

A Search for Blocking of Occasion Setting Using a Nonexplicit Training Procedure

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Three experiments examined the blocking produced by nonexplicitly trained occasion setters—stimuli that acquire control over conditioned responding to a CS as a result of training in which the CS is reinforced in the presence of the occasion setter but never appears in its absence. Experiment 1 examined blocking of explicit occasion setting (produced by the more standard training procedure in which the CS is both reinforced in the presence of the occasion setter and non-reinforced in its absence); although explicitly trained occasion setters proved to be effective blocking stimuli, nonexplicitly trained cues did not. Experiments 2 and 3 examined blocking of nonexplicit occasion setting; in neither experiment did nonexplicit occasion setters produce blocking. Various interpretations of these findings are discussed. © 1994 Academic Press, Inc.

If a conditioned stimulus (CS), A, is reinforced when it is signaled by a second stimulus, B, but not when it is presented alone (i.e., $B \rightarrow A +$, $A -$), B will enhance conditioned responding to A (Looney & Griffin, 1978). The fact that B may do so independently of its own Pavlovian associative strength (e.g., Ross & Holland, 1981) is not easily explicable in terms of traditional associative theory and has consequently attracted considerable attention. A number of theoretical accounts of this phenomenon have been proposed, suggesting that, rather than being Pavlovian CSs, these so-called “occasion-setting” stimuli facilitate retrieval or use of the target CS–US association (e.g., Holland, 1983; Rescorla, 1985; Bouton, 1990).

These theories are chiefly concerned with the way in which occasion setters act on the CS–US association and pay rather less attention to how they might form. The accounts proposed by Holland (1983) and by Bouton

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(1990), for example, do not clearly specify the conditions required to establish an occasion setter, although Rescorla (1988) suggested that a stimulus that accompanies reinforcement of an inhibitory CS will acquire occasion-setting properties. But perhaps the account that is most explicit in this respect is that presented by Bonardi (1988, 1989). She proposed that an occasion setter's properties are the result of a special type of classically conditioned association. Operationally, a positive occasion setter is present on those occasions when CS and US are paired. It is possible that the central state engendered by a CS-US pairing is a unitary representation that may enter into associations in the same way as do those produced by CS or US presentations. Establishing an occasion setter could therefore involve the formation of an association between the occasion setter and the central state accompanying pairings of CS and US.

There are precedents for such a suggestion; for example, it has been argued that the properties of discriminative stimuli, the instrumental analogues of occasion setters, are also the product of associative learning—of an association between the discriminative stimulus and the response-reinforcer relationship (e.g., Mackintosh, 1983; Rescorla, 1990). Moreover, such an account has the advantage of making a number of predictions, because it can draw on the extensive knowledge we have of the conditions required for association formation. For example, it has been assumed that occasion setters are only formed in the standard “explicit” training procedure described above, in which the target CS is both reinforced in the presence of the occasion setter and nonreinforced in its absence (e.g., LoLordo & Ross, 1987; Rescorla, 1988)—indeed this follows directly from Rescorla's (1988) proposal that the CS that is reinforced in the presence of the occasion setter must have some inhibitory strength. But if the associative account proposed here is correct, all that is required is that the CS-US pairings be paired with the occasion setter; nonreinforcement of the CS is not necessary. This will be referred to as a non-explicit training procedure. This prediction has been confirmed, in that nonexplicit training has been found sufficient to generate occasion setting. For example, Bonardi (1992) gave animals nonexplicit training in which two brief CSs, *x* and *y*, were reinforced in the presence of two extended stimuli, *A* and *B*: *x* was reinforced in the presence of *A*, and *y* in the presence of *B*. In a subsequent test the animals were divided into two groups; animals in group *Same* received presentations of *x* in *A* and of *y* in *B*—the same combinations they had experienced during training—whereas animals in group *Different* experienced the opposite arrangement, *x* in *B* and *y* in *A*. Animals in group *Same* responded more to the CSs than those in group *Different*, which suggests that *A* and *B* had acquired a control over responding to their respective CSs, *x* and *y*, that was independent of their own association with reinforcement; in other

words these stimuli had become occasion setters (see also Hall & Honey, 1989).

A further implication of this associative perspective concerns the relationship between explicit and nonexplicit occasion setters. According to this account, both types of occasion setter derive their power from having been present during pairings of CS and US during training; thus both may be regarded as being associated with the same complex "reinforcer." The first experiment reported here was designed to examine this idea; to do so it employed the phenomenon of blocking.

In a blocking experiment a stimulus is paired with reinforcement in compound with a second stimulus that has already been conditioned as a signal for that reinforcer. The animal will not condition readily to the first stimulus as it has been made redundant by the second, already a perfectly good signal for reinforcement (Kamin, 1969); we say that conditioning to the first stimulus has been blocked. This failure to learn about an informationally redundant stimulus is regarded as a fundamental characteristic of associative learning. Thus an account that asserts that occasion setters are established by means of associative learning must predict that occasion setters will show blocking. This prediction has been confirmed; there is evidence that explicitly trained occasion setters block each other in the same way as do Pavlovian CSs (Bonardi, 1991).

