developed when the subjects in Group LI received temporally separated USs in preexposure. This is consistent with other studies showing that post-US inhibition developed when subjects received temporally separated USs. For example, in Goddard (1995, Experiment 2), rats received signaled or unsignaled food pellets at 1 min intervals. Early in training there was a stable and moderate number of magazine entries after food. However, later in training, subjects showed significantly fewer magazine entries shortly after a signaled or unsignaled US (see Goddard, 1995, Figure 2). Additional evidence that post-US inhibition developed when subjects re-

ceived temporally separated USs comes from a study of serial feature-negative learning with a US feature (Goddard & Holland, 1997). In that study, rats received feature-negative training in which operant responding was reinforced when a CS was presented but operant responding was not reinforced when a CS had been preceded shortly before by a US. Subjects received temporally separated USs, so any development of post-US inhibition would presumably act to facilitate discriminative responding. Results showed rapid discriminative responding (Goddard & Holland, 1997, Figure 1; see also Goddard & Holland, 1996; Holland & Forbes, 1982; Reberg & Memmott, 1979). Also, as in Goddard (1995), there was direct behavioral evidence that the post-US period was inhibitory and, in addition, the US suppressed responding when presented prior to other previously conditioned CSs, suggesting that a US would pass a summation test for inhibition (Goddard & Holland, 1997).

One difficulty with the suggestion that latent inhibition of US signal value was due to post-US inhibition, is that post-US inhibition would presumably also develop in Group C during preexposure but Group C showed significantly better conditioning than Group LI. Note, though, that in Group C there was a change in the time of pellet delivery from preexposure to conditioning. This change in the temporal delivery of food may have constituted a sufficiently powerful change in the conditions of preexposure to reduce the latent inhibition of US signal value that would otherwise have occurred. This is supported by research showing that latent inhibition is normally attenuated with a context change between preexposure and conditioning (see Lubow, 1989; Rosas & Bouton, 1997).

If the analysis outlined in Goddard (2003) is correct, it is possible that post-US inhibition may also develop during CS-US training. Note that in CS-US training, subjects may not only learn the CS-US association but may also learn, perhaps unbeknownst to the experimenter, that the US signals a subsequent US-free period (see also Davis, Memmott, & Hurwitz, 1975). If this learning developed during CS-US training, subsequent latent inhibition of US signal value might result. However, other theories do not necessarily predict latent inhibition of US signal value following CS-US training. For example, according to Wagner (e.g., 1978), a signaled US in preexposure is initially primed but is then unprimed during subsequent conditioning. Given that unprimed stimuli should enter into associations more easily than primed stimuli, latent inhibition of US signal value should be attenuated in subjects given signaled, rather than unsignaled, USs in preexposure. Experiment 1 first attempted to replicate the finding that US signal value shows latent inhibition. Experiment 2 then investigated whether latent inhibition of US signal value would result after subjects had received CS-US training.

Experiment 1

Experiment 1 attempted to replicate the finding by Goddard (2003) that US signal value shows latent inhibition. Groups LI and C received identical conditioning, in which a single food pellet (delivered 10 min into a session), was followed, after 20 s, by three additional pellets. However, during preexposure, Group LI received a single pellet 10 min into each session, whereas, Group C received a single pellet at the beginning of each session. As in Goddard (2003), all subjects received a final test 28 days after conditioning.

Method

Subjects. The subjects were 16 individually housed female Sprague-Dawley rats obtained from the Charles River Company. The subjects were about 100 days old at the beginning of the experiment and had not been involved in previous research. The animal holding room was maintained on a 14:10-h light:dark cycle with the lights on at 06:00 h. and off at 20:00 h. Subjects were maintained at 80% of their ad libitum weight, by measured feedings of Purina Rat Chow at the end of a session, and had continuous access to water in their home cages.

