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4

Learning About Associations: Evidence for a Hierarchical Account of Occasion Setting

Charlotte Bonardi and Dómhnall Jennings
University of Nottingham

In 2 experiments rats were trained on a switching discrimination, with 4 occasion setters, A, B, C, and D and 2 target stimuli, x and y. When signaled either by A or by B, x was reinforced with food and y was not, whereas when signaled either by C or by D these reinforcement relations were reversed (i.e., A: $\rightarrow x+$, A: $y \rightarrow -$, B: $x \rightarrow +$, B: $y \rightarrow -$, C: $x \rightarrow -$, C: $y \rightarrow +$, D: $x \rightarrow -$, D: $y \rightarrow +$). In a subsequent Stage A was paired with shock, and then the degree to which food–reinforced (Experiment 1a) and nonfood–nonreinforced (Experiment 1b) presentations of x and y were capable of eliciting fear was assessed. Those CS/US relations that had been operative in the presence of the fear-eliciting occasion setting A (i.e., $x \rightarrow +$, $y \rightarrow -$) elicited more fear than the alternative CS/US combinations (i.e., $x \rightarrow -$, $y \rightarrow +$), The implications of these findings are discussed with reference to theories of occasion setting and of configural learning.

Keywords:

In a positive occasion-setting discrimination a target stimulus t is reinforced when it is preceded by a feature, F, but not when it is presented alone. Accurate performance on such discriminations cannot always be explained in terms of binary associations between F, t and the outcome; in these cases the feature is termed an *occasion setter* (cf. Skinner, 1938). One theory that has been proposed to explain this behavior is that an occasion setter acts on the CS/US association in a hierarchical fashion, operating as an "and-gate" that facilitates flow of activation between CS and US (e.g., Holland, 1983; cf. Bouton, 1990). Elaborating this idea, Bonardi (e.g., 1989; 1998) proposed that the basis of this behavior might be associative—that the CS/US association was an independent entity that can enter into associations, and that occasion setting was the result of an associative link between the occasion setter and the CS/US association. Evidence in support of this idea comes from the demonstration that occasion setters are subject to blocking—it is more difficult to establish a stimulus as an occasion setter if it is trained in compound with another occasion setter than with some other stimulus (e.g., Bonardi, 1991, 2007). As blocking is viewed as a defining feature of associative learning, this suggests that occasion setting might be associative in nature. However, direct evidence for the proposal that the CS/US association can act as an independent unit is less forthcoming. The present experiments aimed to provide such evidence.

Rats were trained with four occasion setters, A, B, C, and D, and two target stimuli, x and y: A and B signaled the reinforcement of x with food ($x+$), and the nonreinforcement of y ($y-$); C and D signaled the opposite (i.e., A: $x+$, A: $y-$, B: $x+$, B: $y-$, C: $x-$, C: $y+$, D: $x-$, D: $y+$; cf. Honey & Watt, 1989, 1999). Thus each occasion setter was paired equally often with x and y, and with food and no food; they differed only in the combinations of these events that they signaled. Then A was paired with shock, while C was nonreinforced, and we examined the extent to which the specific pairings $x+$ and $y+$ (Experiment 1a) and $x-$ and $y-$ (Experiment 1b) were capable of eliciting fear.

Our rationale relies on the assumption that each occasion setter is associated with each of the two CS/outcome relationships that holds in its presence—thus A is associated with $x \rightarrow$ food and $y \rightarrow$ no food, and C with $x \rightarrow$ no food and $y \rightarrow$ food. When A is paired with shock, it should at the same time evoke the representations of the two associations it signals, $x \rightarrow$ food and $y \rightarrow$ no food, which can thus also become associated with the shock. At test the CS/outcome combinations that have been associated with shock should elicit more fear than the alternatives—thus $x \rightarrow$ food should elicit more fear than $y \rightarrow$ food, and $y \rightarrow$ no food more fear than $x \rightarrow$ no food.

This prediction relies on the associatively activated representation of the CS/outcome association becoming directly associated with the shock. Moreover, it assumes that such learning will occur despite the fact that neither constituent event of the association is actually presented. Evidence for learning of this type, which has been termed *mediated conditioning*, has been observed when the to-be-associated entity is an individual event (e.g., Holland, 1981). The critical feature of the present experiment is that the associatively activated representation that is becoming associated with shock corresponds to an association between two further events. If our prediction is supported, then this will provide evidence that the CS/outcome association is acting as an independent entity, as the hierarchical account predicts.