This analysis of blocking in terms of informational redundancy implies that if the blocking stimulus had been paired with a *different* reinforcer when it was pretrained, the added stimulus would not be made redundant, and blocking would not occur—and this is so (e.g., Dickinson, 1977): in other words it is not possible to block acquisition of one type of learning with learning of another type. These characteristics make blocking a useful tool for establishing exactly what has been learned about a stimulus (cf. Ross & LoLordo, 1986), and will allow us to ask whether the same thing is learned during nonexplicit training as during explicit. If explicit and nonexplicit occasion setters are indeed "associated with the same reinforcer," then a nonexplicit occasion setter should block acquisition of explicitly trained occasion setting as readily as does an explicit occasion setter. Experiment 1 was designed to examine this question.

EXPERIMENT 1

The training procedure was essentially that employed by Bonardi (1991; see also Kimmel & Ray, 1978; Wilson & Pearce, 1989). A 3-min presentation of a diffuse stimulus constituted the occasion setter (or "feature"); embedded within each feature were a number of brief CSs, each of which was followed by the delivery of a food pellet. If an explicit training procedure was required, CSs also occurred in the absence of the feature, and these presentations were nonreinforced.

TABLE 1
Design of Experiment 1

| Group | Stage 1 | Stage 2 | Test |
|-------|-----------|------------|------------|
| E | A (x+) x- | AB (x+) x- | B (x-) x-? |
| | C (y+) | CB (y+) y- | B (y-) y-? |
| C | A (x+) x- | AB (x+) x- | B (x-) x-? |
| | C (y+) y+ | CB (y+) y- | B (y-) y-? |

Note. A (x+) x- refers to training in which CS x is reinforced when presented during feature A and occurs nonreinforced in A's absence; C (y+) refers to training in which CS y is reinforced in the presence of feature C but is never presented in C's absence; C (y+) y+ refers to training in which CS y is reinforced in both the presence and absence of C, and B (y-) y- to that in which y is presented nonreinforced in both the presence and absence of feature B. AB refers to a simultaneous compound of features A and B. (See text.)

There were two groups of animals, both of which received pretraining with two CSs, x and y, and two features, A and C (see Table 1). For animals in group E, x participated in an explicit occasion-setting discrimination, being reinforced in the presence of feature A and nonreinforced in its absence. In contrast y was nonexplicitly trained, being reinforced in the presence of the second feature C but never being presented in C's absence. In the second stage of training both x and y were trained as CSs in explicit occasion-setting discriminations; x was reinforced as before during A, but A was presented in compound with a second, novel feature, B. Likewise y was reinforced during C, and C was also presented in compound with B. Both x and y were nonreinforced in the absence of their respective features. Finally, B's control over responding to x and y was assessed.

For animals in group E, A was trained as an explicit occasion setter for x in stage 1; thus A would block B's acquisition of explicit occasion-setting control over x in stage 2 (cf. Bonardi, 1991), so that B would exert little control over responding to x at test. C was also trained as an occasion setter in stage 1, but as a nonexplicit occasion setter rather than an explicit one like A. If nonexplicit training engendered the same type of learning about C as about A, then C would also produce blocking, this time of B's control over responding to y; thus B would also be bad at modulating responding to y at test. But if nonexplicit training were to give C properties that differed from those acquired by A, then C would not block B's acquisition of control over responding to y; consequently subjects would respond more to y than to x in the presence of B.

The purpose of group C was to extend the generality of Bonardi's (1991) finding that explicitly trained occasion setters are subject to block-

ing, by employing a different control condition. These animals were treated exactly the same as those in group E, except for their experience with *y* and C during stage 1. Thus A was established as an explicit occasion setter for *x* in this stage, but C was not established as a nonexplicit occasion setter for *y*; instead animals in this group experienced the same number of reinforced presentations of *y* as did group E, but these presentations occurred in *both* the presence and absence of C. Then, as in group E, both A and C were established as explicit occasion setters for their respective CSs in compound with the added feature B, and finally the effect of B on responding to *x* and *y* was assessed.

During stage 1, A had the opportunity to become an explicit occasion setter for *x* in this group; C, in contrast, conveyed no information about whether or not *y* would be reinforced, as *y* was reinforced both in the presence and absence of this stimulus. This treatment should not give C any control over conditioned responding to *y* and has accordingly been employed by other experimenters as a control for occasion setting (e.g., Davidson & Rescorla, 1986; Wilson & Pearce, 1990). Moreover, the fact that this training procedure does not produce occasion setting follows nicely from the associative account; because C is not a reliable predictor of *y*-US pairings, there is no reason to suppose that an association would form between C and pairings of *y* and the US, and accordingly C should not acquire the properties of an occasion setter. Thus, during stage 2, acquisition of occasion-setting control by B over responding to *x* would be blocked whereas control over *y* would not; thus B would be better able to enhance responding to *y* than to *x* during the test. The results from group C would not only demonstrate that blocking could be obtained with these procedures, but would also allow a comparison of the amount of blocking produced by the nonexplicitly trained occasion setter with that produced by the control stimulus, C.

It should be noted that the design of this experiment assumes that the effects of the occasion setter are specific to a particular conditioned stimulus (cf. Holland, 1983; Bouton, 1990)—otherwise it would not be possible to see a difference in B's ability to control responding to *x* and *y* at test. This assumption contradicts Rescorla's (1985) proposal that occasion setters act solely on the US representation. There is now substantial evidence, however, against this position. If occasion setters act only on the representation of the reinforcer, then they should transfer their properties to any CS associated with that reinforcer, and yet this does not appear to be the case. There have been a number of observations suggesting that although occasion setters do show transfer, that transfer is frequently incomplete (e.g., Holland, 1986a, 1986b, 1989a, 1989b; Wilson & Pearce, 1990), suggesting that occasion setters must act at least in part on the CS representation (Rescorla, 1991).