Apparatus. The experimental chambers consisted of four identical boxes measuring 28 x 21.5 x 21 cm. The two side walls and top of each chamber were clear acrylic and the two end walls were aluminum. The floor consisted of 18 steel bars, each 0.5 cm in diameter, spaced approximately 1 cm apart. The front end wall contained a centrally located magazine, two lights, and a lever. The magazine was a dish-like structure, approximately 3.5 cm in diameter, that protruded from the wall at a height of about 2.5 cm from the floor. A single 45-mg dustless precision food pellet manufactured by BIO-SERV (Holton Industries, New Jersey, U.S.A.) could be delivered into the magazine by a solenoid-operated feeder located behind the front end wall. The right and left lights were approximately 2 cm from the right and left edge of the front end wall, respectively, and 11.5 cm above the floor. Extending down from the center of the chamber was a 12-cm pole. Responses to the lever and pole were not recorded.

Each chamber was enclosed in a wooden shell containing an acrylic window permitting behavioral observation. A fan mounted inside each shell provided air circulation and a constant masking noise of 89 dB (A). Each shell also contained a houselight, mounted above the chamber, which consisted of six 7.5-W, 120-V bulbs, passed through two plastic panels. The plastic panels were translucent which helped to provide constant luminance in the boxes. The houselights were always on at the beginning of a session and were turned off when a session ended.

Mounted approximately 20 cm outside each chamber was a videocamera. In an adjacent room was a videocassette recorder, connected to each camera through a quad processor (National Electronics, Canada), and an IBM-compatible computer that controlled the four chambers.

Procedure. Subjects first received one session of magazine training. Two food pellets were placed into the magazine (before subject placement) and subjects were simply left undisturbed for 10 min. After 10 min, two more pellets were delivered, followed by 10 additional pellets, separated by 1-2-min intervals in the remainder of the 30-min session. Following magazine training, subjects were randomly assigned to one of two groups ($n = 8$): Group LI and Group C.

Preexposure followed magazine training. In Group LI, one food pellet was delivered 10 min into the 14-min session. In Group C, one food pellet was placed into the magazine (prior to subject placement) and subjects were simply left undisturbed for 14 min. In both groups, no other events were presented. Subjects received 20 preexposure sessions, one session per day.

Conditioning followed preexposure. In both Groups LI and C, a single food pellet was delivered 10 min into the 14-min session. This single food pellet was then followed by three additional pellets 20 s later. No other events were presented and subjects received 5 conditioning sessions, one session per day.

Finally, 28 days after conditioning, subjects received one final test session. This final test session was necessary to examine if latent inhibition would remain, given that previous work has shown that latent inhibition may be reduced following a retention interval (e.g., Kraemer & Roberts, 1984). In both Groups LI and C, a single food pellet was delivered 10 min into the 14-min session. No other events were presented in this final test session.

Data Analysis. All observations were made from videotapes by a naive observer blind to the experimental conditions. Magazine entries were scored 20 s before, and 20 s after, the single food pellet delivered 10 min into each conditioning and test session. A magazine entry was defined as the placement of a rat's nose into the magazine (not including a placement to retrieve a food pellet). In preexposure, magazine entries were counted 20 s before, and 20 s after, the food pellet delivered 10 min into the session in Group LI. It was normally impractical to count magazine entries in Group C, during preexposure, as subjects typically consumed the food pellet before the experimenter could move to the adjacent room to commence the session.

In addition, an interobserver reliability check was conducted on final test responding. There was a correlation of 0.83 between the two observers. Only the data from the naive observer was used in all statistical calculations, although the data from both observers supported the same conclusions.

Throughout, data were evaluated by analysis of variance (ANOVA) with a rejection criterion of $p < 0.05$.

Results

Before the single food pellet presentation during conditioning, subjects in Groups LI and C responded at 1.3 ($SEM = 0.3$) and 0.9 ($SEM = 0.2$) magazine entries/min. The rates of responding from the equivalent period during test were 3.8 ($SEM = 0.8$) and 2.3 ($SEM = 1.1$) magazine entries/min. The differences in responding between Groups LI and C were not statistically significant during conditioning or test, $F < 1$ and $F(1, 14) = 1.3$, respectively. Responding after the single food pellet during conditioning and test is shown in Figure 1.

