THE QUARTERLY JOURNAL OF EXPERIMENTAL PSYCHOLOGY, 1997, *50B* (4), 317–331

Stimulus Preexposure, Comparison, and Changes in the Associability of Common Stimulus Features

Michelle Symonds and Geoffrey Hall
University of York, York, U.K.

In four experiments, rats received preexposure either to both of two compound flavours (AX and BX), or to just one (BX). Experiment 1 demonstrated a perceptual learning effect, showing that, for animals given preexposure to both flavours, an aversion conditioned to AX generalized only poorly to BX. Subsequent experiments assessed the properties of the common feature, X. Experiment 3 showed that the two preexposure treatments did not differ in the extent to which they produced habituation of the neophobia evoked by X. Experiment 2 showed that conditioning to X proceeded more rapidly in subjects given preexposure to both AX and BX than in subjects preexposed to BX alone. In Experiment 4, a similar effect was found when the elements of the compounds were presented serially. It is concluded that the perceptual learning effect of Experiment 1 occurs in spite of the fact that preexposure to two stimuli tends to maintain the associability of their common elements.

Preexposure to a pair of stimuli will tend to enhance discrimination or reduce generalization between them. Evidence for this *perceptual learning* effect comes from a variety of experimental procedures (see Hall, 1991, for a review). Here we focus on the flavour-aversion learning paradigm, for which it is well established that prior exposure to flavours A and B will reduce the extent to which a conditioned aversion established to A will generalize to B (Honey & Hall, 1989; Mackintosh, Kaye, & Bennett, 1991; Symonds & Hall, 1995).

A possible explanation for this effect attributes it to the loss of associability that will be suffered during preexposure by features or elements that are common to the critical stimuli (McLaren, Kaye, & Mackintosh, 1989; it should be noted, however, that this is just one of the mechanisms proposed by McLaren et al.). The stimuli A and B can be construed as being compounds *ac* and *bc*, where *c* represents those elements that are common to both, *a* those elements that are unique to A, and *b* those elements that are unique to B. Generalization between A and B will depend on the associative strength acquired by *c* elements as a result of conditioning with A. Now, preexposure to A and B

Correspondence concerning this article and requests for reprints should be addressed to G. Hall, Department of Psychology, University of York, YO1 5DD, U.K. Email: GH1@York.ac.uk

This work was supported by a grant from the United Kingdom Science and Engineering Research Council. We thank C. Bonardi and R. Honey for helpful discussion.

can be expected to produce latent inhibition. This will accrue to all the elements of A and B, but the effect will be more profound for the *c* elements than for the unique elements of the stimuli, as the former are present on both A and on B preexposure trials. During subsequent training with A as the conditioned stimulus (CS), the *c* elements will be particularly poor at acquiring associative strength, and generalization to B will be limited.

One reason to doubt the adequacy of this explanation comes from an experiment by Mackintosh et al. (1991, Experiment 3B; see also Symonds & Hall, 1995). In this study, experimental subjects received six exposures to A and six to B, the stimuli being presented in an alternating sequence; control subjects received 12 exposures to B. These two groups should not differ in the extent to which the common stimulus elements suffer latent inhibition—by definition, these elements will be present on all 12 trials in both cases. If the total amount of preexposure given to the common stimulus elements is the critical factor in generating the perceptual learning effect, then the groups should not differ in their test performance. It was found, however, that experimental subjects were superior to controls in learning a subsequent discrimination in which A was reinforced and B was not.

This outcome has been interpreted as implying that mechanisms other than latent inhibition of common elements may be responsible for the perceptual learning effect. But this conclusion may be premature. An alternative possibility is that the latent inhibition suffered by the common elements does not simply depend on the amount of exposure they receive but is determined by the conditions under which that exposure is given—in particular, the results would be explained if the opportunity to compare the two stimuli to which the elements are common were especially effective in endowing these elements with latent inhibition. Subsequent experiments examine this suggestion by directly testing the changes in associability that occur in a common stimulus feature as a consequence of the two forms of preexposure. As a first step, however, we thought it necessary to confirm that the basic effect of interest could be demonstrated with our chosen stimuli and procedures. Accordingly, in Experiment 1 we sought to show that preexposure to both stimuli would reduce generalization between them and would be more effective in doing so than would preexposure to just one of them.