Method

Subjects

The subjects, 16 naive male hooded (Lister) rats with a mean *ad lib.* weight of 224 g (range, 194–253 g), were housed in pairs. Before the start of training they were reduced to 85% of their *ad lib.* weight and were maintained at this level for the rest of the experiment by being fed a restricted amount of food at the end of each session.

Apparatus

The apparatus consisted of four Campden Instruments lever boxes. Each of the boxes contained a recessed food tray to which 45-mg mixed-composition food pellets could be delivered. Access to this food tray was by means of a rectangular aperture 6 cm high \times 5 cm wide. A transparent plastic flap of the same dimensions was attached by a hinge to the top of the entrance to the food tray. Pushing this flap inwards from its vertical resting position allowed subjects to gain entry to the food tray. This movement actuated a microswitch and each closing of this switch was recorded as a single response. The flap automatically returned to its resting position when the rat removed its snout from the food tray. Illumination was provided by a 2.8-W 14-V houselight which was mounted centrally in the front wall; this light was always on except when the dark stimulus was presented. Two 2.8-W 24-V jewel lights were mounted in the front wall, one on either side of the food magazine. Two speakers were mounted on the back wall through which an 85-dB, 10-Hz clicker, an 85-dB 1-kHz tone, and an 83-dB (scale A) white noise could be delivered from a Campden Instruments tone generator and white noise generator. The boxes were housed in sound and light-attenuating shells; masking noise was provided by the operation of ventilating fans contained in these shells. The apparatus was controlled by BBC microcomputers programmed in a version of BASIC.

Procedure

Pretraining. In the first 30-min session the animals were trained to retrieve food pellets from the food tray. These pellets were delivered according to a variable time 60-s schedule.

Stage 1. Each of the subsequent training sessions consisted of four presentations of a 3-min feature stimulus; each feature was preceded by a 6-min intertrial interval (ITI). In addition there was a 3-min period at both the start and end of each session during which no events were programmed to occur. Two 5-s CSs (x and y) and two 3-min features (A and C) were employed. The features were a click and a tone, the CSs were a burst of white noise, and a flashing light produced by pulsing the

two jewel lights at 1 Hz. The CS reinforced during feature A will be designated x, and that reinforced during C, y. Half of the animals in each group formed a subgroup for whom A was the clicker and C the tone, and for the remainder the reverse was true; for half of each of these subgroups the noise was reinforced during A, and the flashing light during C, and for the remaining animals this arrangement was reversed. The CSs were programmed to occur at semirandom intervals during the feature and, where appropriate, during the ITI, with the constraints that each CS was preceded by a 5-s pre-CS period, and a fixed number of CSs appeared in each interval (see below).

In stage 1 all animals received training with the two CSs, x and y. For both groups x was the target CS of an explicitly trained occasion-setting discrimination with A as the feature. Thus during each presentation of A there were six CS presentations, each of which was followed by the delivery of a food pellet. In addition, in the 6-min ITI preceding each presentation of A, presentations of x were programmed to occur according to the same schedule that determined their delivery during A (one every 30 s on average), and none of these presentations were reinforced.

The other CS, y, was treated differently in the two groups. In group E it participated in a nonexplicit occasion-setting procedure with feature C: thus C and y were treated exactly as x and A, except that no CSs or reinforcers occurred during the ITI. In group C, y occurred both in the presence and absence of C, and was reinforced on every occasion on which it was presented. In order to equate the number of reinforced y presentations in the two groups, y was presented twice during every presentation of the feature itself and four times in the preceding ITI.

There were two training sessions daily, one in the morning (am) and the other in the afternoon (pm). One of these daily sessions consisted of four trials with feature A, the other of four trials with feature C; each feature could be presented either am or pm according to an alternating double alternation sequence (i.e., A am, C pm; C am, A pm; C am, A pm; A am, C pm). There were 10 sessions of each type in this stage.

Stage 2. In the second stage of training all animals received identical treatment. Both x and y were the targets of explicitly trained occasion-setting discriminations identical to those employed in stage 1. CS x was reinforced during presentations of feature A in compound with a third, novel feature, B (the dark), whereas y was reinforced during presentations of feature C in compound with this same B; neither x nor y was reinforced when presented alone. There were eight sessions of each type in this stage.

Test. At this point the animals were tested. There were four test sessions, each consisting of two trials. These were identical to those used in compound training except that, first, only feature B was presented and, second, no reinforcers were delivered. In two of these sessions x was

presented, and in two y , these types of session being presented in the double alternation sequence $y \ x \ x \ y$.

In all the experiments that follow, the measure used was the rate of magazine entry during CS presentations. In addition, each CS was preceded by a pre-CS period of the same duration as the CS; responding was also recorded during these periods. Finally, a significance level of $p < .05$ was adopted in all the analyses that follow.