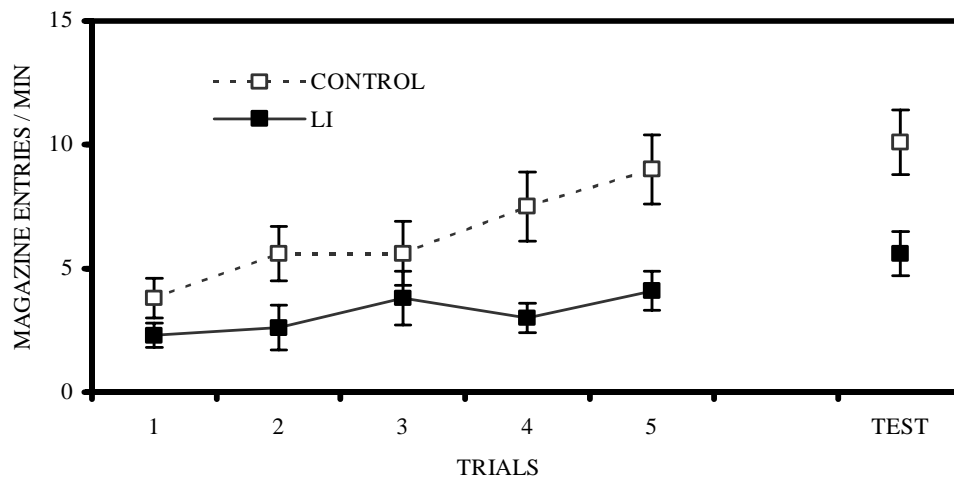


Figure 1. Magazine entries/min after the single food pellet in conditioning and test in Groups Latent Inhibition (LI) and Control in Experiment 1.

A Group x Session ANOVA conducted on the conditioning scores revealed a main effect for Group, $F(1, 14) = 11.8$, and Session $F(4, 56) = 4.5$, but the Group x Session interaction was not significant, $F(4, 56) = 1.5$. During the final test, Group C showed significantly greater responding than Group LI, $F(1, 14) = 8.5$. In addition, levels of responding on the last day of conditioning and the test were compared and the analysis showed only a main effect for Group, $F(1, 14) = 14.6$.

Also of interest was responding in Group LI during preexposure. Responding before (Pre), and after (Post), the food pellet was averaged across 2 session blocks and the results are shown in Figure 2.

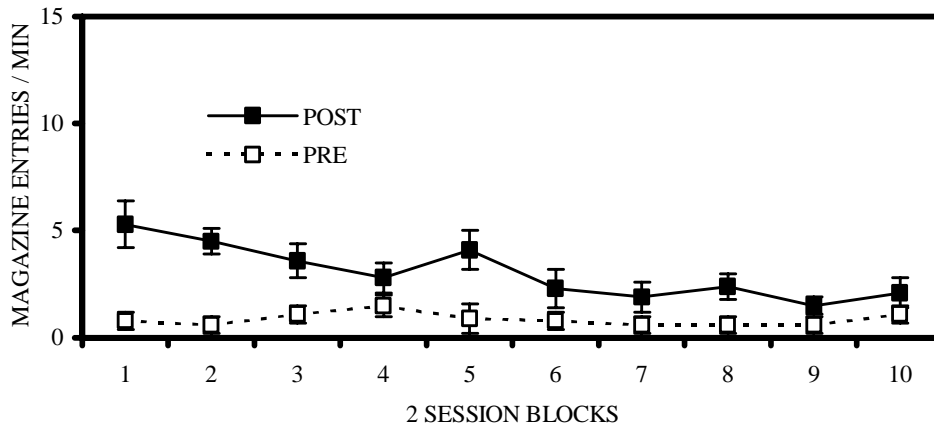


Figure 2. Magazine entries/min before (Pre), and after (Post), the pellet delivered in preexposure in Group Latent Inhibition in Experiment 1.

Responding was generally low and stable before the food pellet. However, responding after the food pellet was higher earlier in preexposure and declined across sessions. A Period (pre vs. post) x Session (averaged 2 session blocks) repeated measures ANOVA showed a main effect for Period, $F(1, 14) = 35.7$, Session, $F(9, 126) = 2.4$, and a significant Period x Session interaction, $F(9, 126) = 2.5$.