EXPERIMENT 1

In this experiment the stimuli used were the compounds AX and BX, where A and B represent sucrose and saline, and X an explicitly added common element (dilute acid). These flavours were those used by Symonds and Hall (1995) in a previous demonstration of the perceptual learning effect. In Experiment 1 only the compounds were used, but subsequent experiments included tests with X presented alone, allowing an evaluation of changes in the properties of an element common to both training stimuli.

There were three groups that differed in the preexposure they received. Group 4AX/4BX received four exposures to each of the compound flavours AX and BX (presented on alternate trials); Group 8BX received a series of eight exposures to flavour BX; Group W received only water during the preexposure phase. All subjects then received a phase of conditioning in which consumption of the AX flavour was paired with an injection of lithium chloride (LiCl). This was followed by a test trial on which consumption of the BX flavour was measured. The critical feature of this design is that it equates the level of exposure to the common X feature (and to any other features that A and B may share) in groups 4AX/ 4BX and 8BX. In principle, therefore, any latent inhibition suffered by the common elements (and hence the contribution of this factor in reducing generalization from AX to BX) will be the same for these groups. On the basis of previous findings (e.g. Honey & Hall, 1989; Symonds & Hall, 1995) it may be expected that both groups given flavour preexposure would show a reduction in generalization of the aversion from AX to BX relative to Group W, presumably because X will have suffered some latent inhibition in both. But if this reduced generalization is determined solely by the amount of pre-exposure given to the common elements, then the two preexposed groups should not differ in this regard.

Method

Subjects and Apparatus

The subjects were 24 male (hooded) Lister rats with a mean free-feeding weight of 359 g (range: 320–390 g). They were housed in a colony room that was lit from 0800 h to 2000 h each day, and they were allowed continuous access to food throughout the experiment. They had previously served as subjects in an experiment that made use of an appetitive conditioning regime, but they were naive with respect to the current stimuli and procedures.

Inverted 50-ml centrifuge tubes equipped with stainless steel, ball-bearing-tipped spouts were used to present measured quantitites of unflavoured tap water, a compound solution of 0.01 M hydrochloric acid (HCl) and 0.16 M saline (flavour AX), or a compound solution of 0.01 M HCl and 0.33 M sucrose (flavour BX). The molarities given are those that apply to the compounds. Fluid consumption was measured, by weighing, to the nearest 0.5 ml. The unconditioned stimulus for the conditioning trials was an intraperitoneal injection of 0.3 M LiCl at 10 ml/ kg of body weight.

Procedure

A schedule of water deprivation was initiated with subjects housed in pairs in their home cages. The standard water bottles were first removed overnight, and on each of the following two days access to water was restricted to two daily sessions of 30 min initiated at 1200 h and 1700 h. Presentations of fluid continued to be given at these times throughout the experiment. The subjects were then individually housed. On the next morning they were given 30 ml of unflavoured tap water in the centrifuge tubes, and consumption was measured in order to establish individual levels of baseline fluid intake. The subjects were then given free access to water in the standard bottles for 30 min at 1700 h.

The rats were then assigned to one of three preexposure conditions. Over the next eight days, subjects in Group 4AX/ 4BX received four presentations of AX and four of BX. They were given access to 10 ml of one of the compound flavours on the morning session of each of these days. The flavours were presented in alternation, beginning with AX on the first preexposure day. Group BX received, on each of the eight days, access to 10 ml of flavour BX in the morning session. Subjects in Group W received 10 ml of water during the morning sessions of the preexposure phase. All subjects received free access to water for 30 min in the afternoon session.

There followed three conditioning trials. On each trial, the subjects received a 30-min presentation of 10 ml of flavour AX followed by an injection of 0.3 M LiCl. Each conditioning trial was followed by a recovery day on which the animals were permitted free access to water for 30 min in the morning and 30 min in the afternoon. A test trial followed the last of these recovery days. On the test trial the subjects were given unrestricted access to flavour BX for 30 min.

Results and Discussion

During the preexposure phase, the animals almost invariably drank all 10 ml of the fluid offered in the morning drinking sessions.

Consumption of flavour AX on the conditioning trials for each of the three groups is shown in the left panel of Figure 1. It is clear that all three groups came to show suppressed consumption of this flavour, but that the rate of acquisition of this aversion differed among the groups. In particular, acquisition appeared to be somewhat retarded in Groups 4AX/ 4BX and 8BX, relative to Group W. This pattern of results presumably reflects a latent inhibition effect in subjects given flavour preexposure. An ANOVA (analysis of variance) was conducted on these data with group and trial as the variables. The rejection level adopted for this and all subsequent analyses was $p < .05$. This analysis showed there to be a significant effect of group, $F(2, 21) = 3.66$, and of trial, $F(2, 42) = 355.38$, and a significant interaction between these two factors, $F(4, 42) = 3.23$. This interaction was explored using an analysis of simple main effects, which revealed that the groups differed on the second trial, $F(2, 56) = 8.48$. Comparison of individual means on this trial using Duncan's test revealed that both groups 4AX/ 4BX and 8BX differed significantly from Group W, and that the former two groups did not differ from each other.