The discrimination we employed, A: $\rightarrow x+$, $y \rightarrow -$, B: $x \rightarrow +$, $y \rightarrow -$, C: $x \rightarrow -$, $y \rightarrow +$, D: $x \rightarrow -$, $y \rightarrow +$, is formally identical to that used in studies investigating *acquired equivalence*—the observation that cues with similar training histories are perceived as more similar than those that do not (e.g., Honey & Hall, 1989): thus A and B, which signal the same outcome relations, might be viewed as more similar to each other than A and C, which do not. There is evidence that acquired equivalence may be observed under these conditions; for example, Honey and Watt (1998, 1999) performed an identical experiment, except that instead of testing the CS/outcome combinations, they tested B and D. They found that B, which had signaled the same CS/outcome relations in training, elicited more fear than D. Our hypothesis would anticipate such an effect: we predict that when A is paired with shock this results in mediated conditioning to $x \rightarrow +$ and $y \rightarrow -$. Thus B, which can also evoke these CS/outcome relations, will elicit more fear than D, which cannot; indeed Honey and Watt (1998) initially proposed this as a possible explanation of their results. Observing acquired equivalence would therefore constitute further, indirect evidence for our hypothesis. Thus we also examined fear to B and D at test. Honey and Watt reported a result complementary to that sought here (1998; Experiment 2). After discrimination training they paired $x+$ or $y-$ with shock, and found that A and B, which had signaled the $x+$ and $y-$ event combinations in training, elicited more fear than C and D. This may be taken as evidence that the $x+$ and $y-$ event combinations were acting as independent entities that could evoke the representations of the conditional cues that had accompanied them during discrimination training; thus when $x+$, for example, was paired with shock, this allowed the evoked representations of A and B to be paired with shock, to evoke fear on test. In our study, however, fear to the critical event combinations was tested directly, rather than via fear to a mediating stimulus.

Method

Subjects

Both experiments employed 16 male hooded Lister rats (Rattus norvegicus) that had previously participated in experiments on flavor aversion learning, but were naïve to the stimuli and procedures employed here. Subjects in Experiment 1a had a mean ad libitum weight of $450g$ (range = 415 to $480g$), and those in Experiment 1b a mean ad libitum weight of $377g$ (range = 335 to $400g$). They were deprived to 80% of their ad libitum weight before the start of the experiment, 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; they were housed in pairs in plastic tub cages with sawdust bedding. The colony rooms were lit from 8 a.m. to 8 p.m.; the subjects were tested during the light portion of the cycle.

Apparatus

A set of eight standard Skinner Boxes (Campden Instruments Ltd.) were used; these were situated in two experimental rooms, with four to a room. Each box had three walls of sheet aluminum, a transparent plastic door as the fourth wall, a grid floor, and a white translucent plastic ceiling. One of the walls adjacent to the door contained a recessed food tray covered by a transparent plastic flap, 6 cm high $\times$ 5 cm wide that was hinged to the top of the opening to the food tray. Pushing this flap inward from its vertical resting position allowed subjects to gain access to the food tray. An inward movement of the flap actuated a microswitch and each closing of the switch was recorded as a single response. The flap automatically returned to its resting position when the subject removed its snout from the food tray. The boxes were normally illuminated by a 2.8 W houselight, operated at 12V, situated on the front wall directly above the food tray. Forty-five mg food pellets (Noyes, Lancaster, NH) could be delivered to the food tray. Retractable levers fitted alongside the food tray remained withdrawn throughout the experiment. Each box was housed in a sound- and light-attenuating shell. There were four visual stimuli, which served as the occasion setters, A, B, C and D, and two auditory stimuli, which served as the targets x and y. One visual stimulus was provided by the steady illumination of two, 2.8 W jewel lights, both of which were situated on the front wall, one to the right of the food tray and one to the left; a second was provided by flashing these same lights (100 ms on alternated with 200 ms off). The third visual stimulus, dark, consisted of turning off the dimmed houselight, and the fourth, traylight, of illuminating a 2.8 W jewel light mounted inside the food tray. The floor was constructed from stainless steel rods 0.5 cm in diameter and 1.5 cm apart; these could be electrified by a Coulborn Instruments shock generator; the shock used was 0.5 mA in intensity and 0.5 s in duration. The two auditory stimuli, a 76 dB white noise and a 10 Hz 75 dB clicker, were provided by Campden instruments noise and tone generators respectively, and delivered through a speaker mounted on the wall of the chamber. The boxes were controlled by a BBC microcomputer programmed in a version of BASIC.