Discussion

Experiment 1 replicated previous results by Goddard (2003) that US signal value shows latent inhibition. Group LI showed attenuated responding in conditioning, and test, compared to Group C, even though both groups were carefully equated on the number of food pellets delivered in sessions of identical duration. This feature in the experimental design made it less likely that latent inhibition resulted from habituation or context conditioning.

The results of Experiment 1 were not consistent with three prominent theories of latent inhibition: CAT (Lubow, 1989), RET (Gallistel & Gibbon, 2000), and motivational state theory (Killcross & Balleine, 1996). Further, LI subjects showed attenuated responding even when tested 28 days after conditioning. This suggests that attenuated responding in conditioning was a learning, rather than performance, deficit (Bouton, 1993; Miller, Kaspro, & Schachtman, 1986).

Experiment 2

Experiment 2 investigated whether latent inhibition of US signal value would result following CS-US training. In Experiment 2, Groups LI and C received the identical conditions as Groups LI and C in Experiment 1. In addition, Experiment 2 included a third group of subjects, Group CS-US, which received similar conditions as Group LI except that the single food pellet, delivered in preexposure, was signaled by a 20-s tone. As in Experiment 1, all groups also received a final test 28 days after conditioning.

Method

Subjects. The subjects were 24 individually housed female Sprague-Dawley rats obtained from the Charles River Company. The subjects were about 110 days old at the beginning of the experiment and had not been involved in previous research. All other conditions were identical to those of Experiment 1.

Apparatus. The apparatus was identical to that used in Experiment 1.

Procedure. Magazine training was identical to that used in Experiment 1. Following magazine training, subjects were randomly assigned to one of three groups with eight subjects per group: Group LI, Group C, and Group CS-US. Groups LI and C were treated exactly as they had been in Experiment 1. Group CS-US received similar conditions as Group LI, except that the single food pellet, delivered 10 min into each preexposure session, was signaled by a 20-s 1500-Hz, 95-dB tone. Tone onset was 20 s prior to food delivery and tone offset was coincident with food delivery. Group CS-US received identical conditioning and test as did Groups LI and C; thus, the tone was not presented in conditioning and test for Group CS-US. Magazine entries were counted 20 s before, 20 s during, and 20 s after the tone CS. A correlation of 0.86 was obtained between two observers who scored responding in the final test session.

Results

Before the single food pellet presentation during conditioning, subjects in Groups LI, CS-US, and C responded at 2.0 ($SEM = 0.4$), 2.2 ($SEM = 0.4$), and 2.3 ($SEM = 0.5$) magazine entries/min. The rates of responding from the equivalent period during test were 2.6 ($SEM = 1.2$), 1.1 ($SEM = 0.6$), and 2.6 ($SEM = 1.1$) magazine entries/min. The differences in responding were not statistically significant during conditioning or test, $F_s < 1$. Responding after the single food pellet during conditioning and test is shown in Figure 3.

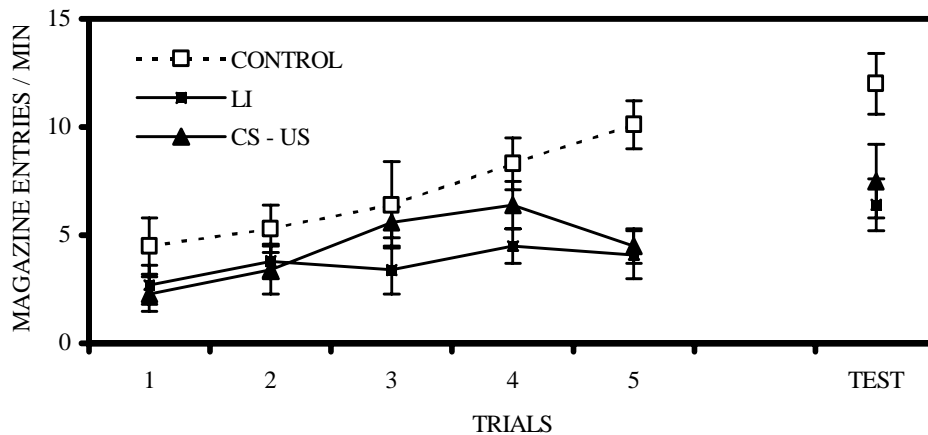


Figure 3. Magazine entries/min after the single food pellet in conditioning and test in Groups Latent Inhibition (LI), Conditioned Stimulus - Unconditioned Stimulus (CS-US), and Control in Experiment 2.