The data from the test trial with flavour BX are displayed on the right of Figure 1. It is clear that subjects in Group 4AX/ 4BX showed substantially more consumption of this flavour than did Group W. The test consumption recorded for subjects in Group 8BX fell between that of groups W and 4AX/ 4BX. These impressions were confirmed by an

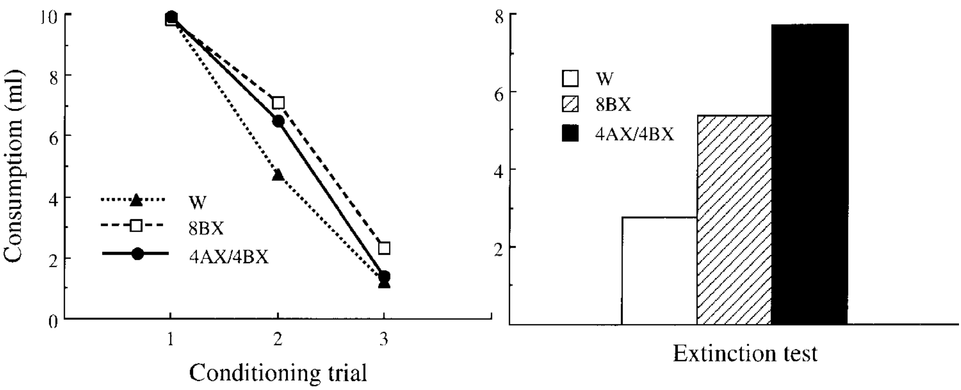

FIG. 1. Experiment 1: Left panel: Group mean scores for three conditioning trials on each of which presentation of compound flavour AX was followed by an injection of LiCl. Right panel: Group mean scores for the test session in which the subjects received nonreinforced presentation of BX. Group 4AX/ 4BX had received preexposure in which trials with AX and BX were alternated; Group 8BX had received preexposure to just the BX compound; Group W received water during preexposure.

ANOVA conducted on the scores summarized in the figure. This revealed a significant effect of group, $F(2, 21) = 16.38$, and Duncan's test showed that both Group 8BX and Group 4AX/ 4BX differed significantly from Group W, and also that Group 8BX and Group 4AX/ 4BX differed significantly from one another.

The results of Experiment 1 were clear-cut. In accord with other findings in the literature, preexposure to a pair of stimuli, in this case the compounds AX and BX, reduced the generalization of an aversion between them—that is, produced a perceptual learning effect (e.g. Honey & Hall, 1989). Also consistent with previous work (see Best & Batson, 1977; Honey & Hall, 1989; Mackintosh et al., 1991) is the finding that generalization is also reduced, although to a lesser extent, by preexposure to just the test stimulus (BX). In most previous studies, however (except that by Mackintosh et al., 1991, Experiment 3B), animals given preexposure to just the test stimulus have received fewer preexposure trials than did those exposed to both stimuli, leaving open the possibility that preexposure to both is more effective simply because it allows for more latent inhibition to accrue to common stimulus elements. The present study confirms that the difference between the groups persists even when they are matched in their exposure to these elements.

EXPERIMENT 2

As the total amount of exposure given to the common elements of AX and BX was the same for the two preexposed groups of Experiment 1, the difference between these groups in their test performance cannot be explained in any simple way in terms of differences in the latent inhibition suffered by these common elements. What remains possible, however, is that the magnitude of latent inhibition produced by a given amount of exposure may be enhanced by a training procedure that presents the critical stimulus in the context of two other stimuli. That is, the training procedure that allows comparison of the two stimuli might have its effect because it facilitates the acquisition of latent inhibition by their common elements. It may be noted that Gibson (1969), in a discussion of the role of stimulus comparison in perceptual learning, suggested that the opportunity to compare stimuli is especially effective in enhancing discrimination between them because it allows the subject to "filter out" the features that the stimuli hold in common. The nature of the filtering out process is not specified, but enhancement of latent inhibition constitutes one possible mechanism.