Procedure

Subjects in Experiment 1a first received a single 40-min session of magazine training in which food pellets were delivered according to a VT-60 s schedule; subjects in Experiment 1b received two such sessions.

Appetitive discrimination training. Animals in Experiment 1a were trained on a switching discrimination in which two of the occasion setters signaled that the noise would be reinforced ($n+$) and the click nonreinforced ($c-$), and the other two signaled the opposite; this yielded eight trial types (see Table 1). The light and the flash always signaled opposite CS/US relations; thus for half the animals the light signaled $n+$ and $c-$ (and the flash the opposite), and for the remainder the light signaled $c+$ and $n-$ (and the flash the opposite). For half of each of these subgroups the traylight and the light signaled the same relations, as did the dark and the flash, and for the remainder the dark and light signaled the same relations, as did the tray and the flash. There were 48 trials per session, 6 of each type, separated by an intertrial interval (ITI) of 30 s plus a variable interval of mean 95 s (giving a mean duration of 125 s, range 30 to 220 s). Each trial was also preceded by a 10-s pre-CS period, and consisted of a 10-s presentation of the occasion setter immediately followed by a 10-s presentation of the target CS. The reinforcer was a single food pellet. There were 56 sessions in this stage. Animals in Experiment 1b received identical training.

Table 1
Design of Experiments 1a and 1b

Switch training		Shock training	Experiment 1a	Experiment 1b
A: $x \rightarrow$ food	A: $y \rightarrow$ no food	A $\rightarrow$ shock	$x \rightarrow$ food	$x \rightarrow$ no food
B: $x \rightarrow$ food	B: $y \rightarrow$ no food			
C: $x \rightarrow$ no food	C: $y \rightarrow$ food	C $\rightarrow$ no shock	$y \rightarrow$ food	$y \rightarrow$ no food
D: $x \rightarrow$ no food	D: $y \rightarrow$ food			

Note. A and C refer to the illumination of the jewel lights and flash, counterbalanced; B and D refer to traylight and dark, counterbalanced; x and y refer to click and noise, counterbalanced. Presentations of A, B, C, and D were of 10 s duration, as were the presentations of x and y that immediately followed them. For details of counterbalancing see text.

Shock training. For half of each of the four subgroups referred to above the light was paired with shock and the flash was not, and for the rest the opposite was true. Three reinforced and three nonreinforced trials were presented in an ABBABA sequence in each session; the first started with a reinforced trial, the second with a nonreinforced trial. The two sessions were conducted, and no behavior was recorded. This stage was identical in both experiments.

Baseline training. A baseline of magazine-entry responding was then established. In the first session animals were rewarded with a food pellet for every response until 30 reinforcers had been delivered. The remaining sessions of this phase were all 40 min in duration; in the first session animals were rewarded according to a variable interval (VI) 30 s schedule, and in the remaining four sessions according to a VI 60-s schedule. This stage was identical in both experiments; the response baseline was maintained throughout the test sessions that followed.

BD test. The degree to which animals showed fear to the traylight and the dark was then examined. In Experiment 1a this stage comprised two sessions, each with three presentations of each stimulus presented in an ABBABA sequence. For half of each of the eight counterbalanced subgroups mentioned above the first session began with a dark trial and the second with a traylight trial; the remainder received the reverse. Each trial was of 10-s duration and was preceded by a 10-s pre-CS period during which response was also recorded; the ITI was 300 s. Animals in Experiment1b were treated identically, except that only one test session was administered.

x/y test. The degree to which pairings of the noise and click with food delivery (Experiment 1a) or nonreinforcement (Experiment 1b) would elicit fear then was assessed. These sessions were identical to those of the BD test except that dark and traylight presentations were replaced by reinforced (Experiment 1a) or nonreinforced (Experiment 1b) presentations of the noise and the click and by the fact that responding was additionally measured in the 10-s period that followed CS presentation (see below).

