Notes and Comment

The US-omission effect and static-cue conditioning: A comment on Kremer, Specht, and Allen

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It is now generally agreed that a reinforcer or US must be unpredicted, or "surprising," for substantial conditioning to result from a series of CS-US pairings. There is, however, little consensus about the mechanisms underlying this observation (see Dickinson & Mackintosh, 1978). One class of theories argues that only surprising or unpredicted USs are reinforcing (Rescorla & Wagner, 1972), whereas other accounts assume that surprising USs act by maintaining the associability of the CS (Mackintosh, 1975; Pearce & Hall, in press). When my colleagues and I (Dickinson, Hall, & Mackintosh, 1976) originally reported that conditioning could be enhanced by the omission of an expected, posttrial US (the US-omission effect), we argued that this result provided difficulties for the Rescorla-Wagner model. Subsequently, however, a number of authors appear to have taken issue with this conclusion (e.g., Maleske & Frey, 1979; Randich & LoLordo, 1979). Most recently, Kremer, Specht, and Allen (1980) have suggested that the US-omission effect can be encompassed by the Rescorla-Wagner model when the role of conditioning to static cues is taken into account. In this comment, I wish to address this claim.

In our original study (Dickinson et al., 1976, Experiment 3), we gave rats in the experimental group a series of S_1 -US₁-US₂ pairings in the first stage of a two-stage conditioned suppression procedure. The first shock, US₁, occurred immediately following the termination of S_1 , and the second, posttrial shock, US₂, was presented 8 sec later. The control group simply received a series of S_1 -US₁ pairings during this first stage. In the second stage, both groups were given a series of S_1S_2 -US₁ pairings, in which S_2 was presented in a simultaneous compound with S_1 , before the amount of conditioning to S_2 was measured by being presented alone.

This test revealed that the experimental group showed more conditioning to S_2 than did the control group, a result that has been replicated in a variety of conditioning procedures (e.g., Dickinson & Mackintosh, 1979; Mackintosh, Bygrave, & Picton, 1977). It appears that the enhanced conditioning occurs through attenuation of the capacity of S_1 to

block conditioning to S_2 in the experimental group (Mackintosh, Dickinson, & Cotton, 1980).

The significance of this US-omission effect lies in the problem it presents for one of the major theories of Pavlovian conditioning, the Rescorla-Wagner model. Rescorla and Wagner (1972) argued that the amount of conditioning accruing to a CS from a pairing of CS and US is a positive function of the discrepancy between the asymptotic level of associative strength (λ) that can be supported by the US and the combined associative strength of all the CSs present on that trial ($\bar{V}$). To account for the US-omission effect, the Rescorla-Wagner theory would have to assume that, during the second stage, the size of this discrepancy is larger for the experimental group than for the control group. This discrepancy can be enhanced either by a relative increase in λ or decrease in $\bar{V}$.

As the value of λ is a positive function of the intensity and duration of the effective US, it is difficult to see how the omission of US₂ could have produced an increment in λ . Randich and LoLordo (1979), however, have suggested that the basic blocking effect may, in part, reflect habituation to the US during the first stage and that the US-omission effect arises from dishabituation of the reinforcing properties of US₁ during the second stage. This is unlikely in view of the fact that the US-omission effect can be demonstrated with a procedure in which US-habituation does not appear to play a role in blocking (Mackintosh et al., 1980).

Two accounts of why the omission of US₂ might decrease $\bar{V}$ on the S_1S_2 -US₁ pairings for the experimental group have been offered. First, Maleske and Frey (1979) suggested that US₂ becomes part of the background context in which the S_1 -US₁-US₂ pairings are presented during the first stage. Presumably this occurs because traces of US₂ from preceding trials persist across the intertrial interval to form a component of the effective CS on the subsequent trial (Neely & Wagner, 1974). The omission of US₂ thus produces a reduction in $\bar{V}$ by generalization decrement. For a number of reasons, it is unlikely that this represents a viable mechanism for all demonstrations of the US-omission effect. For instance, the effect occurs when the intertrial interval is sufficiently long—namely, 24 h (Mackintosh et al., 1977; Mackintosh et al., 1980), to preclude survival of the trace of the preceding US₂. Furthermore, the generalization decrement explanation cannot explain why the US-omission effect depends upon similarity of US₁ and US₂ (Dickinson & Mackintosh, 1979).