In order to test this suggestion, we gave two groups of subjects initial training like that given to the preexposed groups of Experiment 1. We then gave conditioning trials with flavour X, presented alone, as the CS. Poor acquisition by the group given preexposure to both AX and BX would be consistent with the suggestion that this training procedure is especially effective in producing latent inhibition to common stimulus elements.

Method

The subjects were 16 experimentally naive male hooded (Lister) rats with a mean free-feeding weight of 360 g (range: 330–380 g). As in Experiment 1, the rats were introduced over the course of three days to a regime of water deprivation, with fluid being presented twice each day (at 1100 h and

1700 h in this case). They were then assigned to two groups, matched for baseline levels of water consumption. Preexposure proceeded as in Experiment 1, except that flavoured solutions were given twice each day (this schedule was used by Symonds & Hall, 1995, who demonstrated, in their Experiment 2, that it was just as effective in producing a perceptual learning effect as one in which just one session was given on each day). Thus, over the next four days Group 4AX/ 4BX received, on each day, a presentation of flavour AX in the morning and of BX in the afternoon drinking session. For subjects in Group 8BX, the same compound flavour was presented on all preexposure trials. For half the subjects in each group, AX was the acid–sucrose compound and BX was the acid–saline compound; for the remainder the arrangement was reversed. For all subjects, HCl was the target flavour, X.

There were three conditioning trials. All subjects were given access to 10 ml of flavour X for 30 min at 1100 h. This was followed by an injection of LiCl. The concentration of the LiCl was reduced from 0.3 M to 0.15 M in order to slow the rate of acquisition in the hope that between-group differences might be more easily observed. On each conditioning day, the subjects were given free access to water for 30 min at 1700 h. Each conditioning trial was followed by a recovery day on which all subjects received two daily 30-min sessions of access to water. After this cycle had been completed, all subjects received a series of three nonreinforced test trials on which they were given free access to flavour X for 30 min in the morning drinking session; water continued to be made available in the afternoon session. These extinction tests were separated by days on which the subjects were allowed two 30-min sessions of access to water.

Results and Discussion

The left-hand panel of Figure 2 shows group mean scores for the three conditioning trials with flavour X as the CS. Although consumption was substantially suppressed in both groups by Trial 3, it may be supposed that both were showing latent inhibition to some extent—in other studies conducted in this laboratory we have found that, for this CS and US, a single conditioning trial is enough to produce almost total suppression in animals given no preexposure to the CS flavour. The figure reveals no major difference between the two groups except that on the final trial Group 4AX/ 4BX consumed somewhat less than did Group 8BX. This difference, although small, proved to be statistically reliable. An ANOVA conducted on the data summarized in the figure, with group and trial as the factors, revealed no significant main effect of group ($F < 1$), but there was a significant effect of trial, $F(2, 28) = 120.56$, and a significant interaction between these two factors, $F(2, 28) = 4.55$. An analysis of simple main effects revealed that the groups differed significantly on the third conditioning trial, $F(1, 29) = 5.33$.

The pooled data from the three trials in which the subjects received nonreinforced presentations of flavour X are displayed on the right of Figure 2. None of the subjects drank much on these trials, and consumption for several subjects in Group 4AX/ 4BX remained almost completely suppressed. Group 8BX showed some recovery of drinking, however, confirming that for these subjects the aversion formed to X was less profound. Given the substantial number of zero scores, the data summarized in the figure were subjected to nonparametric statistical analysis. This showed that the difference between the groups was statistically reliable (Mann–Whitney $U = 11.5$).

This experiment shows that the acquisition of an aversion to X occurred more readily and was more profound after intermixed preexposure to the AX and BX compounds than