Results

Stage 1. The first stage of training proceeded uneventfully. Animals in both groups learned to respond more to x in the presence of A than in its absence. During the last session with A in this stage the mean response rate to x in the presence of A was 22.38 rpm for group E and 22.00 rpm for group C; the corresponding rates to x during the ITI were 1.94 and 2.88 rpm, respectively. An analysis of variance with group (E or C) and feature (presence or absence of A) as factors revealed that this discrimination was significant, $F(1, 14) = 33.2$; the main effect of group and the interaction between the two factors were not significant, $F_s < 1$. The corresponding rates of responding during the pre-CS periods, for groups E and C, respectively, were 4.31 and 5.44 rpm during the feature and 0.59 and 1.53 rpm during the ITI. An analysis of variance with feature and group as factors revealed a significant main effect of feature, $F(1, 14) = 29.45$; neither the main effect of group nor the interaction term were significant, $F(1, 14) = 2.09$ and $F < 1$, respectively.

In group E, animals also learned to respond to reinforced presentations of y during C; the mean response rate to y during the last session of this stage was 26.38 rpm, the corresponding pre-CS response rate being 4.63 rpm. Responding to reinforced presentations of x and y appeared to be similar in group E, an impression that was reinforced by the results of an analysis of variance performed on the data from the last session of each type in this stage, with CS (x or y) as a factor. This confirmed that rates to x and y did not differ, $F < 1$; nor did the corresponding pre-CS rates differ, $F < 1$.

Animals in group C also responded at high rates to reinforced presentations of y regardless of the presence of C. During the last session of this type the response rate was 29.25 rpm in the presence of C and 28.59 rpm in its absence; these rates did not differ, $F < 1$. The corresponding pre-CS rates were 2.06 rpm in the presence of C and 0.75 rpm in its absence; these did not differ, $F < 1$. There was, therefore, no sign that C had any occasion-setting properties. Nor was there any difference in the level of responding to reinforced presentations of x and y in this group: an analysis of variance that compared the average rate of responding to y (pooled over both the presence and absence of C) with that to

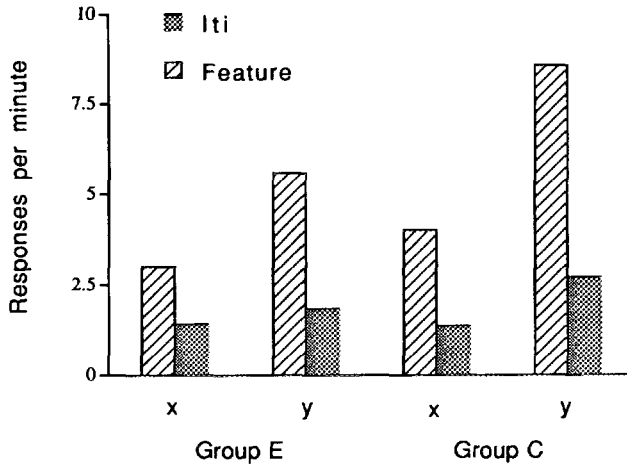


FIG. 1. Group mean response rates to x and y in the presence and absence of B, pooled over the test sessions of Experiment 1.

x in the presence of A revealed no difference, $F(1, 7) = 1.26$. However, this comparison is complicated by the fact that the corresponding pre-CS response rates were significantly higher for x than for y, $F(1, 7) = 11.37$.

Stage 2. By the end of the second stage of training all animals performed on the two feature-positive discriminations with equal facility. In the last session of each type in this stage the mean response rates to x, for groups E and C, respectively, were 1.16 and 2.06 rpm during the ITI, and 23.5 and 25.56 rpm during the feature. The corresponding rates to y were 2.97 and 4.09 rpm during the ITI and 26.38 and 28.75 rpm during the feature. An analysis of variance performed on these data with group (E or C), feature (presence or absence), and CS (x or y) revealed significantly more responding during the feature than during the ITI, $F(1, 14) = 45.39$; this did not interact with any other factor, $F_s < 1$; no other effects or interactions were significant, largest $F(1, 14) = 2.39$. The pre-CS response rates in this session for x were, for groups E and C respectively, 1.19 and 0.75 rpm during the ITI and 6.13 and 5.88 rpm during the feature. The corresponding rates for y were 2.69 and 2.75 rpm during the ITI and 5.88 and 6.56 rpm during the feature. An identical analysis of variance performed on these rates revealed that there was a main effect of feature, $F(1, 14) = 25.54$, but that no other effects or interactions were significant, largest $F(1, 14) = 3.82$.

Test. The results of the test phase are shown in Fig. 1. It is clear that the added feature B acquired more control over responding to y than to x, and this effect did not appear to differ in the two groups. This interpretation was supported by the results of an analysis of variance with

feature (present or absent), CS (x or y), and group (E or C) as factors. This revealed a significant main effect of feature, $F(1, 14) = 12.20$, and of CS, $F(1, 14) = 8.58$, and a significant interaction between these two factors, $F(1, 14) = 4.95$; there was no main effect of group, $F(1, 14) = 1.12$, and no other interactions were significant, $F_s < 1$. Subsequent pairwise comparisons using the Newman-Keuls procedure revealed that responding to y was higher in the presence of B than in its absence, but that the same was not true for x; responding to x and y alone did not differ.