A Group x Session ANOVA conducted on the conditioning scores revealed a main effect for Group, $F(2, 21) = 4.4$, and Session, $F(4, 84) = 9.4$, but the Group x Session interaction was not significant, $F(8, 84) = 1.9$. Subsequent Newman-Keuls comparisons showed that both Groups LI and CS-US differed significantly from Group C, $Q = 4.0$ and $Q = 3.1$, respectively; Groups LI and CS-US, however, did not significantly differ, $Q = 1.1$. The groups also differed significantly during the final test, $F(2, 21) = 4.3$; subsequent Newman-Keuls comparisons showed that both Groups

LI and CS-US differed significantly from Group C, $Q = 3.9$ and $Q = 3.1$, respectively; Groups LI and CS-US, however, did not significantly differ, $Q = 0.8$. In addition, levels of responding on the last day of conditioning and test were compared and the analysis showed a main effect for Group, $F(2, 21) = 12.1$, and Session, $F(1, 21) = 5.7$, but the Group x Session interaction was not significant, $F < 1$.

Also of interest was responding in Groups LI and CS-US during preexposure. Responding before (Pre), and after (Post), the food pellet was averaged across 2 session blocks and the results are shown in Figure 4.

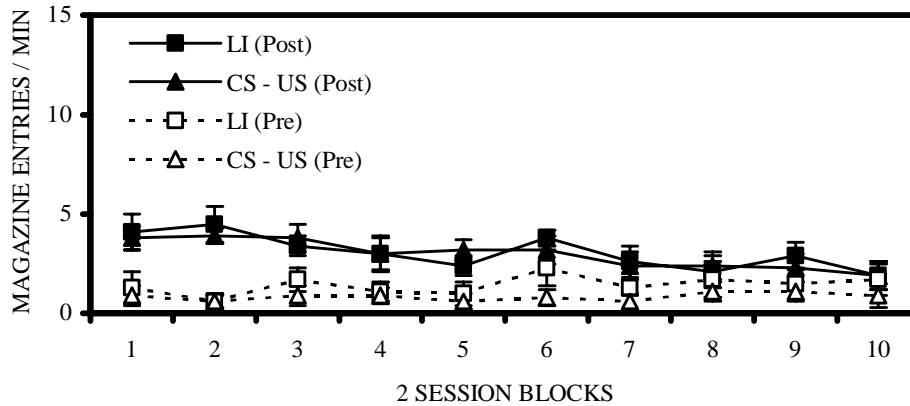


Figure 4. Magazine entries/min before (Pre), and after (Post), the pellet delivered in preexposure in Groups Latent Inhibition (LI) and Conditioned Stimulus - Unconditioned Stimulus (CS-US), in Experiment 2.

Responding was generally low and stable before the food pellet. However, responding after the food pellet was higher earlier in preexposure and declined across sessions. A Period (pre vs. post) x Group (LI vs. CS-US) x Session (averaged 2 session blocks) repeated measures ANOVA showed a main effect for Period, $F(1, 28) = 26.4$, and a significant Period x Session interaction, $F(9, 252) = 2.8$. In addition, there was clear evidence of tone-food conditioning in Group CS-US; subjects showed 0 magazine entries/min during the tone in the first two preexposure sessions and 15.5 ($SEM = 3.5$) magazine entries/min during the tone in the last two preexposure sessions, $F(1, 14) = 126.5$.

Discussion

Experiment 2 replicated the results from Experiment 1 as Group LI showed attenuated responding, in conditioning and test, compared to Group C. However, of most interest, Group CS-US also showed attenuated responding, in conditioning and test, compared to Group C and both Groups LI and CS-US showed similarly attenuated responding. This suggests that during Pavlovian conditioning, subjects not only learn the CS-US association but also learn that the US signals a subsequent US-free period.