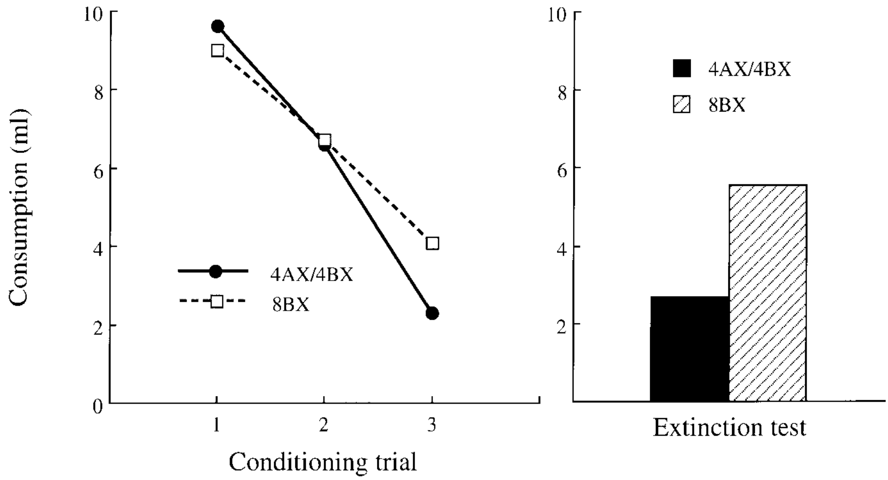

FIG. 2. Experiment 2: Left panel: Group mean scores for three conditioning trials on each of which presentation of flavour X was followed by an injection of LiCl. Right panel: Group mean total consumption over three nonreinforced test trials with flavour X. Group 4AX/ 4BX had received preexposure in which trials with AX and BX were alternated; Group 8BX had received preexposure to just the BX compound.

after preexposure to BX alone. If this outcome reflects differences between the groups in the latent inhibition suffered by X during preexposure, then we must conclude, in disconfirmation of the hypothesis that prompted this experiment, that the AX/ BX preexposure procedure is actually *less* effective than is BX preexposure in producing latent inhibition of X. In the next two experiments we investigate possible explanations for this finding; its implications for the basic perceptual learning effect is taken up in the General Discussion.

EXPERIMENT 3

The results of Experiment 2 provide no support for Gibson's (1969) suggestion that the opportunity to compare stimuli allows their common elements to be "filtered out". But another aspect of Gibson's (1969) account of perceptual learning–the notion of "stimulus differentiation"—provides a possible explanation of the findings. The proposal is that experience with a given stimulus renders the subject sensitive to aspects and details that were not perceived when the event was first encountered. Thus, on its early presentations, the compound BX, for instance, would be perceived as some undifferentiated whole; only with experience would the individual B and X elements come to be perceived. It follows that animals would need a certain amount of experience with a compound stimulus before exposure to it could be effective in generating latent inhibition to its elements. It is possible, then, that the training in which subjects received only four presentations of a given compound stimulus would be insufficient to produce differentiation and thus would not allow the development of latent inhibition by the elements of the compound. Such was the training given to group 4AX/ 4BX. For group 8BX, on the other hand, the eight presentations of BX might have been enough to produce differentiation and thus permit the development of latent inhibition to X.

In order to test this proposal, the present experiment investigated the effects of these preexposure treatments, not on the latent inhibition suffered by X, but on the extent to which they allow habituation of such unconditioned responses as this stimulus will evoke. Subjects received initial training identical to that given to the preexposed subjects in Experiment 2; thus group 4AX/ 4BX received alternating presentations of AX and BX; group 8BX received exposure just to BX. The test phase differed in that the subjects were simply given free access to flavour X. Previous work in this laboratory has shown that this flavour (dilute acid) evokes marked neophobia—rats are initially unwilling to consume it, but intake rises reliably over the course of subsequent presentations. If the training given to group 4AX/ 4BX is incapable of producing differentiation, X will not be perceived during preexposure, and, being effectively novel on test, it should evoke a neophobic response. For group 8BX, on the other hand, the hypothesis being tested assumes that X will be perceived on at least some of the preexposure trials; there will thus be an opportunity for habituation to occur, and neophobia will be less marked in this group.

Method

The subjects were 16 male hooded (Lister) rats with a mean free-feeding weight of 383 g (range: 350–470 g). They had previously served as subjects in an appetitive conditioning experiment but were naive with respect to the current stimuli and training procedures. After a schedule of water deprivation had been established, the subjects were randomly assigned to two groups. On the next four days, group 4AX/ 4BX and group 8BX received, as before, a preexposure schedule in which they experienced twice-daily presentations of a compound flavour, initiated at 1100 h and 1700 h. Over the next three days, all subjects received a test trial in which they were given free access to flavour X for 15 min at 1100 h. Other procedural details were identical to those described for Experiment 2.

Results and Discussion

Figure 3 shows group mean scores for consumption of X on the test sessions. It is evident that the animals consumed less on the first trial than on subsequent trials, suggesting that X initially evoked a neophobic response that underwent habituation. This was true for both groups. An ANOVA conducted on the data summarized in the figure showed only a significant effect of trial, $F(2, 14) = 13.37$. The effect of group and the Group $\times$ Trial interaction were not significant (Fs < 1). There is no indication that the extent of habituation of neophobia to X was influenced by the type of preexposure given, and thus no support for the suggestion that X might be less readily perceived in group 4AX/ 4BX than in group 8BX.

