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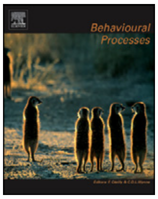

Occasion setting in Pavlovian ambiguous target discriminations

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ABSTRACT

Rats were trained in a Pavlovian serial ambiguous target discrimination, in which a target cue was reinforced if it was preceded by one stimulus (P → T+) but was not reinforced if it was preceded by another stimulus (N → T−). Test performance indicated that stimulus control by these features was weaker than that acquired by features trained within separate serial feature positive (P → T+, T−) and serial feature negative (N → W−, W+) discriminations. The form of conditioned responding and the patterns of transfer observed suggested that the serial ambiguous target discrimination was solved by occasion setting. The data are discussed in terms of the use of retrospective coding strategies when solving Pavlovian serial conditional discriminations, and the acquisition of special properties by both feature and target stimuli.

1. Introduction

In a feature positive (FP) discrimination, presentations of a compound of a feature and a target stimulus are followed by reinforcement, but presentations of the target (T) stimulus alone are not followed by reinforcement (PT+, T−, where P refers to the positive feature). In a feature negative discrimination procedure, the target is followed by reinforcement when it is presented alone, but it is not followed by reinforcement when it is accompanied by the feature (T+, NT−, where N refers to the negative feature). Substantial evidence indicates that the salience and temporal arrangement of the elements within the compound stimulus can affect the way rats solve these discriminations (e.g., Holland, 1992; Swartzentruber, 1995). For example, when the feature and target are of comparable salience, in simultaneous FP discriminations, P acquires direct excitatory control over behavior and T plays little role. Likewise, within simultaneous FN discriminations, N acquires inhibitory control of behavior and T acquires excitatory control. However, when the feature precedes T on compound trials, it may acquire conditional control over behavior, "setting the occasion" (Ross and Holland, 1981; Moore et al., 1969; Skinner, 1938; Schmajuk and Holland, 1998) for either responding (FP) or not responding (FN) to T.

Holland (1983, 1992) noted that these direct and conditional solutions of FP and FN discriminations may be distinguished by the form of conditioned responses (CRs) observed and by patterns of transfer of discriminative control. In some conditioning preparations, the physical characteristics of conditioned stimuli (CSs) influence the form of CRs. For example, Holland (1977) found that with discrete visual signals for food, rats displayed CRs that included orienting toward the light source and relatively passive monitoring of the food cup, but with auditory cues for food, they showed startle responding and a more agitated monitoring of the food cup, characterized by rapid head movements. Consequently, the form of responding during a visual + auditory compound stimulus can reveal which of those cues controls behavior. Ross and Holland (1981) found that with simultaneous FP discriminations (PT+, T−), behavior during the compound took the form appropriate to the nature of the positive feature (P), indicating direct control by P, but with serial FP discriminations (P → T+, T−), behavior during T on compound trials was of a form appropriate to T, suggesting that the feature acted by setting the occasion for responding controlled by T.

The results of transfer tests also distinguish between direct association and occasion-setting solutions of FP discriminations. If a feature controls behavior because of its direct associations with the reinforcer, then it should do so whether presented in compound with its original training target, with another target cue, or when presented alone. In contrast, if the feature acts by setting the occasion for responding controlled by T, then its action might be more limited in scope. For the most part, transfer of control has been observed to be broader after discrimination training involving simultaneous compounds than after training with serial compounds (see Holland, 1992, for a review; but see Jarrard and Davidson, 1991, for some contrary findings).

Several studies (e.g., Holland, 1991; Holland and Reeve, 1991; Nakajima, 1992, 1998) have shown a striking example of the

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specificity of the conditional control acquired in serial discriminations. In these studies, animals were trained on discriminations in which a single stimulus served as the feature in both serial FP and serial FN discriminations. In this "feature ambiguous" (FA) discrimination (A → T+, T−, W+, A → W−), the ambiguous feature (A) signaled reinforcement of one target (T), but nonreinforcement of another target stimulus (W). Remarkably, in these experiments, A rapidly acquired the ability to facilitate responding to T and suppress responding to W. In fact, in Holland's studies, the acquisition of the FA discrimination was as rapid as the acquisition of either the FP (P → T+, T−) or FN (W+, N → W−) components of this discrimination when they were trained individually in other groups of rats. Thus, the ambiguous feature seemed to independently acquire the ability to set the occasion for responding to one cue and for nonresponding to another cue, without mutual interference.

This lack of interference in the acquisition of "positive occasion setting" and "negative occasion setting" contrasts with well-known interference effects in the acquisition of simple excitatory and inhibitory control. Indeed, at least two standard measures of inhibitory control (e.g., Hearst, 1972; Rescorla, 1969), the retardation (resistance to reinforcement) test and the summation (combined cues) test, rely on the mutual competition of excitatory and inhibitory control.