The corresponding pre-CS response rates for x were, for groups E and C, respectively, 1.57 and 1.00 rpm in the presence of B, and 0.78 and 0.94 rpm in its absence. The corresponding rates for y were 1.38 and 3.13 in the presence of B and .88 and 1.16 rpm in its absence. An analysis of variance performed on these data with feature, CS, and group as factors revealed a significant main effect of feature, $F(1, 14) = 9.07$; however, this factor did not interact with CS, $F(1, 14) = 2.12$. No other effects or interactions were significant, largest $F(1, 14) = 3.85$.

Discussion

The present results replicated the observation (Bonardi, 1991) that an explicitly trained occasion setter can block acquisition of explicitly trained occasion setting. However, there was no evidence that a nonexplicitly trained occasion setter could produce blocking under these circumstances—the nonexplicit occasion setter was no more effective a blocking stimulus than was the control stimulus in group C.

These results challenge the associative account of occasion-setter formation outlined above, because they provide no support for the idea that nonexplicit and explicit occasion setters convey the same information. However, a closer analysis reveals possible reasons why the nonexplicit feature might be an ineffective blocking stimulus in the present experiment. It is well documented that blocking may be disrupted if, for example, the size of the reinforcer is altered between the first and second stages of a blocking experiment—even though the reinforcer is *qualitatively* unchanged (e.g., Dickinson, Hall, & Mackintosh, 1976). Moreover, this phenomenon (known as unblocking) has been accounted for quite satisfactorily in terms of associative theory.

It has been argued that both explicit and nonexplicit training result in the formation of an association between the occasion setter and the CS-US association. Suppose, however, that this association differs in strength in the two procedures. For example, in explicit training the CS is nonreinforced in the absence of the feature, whereas in nonexplicit training it is not. This might make the CS-US pairing that occurs during the feature more surprising in explicit training than in nonexplicit and hence a more effective reinforcer. If this may be regarded as effectively equiv-

alent to making the "CS-US reinforcer" different in size in the two cases, then one would not expect to see perfect blocking of one sort of occasion setting by another.

This analysis of course still requires that similar occasion setters should block each other, and there is evidence that this is true of explicitly trained occasion setters. There is not as yet corresponding evidence for nonexplicitly trained occasion setters, however. Experiments 2 and 3 were designed to provide such evidence.

EXPERIMENT 2

A within-subjects design was employed (see Table 2). All subjects received nonexplicit training in which presentations of a CS, *x*, were reinforced while embedded within feature A; *x* was never presented in the absence of A. In a subsequent stage this training continued, but presentations of A were now accompanied by a second, novel feature, B. If blocking were to occur, the added B should acquire little control over responding to *x*. The degree to which blocking was achieved was evaluated by comparing responding to *x* with that to a second CS, *y*. In the first phase of training *y* was reinforced in the presence of feature C, and in the second stage it was, like *x*, reinforced in the presence of B; however, its treatment differed from *x*'s in that C was exchanged for a further novel feature, D, during the compound training stage. It was predicted that, although C would acquire control over responding to *y* in the first stage, the replacement of this feature by D during compound training would ensure that acquisition by B over responding to *y* would not be blocked. Consequently it was predicted that B would exert more control over responding to *y* than to *x* during the test.

Method

Subjects

The subjects, eight naive male hooded (Lister) rats with a mean *ad lib.* weight of 465 g (range, 430–520 g), were housed in pairs and maintained at 80% of their *ad lib.* weight in exactly the same manner as in Experiment 1. The stimuli were an 83-dB white noise, an 80-dB, 10-Hz clicker, an 80-dB 1-kHz tone, and an 83-dB 4-kHz tone pulsed at 1 Hz, and also dark and pulsed jewel lights as in the previous experiment. All other aspects of the apparatus were identical to those in the previous experiment.

Procedure

All aspects of the procedure that are not specified were identical to those of Experiment 1.

Stage 1. After magazine training all animals received pretraining in which CS *x* was reinforced during feature A and CS *y* during feature C.

TABLE 2
Design of Experiment 2

| Stage 1 | Stage 2 | Test |
|---------|---------|---------|
| A (x+) | AB (x+) | B (x-)? |
| C (y+) | DB (y+) | B (y-)? |

Note. A (x+) refers to training in which CS x is reinforced in the presence of feature A but is never presented in A's absence and B (y-) to that in which y is presented nonreinforced in the presence of feature B, but never occurs in B's absence. AB refers to a simultaneous compound of features A and B (etc.—see text).

There were six CSs during each presentation of the feature; these were programmed in exactly the same way as those for nonexplicit occasion-setting training in Experiment 1. Feature A was the click for half the animals and the steady tone for the rest; feature C was the pulsed tone for all the animals. For half of each of these subgroups x was the noise and y the flashing light; for the remaining animals the reverse was the case. The CSs were never presented in the absence of the features. There was a total of 10 sessions with each feature in this stage.

Stage 2. In the second, compound training stage x and y continued to be reinforced during feature presentations. CS x was reinforced, as before, during feature A, but A was presented in compound with a second, novel feature, B. CS y was also reinforced in the presence of B, but B was presented in compound with a second, novel feature, D. B was dark for all animals; for those animals for whom A was the click, D was the steady tone, and vice versa. All other aspects of compound training were identical to those of stage 1. There were 14 sessions with each type of feature in this stage.