Recently, Kremer et al. (1980) proposed yet another explanation of why a decrement in $\bar{V}$ might be induced by omitting US_2 . They argued that the presentation of S_1 - US_1 - US_2 pairings to the experimental group during the first stage effectively institutes two types of pairings: S_1S_3 - US_1 and S_3 - US_2 pairings, in which S_3 represents the static cues of the conditioning environment. By contrast, in terms of this analysis, the control group receives only S_1S_3 - US_1 pairings. With extended training, the combined associative strength of S_1 and S_3 will tend to λ for both groups. In the experimental group, however, the associative strengths of S_1 , V_{S_1} , will constitute a smaller proportion, and that of S_3 , V_{S_3} , a larger proportion, of the total associative strength than they will in the control group. This is because the S_3 - US_2 pairings received by the experimental group should maintain V_{S_3} at a higher level than in the control group and so block conditioning to S_1 on S_1S_3 - US_1 pairings. During the second stage, both groups receive the same schedule of reinforcement—namely, a series of $S_1S_2S_3$ - US_1 pairings. As S_3 is no longer independently paired with US_2 in the experimental group, V_{S_3} for this group should decrease to the level maintained in the control group. Since V_{S_1} is lower for the experimental group at the end of the first stage, the discrepancy between λ and $\bar{V}$ will be greater for this group as conditioning to S_3 extinguishes, thus producing the omission effect by allowing greater conditioning to S_2 . Kremer et al. (1980) supported this explanation by demonstrating that the US-omission effect can occur in a context in which a measure of V_{S_3} , the degree of suppression of baseline responding, indicates greater conditioning to S_3 in the experimental than in the control group at the end of the first stage.

Although this static-cue account may well provide a mechanism by which a US-omission effect can be produced, I do not believe it explains the effect observed by Dickinson et al. (1976) for two reasons. First, there was no evidence that the baseline responding of the experimental group was more suppressed than that of the control group in the last session of the first stage. Kremer et al. measured the level of suppression by comparing the response rate in pre-CS periods during conditioning with that in equivalent periods during the session immediately preceding conditioning, using the standard Annau-Kamin ratio. When similar ratios are calculated for the experimental (Group C++CL+) and control (Group C+CL+) groups of Experiment 3 reported in the Dickinson et al. (1976) paper, we find that the experimental group (suppression ratio = .51) showed, if anything, less suppression to the static cues than did the control group (suppression ratio = .44) on the last session of the first stage.

The data reported by Dickinson et al. (1976) provided an even more compelling reason for rejecting

the static-cue explanation in this particular instance. As I have pointed out, this account assumes that the associative strength of S_1 for the experimental group is lower than that for the control group at the end of the first stage. This assumption is critical, for, unless V_{S_1} is lower for the experimental group, the reduction of V_{S_3} during the second stage will not induce a larger discrepancy between λ and $\bar{V}$. We found, however, that S_1 - US_1 - US_2 pairings led to more rapid conditioning to S_1 in the experimental group than did the S_1 - US_1 pairings received by the control group. The obvious implication is that, contrary to the static-cue hypothesis, V_{S_1} was, if anything, greater in the experimental group at the end of the first stage. My colleagues and I (Dickinson, Colwill, & Pearce, 1980) have recently confirmed this finding and have demonstrated that the enhanced conditioning to S_1 resulting from the S_1 - US_1 - US_2 pairings depends on the association of S_1 with US_2 both directly and via US_1 .

Although the static-cue account remains a viable, but as yet undemonstrated, mechanism for inducing a US-omission effect, it seems unlikely that such a mechanism underlies the effect reported by Dickinson et al. (1976). As a result, this finding still lies outside the scope of the Rescorla-Wagner theory and encourages us to consider alternative explanations of how surprising, posttrial events control learning. Theories that assume that surprising reinforcers and posttrial events act, in part, by modulating the associability of the CS (e.g., Mackintosh, 1975; Pearce & Hall, in press) provide a ready explanation of the US-omission effect (see Dickinson & Mackintosh, 1979).

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