General Discussion

Experiment 1 replicated prior research by Goddard (2003) that US signal

value shows latent inhibition. In Experiment 1, Group LI showed attenuated responding in conditioning, and test, compared to Group C, when a single food pellet, delivered 10 min into a 14-min session, was followed by three additional pellets. Prior to conditioning, Group LI had received a single pellet 10 min into each preexposure session, whereas, Group C had received a single pellet at the beginning of each preexposure session. Experiment 2 replicated the results from Experiment 1 and showed that Group CS-US also showed attenuated responding to the signal value of the US, in conditioning and test, compared to Group C and both Groups LI and CS-US showed similarly attenuated responding. The results from Experiment 2 support the hypothesis that during Pavlovian conditioning, subjects not only learn the CS-US association but also learn that a US signals a subsequent US-free period.

The hypothesis that post-US inhibition develops during Pavlovian conditioning is supported by other research (e.g., Davis et al., 1975; Goddard, 1995) and was consistent with the loss in responding, during preexposure, that followed US delivery in Groups LI and CS-US. The development of post-US inhibition is also consistent with the rapid acquisition of serial feature-negative learning with a US feature (Goddard & Holland, 1997; see also Holland & Forbes, 1982; Reberg & Memmott, 1979).

Inhibitory conditioning normally depends upon the omission of an otherwise expected reinforcer (Mackintosh, 1974) so, at first glance, it is unclear how post-US inhibition developed when Groups CS-US and LI received a signaled or unsignaled food pellet in preexposure. One possibility, however, is that the first signaled or unsignaled pellet resulted in a transient increase in a subject's expectation that additional food might follow. This transient increase may have been "innate" or may have resulted because the delivery of food had been followed by additional pellets in magazine training. Since no additional food was presented, the conditions were in place for the development of post-US inhibition, as subjects received the omission of an otherwise expected reinforcer. What remains unclear, however, is why postresponding was higher than preresponding throughout preexposure, if post-US inhibition was being acquired during the preexposure phase.

While the above theoretical explanation may explain latent inhibition of US signal value it appears, at first glance, to be unable to explain latent inhibition of CS signal value, as there is considerable evidence that a CS is not inhibitory in a typical latent inhibition study (Lubow, 1989; Mackintosh, 1974; Rescorla, 1971). Although latent inhibition of US signal value may be qualitatively different from conventional latent inhibition, a more exciting possibility is that both may be unified in a common theory. For example, in both latent inhibition of CS and US signal value, an organism may first learn a CS-no event, or US-no event, association which subsequently impairs CS-US, or US-US, learning. An organism may also learn that, in preexposure, the first stimulus is not followed by the same first stimulus. That is, there may be a CS-no CS association learned during latent inhibition of CS signal value and a US-no US association learned during latent inhibition of US signal value. Therefore, in both cases a CS-no event, or US-no event, association impairs subsequent learning, but inhibition accrues to the signaling stimulus only during latent inhibition of US signal value.

In Group C, subjects received a single food pellet at the beginning of the session but the pellet was omitted at the beginning of the session during conditioning and test. This raises the possibility that Group C showed better conditioning, compared to Groups LI or CS-US, because the conditions at the beginning of the session cued the

upcoming events in a session. However, in Goddard (2003, Experiment 2), Group LI also showed significantly attenuated conditioning, compared to Group C, when Group C received a food pellet at the beginning of each preexposure, conditioning, and test session (preventing the pellet from cuing the upcoming events in a session). Pilot studies had also shown that Group LI showed attenuated responding, in conditioning and test, compared to no preexposure controls.