Test. Then the subjects were given four test sessions, each of which consisted of four presentations of feature B; during two of these x was presented and during two y. These two types of trial were presented in a double alternation, with half the subjects receiving the sequence x y x and the remainder y x x y. No reinforcers were delivered in these sessions, all other aspects of which were identical to those of the previous stages.

Results

Stage 1. During stage 1 the animals learned to respond during CS presentations. In the last training session of each type in this stage the mean rates of responding during x and y were 16.57 and 19.38 rpm, respectively; an analysis of variance performed on these data with CS (x

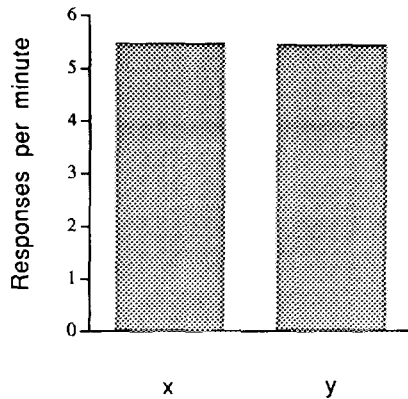


FIG. 2. Mean response rates to x and y in the presence of B, pooled over the four test sessions of Experiment 2.

or y) as a factor revealed no difference between the two CSs, $F < 1$. The mean rate of responding in the pre-CS periods during these sessions was 5.69 rpm for x and 7.38 rpm for y; an analysis of variance with CS as a factor confirmed that these rates did not differ, $F < 1$. Thus there was no evidence for any difference in responding to the two CSs at the end of stage 1 training.

Stage 2. Animals continued responding to the two CSs during stage 2; response rates during the last session of each type in this stage were 20.63 rpm to x and 23.25 rpm to y. These rates did not differ, $F < 1$. The corresponding rates of pre-CS responding were 11.38 and 11.00 rpm, respectively; these did not differ either, $F < 1$.

Test. The data of central interest, response rates to x and y during feature B in the test, are shown in Fig. 2. It is clear from the figure that, contrary to what was predicted, there was no difference in responding to the two stimuli. An analysis of variance with CS as a factor confirmed this impression, $F < 1$. The corresponding pre-CS rates were 1.92 rpm for x and 2.41 rpm for y; an analysis of variance revealed that these rates did not differ either, $F < 1$.

Discussion

There was no evidence in the present experiment that blocking had occurred—during the test session animals responded no more to y than to x in the presence of B. But it is of course hasty to conclude on the basis of one null result that nonexplicitly trained occasion setters are not subject to blocking; there are a number of other potential explanations for why no difference was observed. For example, blocking of occasion setting can hardly be obtained if there is no occasion setting in the first

TABLE 3
Design of Experiment 3

| Group | Stage 1 | Stage 2 | Test |
|-------|---------------|-----------------|----------------|
| C/S | A (x+) C (y+) | | A (x-) C (y-)? |
| C/D | A (x+) C (y+) | | A (y-) C (x-)? |
| B/S | A (x+) C (y+) | AB (x+) CB (y+) | B (x-) B (y-)? |
| B/D | A (x+) C (y+) | AB (y+) CB (x+) | B (x-) B (y-)? |

Note. A (x+) refers to training in which CS x is reinforced in the presence of feature A but is never presented in A's absence and A (y-) to that in which y is presented non-reinforced in the presence of feature A, but never occurs in A's absence. AB refers to a simultaneous compound of features A and B (etc.—see text.)

place. Although the training procedures used in Experiment 1 were almost identical to those employed by Bonardi (1992), there were some differences, and this introduces the faint possibility that occasion setting was not in fact obtained here. A second potential problem concerns the stimuli employed. If, for example, the animals could not discriminate C (the pulsed tone) from A and D (the click and the steady tone), then x and y would, effectively, have been treated identically throughout the experiment, so that one could hardly expect differential responding during the test. A related possibility (although a less plausible one, given the nature of the stimuli used) is that the animals could not discriminate x and y. Experiment 3 was designed to repeat the present experiment while at the same time addressing some of these potential problems.

EXPERIMENT 3

Experiment 3 used a between-subjects design. All animals received nonexplicit training in which the two CSs, x and y, were reinforced during the presentation of two feature stimuli, A and C (click and dark); x was reinforced during A and y during C (see Table 3). Then the animals were divided into two groups. Group B/S (blocking same) continued to experience reinforced presentations of x in A and of y in C; however, both A and C were always presented in compound with a third, novel feature, B (a tone). Group B/D (blocking different) also received presentations of the AB and CB feature compounds; however, for these animals the original CS/feature combinations were reversed, so that y was now reinforced during AB and x during CB. It was predicted that B would acquire control over responding to both x and y in group B/D, but that acquisition of such control would be blocked in group B/S.

Finally, a further two groups were included to confirm that these training procedures produced occasion setting. These animals were treated exactly like the two blocking groups during the first stage of training, but then received an immediate test to establish whether A and C had indeed

become occasion setters. Accordingly group C/S (control same) received test presentations of x in A and of y in C, as they had experienced during training, whereas group C/D (control different) received the converse arrangement, presentations of y in A and x in C. If A and C had become occasion setters for x and y, respectively, then animals in group C/S would respond more than those in group C/D. Moreover, such a difference between the two groups in responding could not arise unless the animals discriminated x from y and A from C.