Data treatment. Performance on training discrimination was assessed by comparing the rates of responding during target CS presentations on reinforced and nonreinforced trials, from which the mean response rate during the pre-CS periods for that particular type of trial had been subtracted. There was substantial variation in absolute response rate across animals (of up to 20 rpm) and so nonparametric analyses were employed. Fear of $x+/y+$ and $y-/x-$ was assessed by taking a suppression ratio of form $b/(a + b)$, where a was the response rate during the pretrial period, and b the rate during the 10-s posttrial period—as it was only after food had

been delivered that the animal knew the target stimulus had been reinforced rather than nonreinforced, and hence when differences in fear might be anticipated. Fear of the dark and the traylight was also assessed by taking suppression ratios, but here b was the rate of responding during the CS itself. A significance level of $p < .05$ was adopted in all analyses. All suppression ratio data were subject to an arcsin transformation (Sokol & Rohlf, 2001, p. 419). All the comparisons were within-subject; standard errors are presented in the text.

Results

Appetitive Discrimination Training

In Experiment 1a one animal, and in Experiment 1b two animals, failed to discriminate in any of the last three blocks of training, and so were eliminated from all analyses. Data from the remaining animals were pooled in eight, seven-session blocks. In Experiment 1a response rates for S+/S– trials were for Blocks 1 through 8, respectively, 9.52 versus 9.26, 7.25 versus 6.95, 9.26 versus 8.45, 9.64 versus 9.25, 9.01 versus 8.42, 8.19 versus 7.66, 7.56 versus 6.71, and 6.96 versus 6.51 rpm; the corresponding standard errors were 1.30/1.27, 1.17/1.07, 1.73/1.79, 1.82/1.71, 1.82/1.71, 1.68/1.54, 1.69/1.42, and 1.64/1.47. The discrimination was modest, but was highly significant according to a Wilcoxon's T test performed on the data from the last three blocks, $T = 10$, $p < .01$. A corresponding analysis on the first three blocks of training revealed no significant effect, $T = 46.5$. To confirm that there were no preexisting differences in responding to the test stimuli, response rates to x, y, B and D were calculated for this same period. The mean rates for x and y were both 7.88 rpm, and those for B and D were 1.57 and 1.70 rpm; neither pair of scores differed, $T = 57$ and $T = 56$. Rates of responding for Experiment 1b for S+/S– trials were, for Blocks 1 through 8, respectively, 7.49 versus 7.81, 8.21 versus 8.24, 8.55 versus 8.50, 9.34 versus 9.07, 9.71 versus 9.36, 10.96 versus 10.47, 10.57 versus 10.18, and 11.53 versus 11.19 rpm. The corresponding standard errors were 1.12/1.12, 1.29/1.31, 1.05/1.09, 1.40/1.36, 1.70/1.61, 0.89/1.72, 1.85/1.84, and 2.04/1.90. A Wilcoxon's T test performed on the data from the last three blocks of training revealed that the discrimination was significant, $T = 17$ $p < .03$; a corresponding analysis on the first three training blocks was not significant, $T = 38.5$. In the last three training blocks the mean response rates to x and y were 10.05 and 9.99 rpm respectively, and the corresponding scores for B and D were 1.50 and 1.68 rpm; neither pair of scores differed, $T = 52$ and $T = 49$.

BD Test

In Experiment 1a responding was not recorded on a trial-by-trial basis. The results from the two sessions were thus analyzed as suppression ratios calculated from the pooled rates of responding during CS and pre-CS periods for the two trial types, B (the visual stimulus that had signaled the same outcome relations as the shock-associated A and D (the alternative test stimulus) for each session. One animal was omitted from this analysis as it did not make any responses during the test, and so its baseline response rate could not be assessed. The mean ratios for the remaining animals were, for Sessions 1 and 2, respectively, .40 and .41 for B trials, and .49 and .49 for D trials. These means were in the predicted direction (more suppression to B); but they did not differ significantly. Analysis of variance with trial type (reinforced or nonreinforced) and session as factors revealed no significant effects or interactions, largest $F(1, 13) = 1.90$. Standard errors were .06 and .06 for B trials, and .06 and .05 for D trials, for Sessions 1 and 2, respectively. In Experiment 1b responding was recorded separately for each trial during this test; however, eight of the animals failed to make pre-CS responses on some trials, making it impossible to obtain a suppression ratio for each trial individually. Consequently, as in Experiment 1a ratios were calculated from the pooled number of CS and pre-CS responses for each particular type of trial. The mean ratios for B and D trials were .50 and .47, respectively (respective standard errors being .06 and .05), and these values did not differ significantly, $F < 1$.