Group C also differed from Group LI in the manner in which the single food pellet was delivered. That is, in Group C, the solenoid-operated feeder was not activated in preexposure, because the pellet was placed into the magazine at the beginning of the session, but, in Group LI, the solenoid-operated feeder was activated when the pellet was delivered 10 min into each preexposure session. This raises the possibility that Group LI may have formed a noise-single pellet association in preexposure which attenuated learning a noise-three pellet association in conditioning; a result which would resemble the Pearce-Hall effect (Pearce & Hall, 1979, 1980). Alternatively, if the single pellet was considered a compound stimulus (the pellet plus the noise accompanying the pellet), there would be no opportunity for habituation to occur to the noise, during preexposure, in Group C. Therefore, conditioning in Group C would be more rapid than in Groups LI and CS-US, because of reduced habituation to the compound stimulus subsequently used to signal the three pellet sequence. However, in Goddard (2003, Experiment 3), latent inhibition in Groups LI and C was compared when the pellet was delivered by the solenoid operated feeder 10 min into each preexposure session (in Group LI) or delivered by the solenoid operated feeder at the beginning of each preexposure session (in Group C). Further, to prevent cuing the conditions in a session (as outlined above), the pellet was also delivered by the solenoid-operated feeder at the beginning of each conditioning and test session in Group C. Based on the preceding arguments, Group C should have shown poorer responding, in conditioning and test, compared to Group LI, either because subjects would have formed a stronger noise-single pellet association or because there was more opportunity for habituation to the feeder noise. However, Group LI continued to show significantly attenuated responding, in conditioning and test, compared to Group C (Goddard, 2003, Experiment 3).

In addition, the context may have been more excitatory 10 min into the session for Group LI, compared to Group C, because Group LI received food 10 min into each preexposure session but Group C did not. Context conditioning may then have better blocked the associative strength of the first food pellet in Group LI, compared to Group C. However, in Goddard (2003, Experiment 3), conditioning in Group LI was compared to subjects which received similar conditions, except that 10 sessions of context extinction intervened between preexposure and conditioning. Although context extinction significantly reduced responding around the 10-min period in the session, there was little effect on conditioning of the single pellet-three pellet sequence (Goddard, 2003, Experiment 3). This result was also incompatible with Wagner's theory (e.g., Wagner, 1978), which predicted that context extinction should reduce the ability of the context to prime the representation of the preexposed stimulus, allowing for improved conditioning. Other studies have also shown that context extinction, after CS preexposure, typically fails to affect latent inhibition (Lubow, 1989).

Although latent inhibition of US signal value was not predicted by RET (Gallistel & Gibbon, 2000), it may be possible to modify RET to accommodate the present results. For example, if the calculation of I does not begin until food is delivered, the

calculation of I would begin at the start of the session, for Group C, but would not begin until 10 min into the session for Group LI (e.g., Papini, Linwick, & Overmier, 1987). Attenuated acquisition in Group LI, rather than Group C, would then result because the effective I term is much longer for Group C, than for Group LI. This modification is consistent with other research showing that the local context surrounding a particular CS may exert a more powerful conditioning effect than the global context (Barnett, Grahame, & Miller, 1993; Schachtman & Reilly, 1987).

Further, although the results of the present experiment seemed inconsistent with CAT (Lubow, 1989), it is possible that attention to a stimulus may be lost even though subjects may still show a strong response to that stimulus. For example, the Pearce-Hall effect (Pearce & Hall, 1979, 1980), previously noted, suggests that the associability of a stimulus may decline while subjects continue to show a moderate CR. Perhaps a subject's attention to the delivery of a single food pellet, in preexposure, is not well indexed by a subject's approach, and subsequent contact with, that food pellet. The difficulty with this alternative, however, is that it becomes less clear how attention to a food pellet can be independently measured apart from any conditioning effects that such attention is hypothesized to modulate.

Finally, while the present experiments, and those of Goddard (2003), could find no evidence for a performance theory of latent inhibition, a performance effect cannot be discarded as a potential explanation for these results. The choice of a test delay of 28 days was somewhat longer than the test delay of 21 days used in other studies (e.g., Kraemer & Roberts, 1984), so it is possible that parametric manipulations of the retention interval alone, or in combination with manipulations of the salience of the signaling or signaled stimulus, may have uncovered a possible performance effect. Latent inhibition of US signal value appears robust and the current paradigm may prove useful in future studies investigating learning and performance theories of latent inhibition.

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Received December 15, 2002.

Revision received March 8, 2003.

Accepted April 1, 2003.