Method

Subjects and Apparatus

The subjects, 32 naive male hooded (Lister) rats with a mean *ad lib.* weight of 432 g (range, 370–485 g), were housed in pairs and maintained exactly as in Experiment 1. The stimuli were a 76-dB, 1-kHz tone, an 76-dB, 10-Hz click, and an 81-dB white noise, and dark and pulsed jewel lights as in the previous experiment. All other aspects of the apparatus were identical to those in the previous experiment.

Procedure

All aspects of the procedure that are not specified were identical to those of Experiment 2.

Stage 1. After magazine training, all animals received pretraining in which x was reinforced during feature A, and y during feature C. CS x was the noise and y the pulsed jewel lights for half the animals and the converse for the remainder. A and C were the click and the dark; the noise was reinforced during the click and the pulsed lights during the dark for half the animals and for the remainder the converse. In this and subsequent stages of the experiment animals only received one session per day.

After eight sessions with each of the features, some animals were not responding much during the CSs; in an attempt to improve performance the number of CSs per 3-min feature was reduced from six to three. Animals received two more sessions with each feature with this reduced rate of CS presentation, which was indeed successful at increasing response rates. Consequently this schedule was maintained for the remainder of the experiment.

Test 1: Groups C/S and C/D. At this point the animals were divided into four groups, each of which had been treated identically during stage 1. Two of these, groups C/S and C/D, were tested at this point. These animals received four test sessions, two with feature A and two with C. The test sessions were identical to those administered during stage 1 except that, first, each contained only two trials, second, no reinforcers were delivered, and third, the arrangements of CSs and features varied. Spe-

cifically, group C/S experienced presentations of x in A and y in C, such that each CS was presented in the feature during which it had been reinforced in training; group C/D received the converse arrangement, presentations of x in C and y in A.

Stage 2: Groups B/S and B/D. Groups B/S and B/D received further training. Group B/S continued to receive reinforced presentations of x during A trials and of y during C trials but both A and C were always presented in compound with a third, novel feature, B (the tone). Group B/D experienced the converse arrangement, reinforced presentations of x during the CB compound and of y during the AB compound. There were six sessions with each feature during this stage.

Test: Groups B/S and B/D. Finally, these animals received four test sessions, two with CS x and two with CS y. These were identical to those given to groups C/S and C/D, except that only feature B was presented.

Results

Stage 1. The initial training stage proceeded uneventfully; by the end of it all animals were responding at a substantial rate during the two CSs. The pooled rates of responding for the last sessions of each type in this stage were 17.57 rpm for group C/S, 22.07 for group C/D, 22.19 for group B/S, and 17.44 for group B/D. A factorial analysis of variance performed on these data, with blocking or control (B/S and B/D versus C/S and C/D) and same or different (B/S and C/S versus B/D and C/D) as factors revealed no significant effects or interactions, $F_s < 1$. The rates of pre-CS responding during these sessions were 8.19 and 8.69 rpm for groups C/S and C/D, respectively, and 10.44 and 8.50 rpm for groups B/S and B/D, respectively. A second, identical factorial analysis of variance performed on these data revealed no significant effects or interactions, $F_s < 1$. Thus there was no evidence for any differences among the various groups at the end of this stage.

Test 1. The data from the test sessions administered to groups C/S and C/D are shown in Fig. 3. It is evident that group C/S responded at a substantially higher rate than group C/D during these sessions. An analysis of variance performed on these data with group (C/S or C/D) as a factor revealed that this difference was significant, $F(1, 14) = 4.82$. The mean rate of pre-CS responding during these test sessions was 3.07 rpm for group C/S and 3.00 rpm for group C/D. This difference was not significant, $F < 1$. Thus there was evidence in the present experiment that the nonexplicit pretraining made features A and C into occasion setters.

Although it is being argued that the difference between groups C/S and C/D is evidence that the features had become occasion setters, there is at least one other potential explanation for this effect. Animals in group C/D might have responded less in the test because x and y suffered generalization decrement when presented in the new features during the

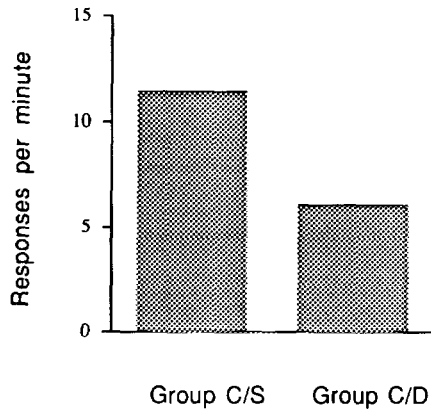


FIG. 3. Group mean response rates to the CSs during features A and C, for groups C/S and C/D, pooled over the four sessions of test 1 in Experiment 3.

test. There is no evidence in the present experiment to dispute this possibility, but the results reported by Bonardi (1992) provide some grounds for rejecting it. She also observed a loss of conditioned responding when a CS was presented in a new feature after nonexplicit training and reasoned that if this loss were due to generalization decrement, then these stimuli were effectively being perceived as partly novel—hence their inability to retrieve the representation of food with which they had been associated during training. But to the extent that the CSs were being experienced as novel, then they should elicit renewed unconditioned responding when presented in the new features. This, however, was not the case: in a series of experiments using the same stimuli and training procedures very similar to those employed here, she could find no evidence for such a return of unconditioned responding. On these grounds Bonardi (1992) argued that her evidence for occasion setting could not be interpreted as an instance of generalization decrement. Those arguments are equally appropriate for the present experiment.