x/y Test

F1

The test data are shown in Figure 1, pooled over all three test trials. In Experiment 1a (top panel) there was greater suppression of responding on $x+$ trials (which had followed presentation of the shock-associated occasion setter A during initial training) than on $y+$ trials; means for Trials 1 to 3 were .63, .44, and .65 for $x+$ trials and .72, .68, and .66, for $y+$ trials. This description was supported by the results of analysis of variance with trial type ($x+$ or $y+$) and trial (1 to 3) as factors, which revealed a significant main effect of trial type, $F(1, 14) = 5.60, p < .04$; the effect of trial approached significance, $F(2, 28) = 3.23, p < .06$, but the interaction was not significant, $F(2, 28) = 2.10$. The standard errors for $x+$ trials were .04, .07, and .05, and .06, .05, and .06 for $y+$ trials, for Trials 1, 2, and 3, respectively. In Experiment 1b (lower panel) the corresponding result was observed—greater suppression on $y-$ than on $x-$ trials; the means for Trials 1 to 3 were .53, .56, and .54 for $y-$ trials and .65, .52, and .70 for $x-$ trials. A corresponding analysis revealed a significant main effect of trial type, $F(1, 12) = 6.30 \ p < .03$; neither the effect of trial nor the interaction was significant, $F(2, 26) = 1.56$ and 2.79, respectively. The standard errors for $y-$ trials were .04, .05, and .08, and for $x-$ trials .05, .06, and .08, for Trials 1, 2, and 3, respectively.

It is worth noting that the mean ratios in the test phase were almost all greater than 0.5, implying that levels of responding were higher in the posttrial period than the corresponding pretrial period. Usually a conditioned suppression test of this kind indexes fear as a suppression of background responding, and so this deserves comment. However, there are good reasons why such a pattern should have been observed here. In the test pretrial responding was compared to responding immediately after either
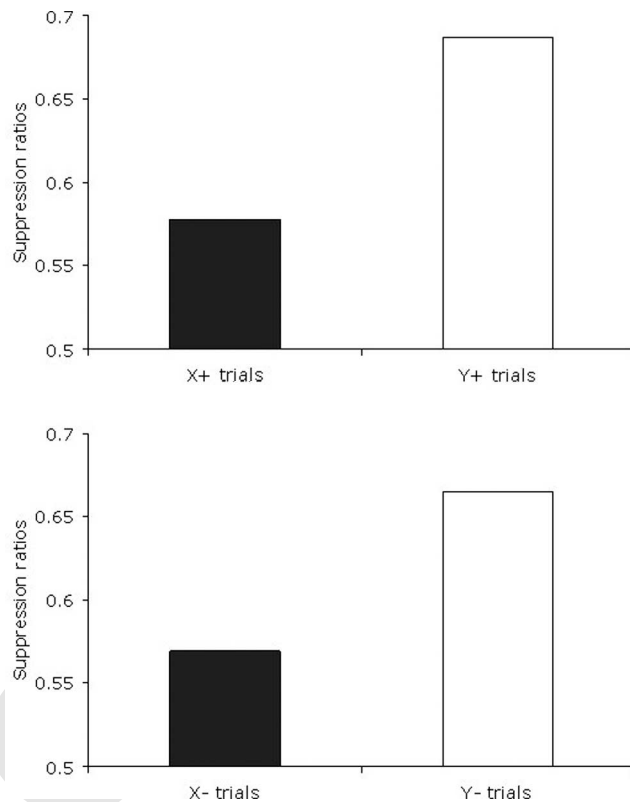

Figure 1. Mean suppression ratios for $x+$ trials and $y+$ trials in the test of Experiment 1a (upper panel) and for $y-$ and $x-$ trials (lower panel) in the test of Experiment 1b.