Bueno and Moreira (1998) suggested that the apparent independence of positive and negative conditional control in Holland and Reeve's (1991) study is consistent with the notion that these serial discriminations are solved using retrospective memory strategies. That is, when the rats receive a target cue, the decision to respond or not depends on the result of a search of short-term memory for information about the feature on that trial. In the serial FA task, as well as simple serial FP and FN discriminations, the rat merely has to remember if a feature occurred on any particular target trial. Thus, the feature's conditional cue function might not involve either special positive or negative modulatory powers; rather, it is the *target* that must acquire special properties. From this perspective, occasion-setting in serial FP, FN, or FA discrimination training involves the target cue's acquisition of the ability to have its response-evoking powers gated by the prior presentation of a feature cue (for similar suggestions, see Bouton and Nelson, 1994; Nelson and Bouton, 1997; Swartzentruber, 1998).

This view has several implications. First, if occasion-setting in these discriminations depends on the acquisition of special properties to the target, then features should only modulate responding to target cues that had the opportunity to acquire those properties. Holland (1992) reviewed substantial evidence that the transfer of features' control of performance in these discriminations is indeed limited to targets that have themselves been trained in comparable discriminations. For example, a feature trained with a serial FP procedure also modulates responding controlled by the target of another serial FP discrimination or the target of the FP component of a serial FA discrimination, but does not control responding generated by a novel cue or a separately trained cue.

Second, the solution of the FA discrimination should be comparable to the solution of separate FP and FN discriminations. Because within this perspective the features need not acquire either positive or negative modulatory powers, the ambiguity of the feature's treatment is irrelevant. Instead, it is the treatment of the *targets* that is critical to conditional performance, and the treatment of the targets is no more ambiguous in the FA discrimination than in FP or FN discriminations. As noted earlier, Holland and Reeve (1991) found just this outcome. A related prediction is that after separate FP and FN training, each of the targets would be modulated equivalently by each of the features. If this learning involved coding only whether or not a feature had occurred, then, for example, responding to the FN target would be suppressed when it was preceded by either the positive or negative feature. This prediction is tested in the current studies.

A third implication of the use of such a retrospective strategy in solving serial discriminations is that ambiguous treatment of the *target* cue, that is, using the same stimulus as the target of both serial FP and serial FN discriminations, should slow learning substantially. Not only must the subject discriminate between two feature cues in memory but also the target cue must acquire both the ability to have its control over responding enhanced and the ability to have that control suppressed. Consistent with this prediction, Bueno and Moreira (1998) found very slow learning in an "ambiguous target" discrimination, in which a single stimulus served as the target in both serial FP and serial FN discriminations: P → T+, T−, T+, N → T−.

The experiments reported here extended the work of Bueno and Moreira (1998) by directly comparing performance of rats trained with an ambiguous target (P → T+, N → T−) task with performance of rats trained with separate FP (P → T+, T−) and FN (W+, N → W−) discriminations. We used three methods to identify the nature of stimulus control acquired. First, we observed the form of conditioned behavior, as described earlier. Second, we examined the patterns of transfer of control to target cues with a variety of training histories. Finally, we examined transfer of training effects, by comparing discrimination learning on a common task after prior training with different procedures.

2. Experiment 1

In Experiment 1 we compared learning of an ambiguous target discrimination with learning of separate FP and FN discriminations. In Experiment 1A, rats in Group AT received P → T+, N → T− (ambiguous target) training, whereas rats in Group FPN received training on both P → T+, T− (FP) and W+, N → W− (FN) discriminations. In addition, the rats in Group AT received intermingled reinforced and nonreinforced trials with another target stimulus (W+ and W−), so as to equate the number of reinforced and nonreinforced presentations of each of the 4 stimuli (P, N, T, and W) in the two groups. The results of Bueno and Moreira's study (1998) suggest that discrimination learning should be relatively slow in Group AT. A transfer test then examined responding during all combinations of feature and target cues. This test allowed us to determine the extent to which simple and conditional (occasion setting) stimulus control strategies were used in the two groups, and to evaluate predictions about transfer of occasion setting. First, if in the AT discrimination the target must acquire the abilities to have its control over responding both enhanced and suppressed, then transfer to targets not also trained in that manner should be minimal. Second, if in the FPN treatment, rats coded simply whether or not a feature had occurred, and not its detailed sensory properties, then responding to the transfer compounds would be governed by the targets rather than the features. That is, rats in Group FPN would respond to the T target both after the P feature and the N feature, and would withhold responding to the W target after either feature. In Experiment 1B we used the same subjects to examine transfer of their prior training to a task that involved two ambiguous target discriminations with the same feature cues. This procedure was intended to permit comparison of the learning established by the AT and FPN treatments by examining transfer of that learning to a common task. If the FPN and AT treatments encouraged similar learning, then positive transfer (faster learning) would be observed but if the rats adopted different strategies for the solution of these discriminations, negative transfer (slower learning) would be observed.