Stage 2. Groups B/S and B/D received further, compound training. Response rates to the two CSs rose slightly in both groups during this stage. The pooled response rates for the last sessions of each type in this stage were 22.69 rpm for group B/S and 19.32 rpm for group B/D. An analysis of variance revealed that these rates did not differ, $F < 1$. The corresponding pre-CS response rates were 9.13 rpm for group B/S and 4.57 rpm for group B/D; these rates did not differ, $F(1, 14) = 2.12$.

Test 2. The results of the test sessions are shown in Fig. 4. There did appear to be a small difference in the predicted direction; specifically, animals in group B/S responded slightly less than those in group B/D. However, an analysis of variance revealed that this effect did not even

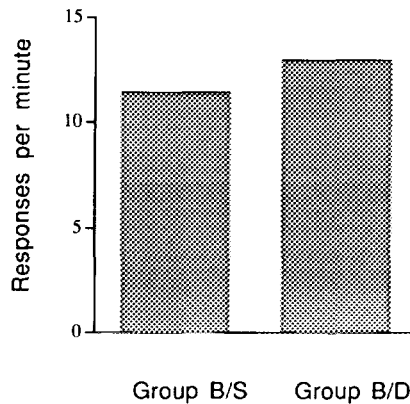


FIG. 4. Group mean response rates to the CSs during feature B, for groups B/S and B/D, pooled over the four sessions of test 2 in Experiment 3.

approach statistical significance, $F < 1$. The corresponding rates of pre-CS responding were 3.64 rpm for group B/S and 5.19 rpm for group B/D; these rates did not differ, $F < 1$.

Discussion

As in Experiment 2, there was no evidence for blocking of nonexplicitly trained occasion setting in the present experiment. Moreover, some features of this experiment make it harder to dismiss this second null result as an artefact. First, there was good evidence that the training procedures employed were capable of producing occasion setting. Second, this demonstration in itself requires one to assume that the animals could discriminate x from y and A from C during the pretraining stage. It is not, then, possible to argue that the failure to find a blocking effect resulted from a failure to discriminate among the various cues during pretraining.

GENERAL DISCUSSION

The associative account of occasion setting predicts that occasion setters should be produced by nonexplicit training procedures as well as by explicit ones, a prediction that has been confirmed (Bonardi, 1992). The present experiments constituted an attempt to test the implications of this account for the relationship between explicit and nonexplicitly trained occasion setters. Experiment 1 examined whether nonexplicit occasion setting can block explicit, which would be consistent with the notion that both types of occasion setter derive their properties through being associated with the same event, the CS-US pairing. No evidence for such blocking was obtained; however, given certain assumptions about the strength of the CS-US associations resulting from these different procedures, one may

accommodate this result in the associative framework. But these assumptions do not influence the prediction tested in Experiments 2 and 3, that nonexplicitly trained occasion setters should block each other in the same way as do explicit occasion setters. Nevertheless, Experiments 2 and 3 failed to find any evidence for blocking of this type.

There are a number of conclusions one could draw from these findings. The most trivial is that the training procedures employed were simply not sensitive enough to detect blocking. This possibility cannot be ruled out, but is made less plausible by the positive results of Experiments 1 and 3. The procedures used in Experiment 3 were sensitive enough to detect the difference in responding between groups C/S and C/D and, in Experiment 1, to detect blocking of occasion setting by the explicitly pre-trained feature. These observations must qualify any attempts to dismiss the present results on the grounds of insufficient sensitivity. A second possibility is that the nonexplicit training procedures used in these experiments did not generate occasion setting—hence the failure of the nonexplicit cue to produce blocking of occasion setting in Experiment 1—and that the difference between groups C/S and C/D observed in Experiment 3 is better interpreted not as occasion setting but as generalization decrement. Although this is possible, again it seems unlikely. As was argued earlier, Bonardi (1992) was unable to find any evidence for generalization decrement using training procedures very similar to those employed in the present experiments.

Before we conclude that the associative account is unable to accommodate these results, it is worth examining the possibility that, although the associative account must predict that nonexplicit occasion setters show blocking, it might also predict that detecting it might be difficult. The reasoning behind this suggestion is derived from a consideration of the role of the context. The associative account predicts that, in a nonexplicit training procedure, the context *as well as* the feature will acquire occasion-setting properties. (This is not so during explicit training, because any strength that the context acquires when the CS is reinforced during the feature will be lost when the CS is nonreinforced during the context alone (Rescorla, 1986).) The possible role of the context complicates the predictions about blocking in Experiments 2 and 3. Since the context is part of the blocking stimulus, although blocking of the added feature will occur as before, part of the blocking stimulus will be present during the test phase, thus reducing the size of the blocking effect. (It also means that the context will produce some blocking in the “control” condition, although this will also be partly masked by the presence of the context at test.) In other words, acquisition of occasion setting by the context will mask any blocking effect, something that may in part account for the failure to observe blocking in Experiments 2 and 3. Thus the associative account might be able to provide an explanation of why blocking was

difficult to find in the present experiments. Nevertheless, a more rigorous test of that explanation will require further experimentation.

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