$x \rightarrow$ food or $y \rightarrow$ food pairings (Experiment 1a) or $x \rightarrow$ no food or $y \rightarrow$ no food pairings (Experiment 1b); thus the animals had just experienced a food-associated CS, and in Experiment 1a had also just received a food pellet, at the start of the posttrial period; both would be likely to elicit tray-entry responding. As neither of these events would have occurred in the pretrial period (except on the rare occasions when the animal earned a pellet in this time), then this could explain an overall elevation in posttrial responding, and hence a "suppression" ratio greater than 0.5. The critical point is that superimposed on this general elevation was an apparent reluctance to make these responses when the trial had involved presentations of $x+$ or $y-$; this, we suggest, was because this specific event combination elicited fear, relative to the alternatives, $y+$ and $x-$.

Discussion

In two experiments animals were trained on a biconditional switching discrimination in which the significance of cues x and y reversed according to whether they were signaled by A and B, or by C and D. Then A was paired with shock whereas C was nonreinforced, and finally animals were given reinforced (Experiment 1a) or nonreinforced (Experiment 1b) presentations of x and y. Animals showed more fear of $x+$ than of $y+$, and more fear of $y-$ than $x-$. Both $x+$ and $y-$ were the event combinations signaled by the aversive A, and so these results may be explained if these

event combinations were evoked by A during shock conditioning, and they became associated with shock. This result complements one previously reported by Honey and Watt (1998) in which they paired either $x+$ or $x-$ with shock, and examined responding to A, B, C and D. In parallel with our findings they found that pairing $x\pm$ with shock resulted in animals displaying more fear to A and B than to C and D, whereas pairing $x-$ with shock produced the opposite pattern. These results are consistent with our original hypothesis that event combinations can enter into associations as independent entities.

A possible corollary of our hypothesis is that we should also have observed equivalence between A and B and between C and D (cf. Honey & Watt, 1998, 1999). lf, when it is paired with shock, A can evoke a representation of the event combinations it signaled during discrimination training, then B should also be able to evoke these fear-evoking event combinations when it is tested, and so animals should show more fear of B than of D. Although in Experiment 1a animals suppressed more to B than to D, this effect was not statistically significant. We did not record the data from individual trials in this test, however, but pooled the data from the entire session. It is therefore possible that a transient equivalence effect was present, but that our measure did not have the temporal resolution to detect it. Accordingly in Experiment 1b we recorded responding on a trial-by-trial basis; but despite this precaution the loss of baseline responding in several animals meant that again we had to pool data across all trials of each type in the test session, and so this might be why we saw little sign of an equivalence effect. This suggestion is supported by the fact that if we take the data from Trial 1 of Experiment 1b (deleting the two animals who made no pre-CS responses) the mean suppression to B was 0.35, and that to D was 0.50; this difference was in the predicted direction, although not statistically significant, $F(1, 13) = 3.14$ $p = .099$. Nonetheless, this null effect does not compromise our hypothesis. Our prediction was that in the first phase of training each occasion setter becomes associated with each of the event combinations operative in its presence; thus A and B become able to evoke both $x+$ and $y-$. When A is then paired with shock, it evokes the representations of $x+$ and $y-$, which also become associated with shock. In the subsequent test of B and D, B, which should also be able to evoke $x+$ and $y-$, should accordingly elicit more fear than D, which cannot evoke these event combinations. However, it is possible the ability of A and B to evoke the representations of $x+$ and $y-$ declines with time after the end of discrimination training. Thus although A might have been able to evoke both $x+$ and $y-$ during shock conditioning, which occurred the day after the last discrimination session, the ability of B to do so might have declined a week later when the equivalence test was given (delayed because baseline training was interposed between the off-baseline shock conditioning sessions and the first test). This would compromise our ability to observe the equivalence effect—but not affect performance in the test in which the event combinations were directly presented, as here showing fear does not depend on evocation of the event combinations by A or B. There were also several other differences between our procedure and that employed by Honey and Watt that might be relevant. For example our A/B/C/D cues were visual and our x/y cues auditory, whereas in Honey and Watt's study the reverse was the case. This may have influenced the ease with which animals could learn the discrimination (indeed Honey and Watt's animals showed greater differ-

ences in responding between reinforced and nonreinforced trials than ours) and this in turn could have influenced the degree to which the ability of the conditional cues to evoke their respective event combinations persisted over time.

In both experiments performance on the biconditional discrimination, although statistically significant, was numerically small. This was disappointing but it does not compromise our interpretation of the results. The critical point is that the test stimuli, x and y, were paired with A and C an equal number of times during discrimination training, and elicited similar levels of responding at the end of this phase. It is not at all clear how one could explain the test results except in terms of what the animals had learned during discrimination training.

These results are problematic for configural theories, which posit that occasion-setting discriminations result from an association between a configural cue, produced by co-occurrence of the occasion setter and the target CS, with reinforcement (e.g., Brandon, Vogel & Wagner, 2000; McLaren & Mackintosh, 2002; Pearce, 1987). Although the various theories differ in the precise relationship they propose between the configural cue and its constituent elements (Brandon et al., 2000), they all share the assumption that the configural cue differs from the sum of its parts. This explains the defining feature of occasion setting, that manipulations of the feature's Pavlovian properties do not affect occasion setting performance, because the feature does not generalize perfectly to the configural cue. However, such theories have trouble explaining the results reported here. They predict that solution of the switching task would entail formation of four reinforced configural cues, Ax, Bx, Cy, and Dy, and four nonreinforced ones, Ay, By, Cx, and Dx. Fear is then evoked to the extent that the test stimuli can activate configural cues that include the fear-evoking A. However, presentations of x and y would both be able to activate the same number of configural cues that include A, and thus should elicit fear to the same extent. Configural theory may, however, be extended to explain our results by assuming that the outcome is included in the configural cue (cf. Honey & Watt, 1998). Then the configural cues that form during training could be characterized as Axf, Bxf, Ayn, Byn, Cyf, Dyf, Cxn, Dxn, where f and n refer to food and no food outcomes respectively, and the degree to which $x+$ (xf) and $y+$ (yf), say, can elicit fear will depend on the degree to which they can activate the fear-evoking configures Axf and Ayn. If we assume that xf is better at activating these configures than yf because xf provides a dual source of activation to Axf, whereas yf produces two single sources of activation to Axf and Ayn (cf. Pearce, 1987), then this pattern of results may be explained. However, although such an extended configural account can explain the present results, Honey and colleagues have explicitly tested this account and found grounds to reject it (Honey & Ward-Robinson, 2001). Instead they proposed an alternative associative framework, involving a layer of hidden units that separate the representations of signals and outcomes, and that are activated by the events present on a particular trial—including the outcome (Honey & Watt, 1999). Thus A, B, x and $+$ elements become linked to the same hidden unit. This account can explain both acquired relational equivalence and mediated conditioning: when A is conditioned its hidden unit is paired with shock, so B and both $x+$ and $y-$ can elicit fear by activating this hidden unit.

It should be noted, however, that none of the accounts considered so far captures the intuitive description of the conditional learning task—that the retrieval or use of the $x+$ and $y-$ associations is controlled by the presence of A or B. This intuition implies that occasion setters and targets play qualitatively different roles in controlling behavior—the CS elicits the CR, whereas the occasion setter controls its ability to do so. In contrast to this perspective, both extended configural theory and the account proposed by Honey and Watt (1999) regarded A, B, x and y as functionally equivalent—the former regarding them as no more than components of a configural cue, and the latter as equivalent potential activators of the critical hidden units. An alternative, hierarchical approach might therefore be preferred, which posits a hidden unit that is associated with the occasion setter and when activated can facilitate the flow of activation between the CS and the US. If this hidden unit were also activated by the flow of activation between CS and US, then the present pattern of results could be explained. When A is paired with shock, its hidden unit is activated and thus associated with shock. Both B and the x/food and y/no food pairings can activate this same hidden unit and therefore can also elicit fear. However, although as noted above there are grounds why one might want to question extended configural theory, there is as yet no empirical reason to prefer the account we have proposed to that proffered by Honey and Watt. It remains to be seen whether the conceptual differences between them will yield testable predictions that could allow a more formal discrimination between them.

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