The fact that both groups in this experiment showed evidence of neophobia on the test indicates that the eight presentations of X given during preexposure were not enough to produce complete habituation in either group. This is probably a consequence of generalization decrement, the X stimulus experienced alone for the first time on test being perceived as a slightly different (and therefore somewhat novel) stimulus from the X

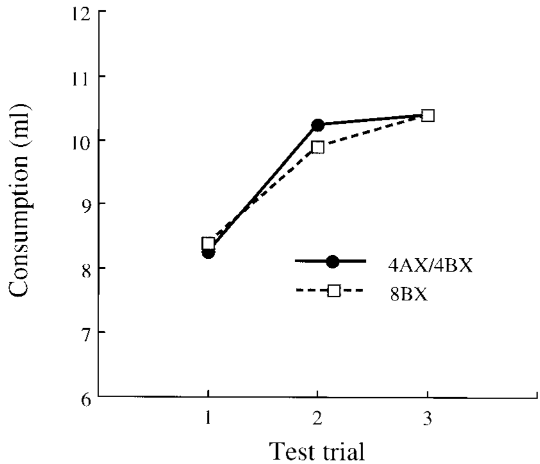

FIG. 3. Experiment 3: Group mean scores on the neophobia test sessions with flavour X. Group 4AX/ 4BX had received intermixed preexposure to AX and BX, and Group 8BX had received preexposure to just the BX flavour.

that had been experienced as part of a compound during preexposure. But the lack of difference between the groups indicates (as well as any null result can) that the degree of generalization decrement was the same in the two groups. This finding argues against another possible interpretation of the results of Experiment 2. We have assumed that the difference between the groups in learning about X in that experiment indicates that the AX/ BX preexposure treatment generated less latent inhibition to X than did exposure to just BX. An alternative is that latent inhibition was established equally readily in the two groups during preexposure but that it transferred more successfully to the test phase in group 8BX than in group 4AX/ 4BX. This could happen if the X stimulus presented alone on test were perceived as being more similar to an X that had been presented in compound with just B than to an X presented in compound with both A and B. It may be noted, however, that this analysis predicts that the transfer of habituation from preexposure to the test should also differ between the groups—that the X presented on test should be perceived as effectively novel in group 4AX/ 4BX, making neophobia particularly marked in this group. Our present results give no support to this prediction.

EXPERIMENT 4

The essence of the proposal tested in Experiment 3 was that the difference between the groups in the degree to which X undergoes latent inhibition was a consequence of changes in the way in which the stimuli were perceived over the course of preexposure. It is possible, however, to derive the prediction that X will suffer less latent inhibition in group 4AX/ 4BX than in group 8BX from a theory of latent inhibition that assumes no perceptual learning in this sense. According to Pearce and Hall (1980), the associability of a stimulus will change with experience, being determined by how well it predicts its associates. In particular, as the associative strength of a stimulus as a CS for some other event grows greater, so the associability of that stimulus will diminish. For group 8BX of Experiment 2, presentations of X are always accompanied by B; an X–B association should therefore be formed readily, and in consequence the associability of X will decline. For subjects in group AX/ BX, on the other hand, X has no consistent associate, being accompanied by A on some trials and B on others. The Pearce–Hall (1980) model predicts that such uncertainty of outcome prevents or attenuates loss of associability (see also Swan & Pearce, 1988).

According to this account, the critical associations responsible for producing the effect seen in Experiment 2 are those between the elements B and X and A and X that were formed as a consequence of them occurring together as compounds. But exactly the same effect would be expected if the flavours were presented in a serial fashion during pre-exposure, with presentations of X being followed by a separate presentation of another flavour. In contrast, the proposal that the critical difference between the two preexposure procedures lies in the extent to which they allow the animal to differentiate a compound stimulus into its components can predict no effect when the flavours are presented serially.

Accordingly, in this experiment we repeated Experiment 2 but with the modification that the critical stimuli were presented serially. For subjects in group 4AX/ 4BX, X was followed by A on AX trials, and by B on BX trials. Subjects in group 8BX received X followed by B on all trials. To replicate the finding of the previous experiment under these conditions would be consistent with the suggestion, derived from the Pearce–Hall (1980) model, that exposure to AX and BX is more likely to maintain the associability of X than is exposure to just BX.

Method

The subjects were 16 male hooded (Lister) rats with a mean free-feeding weight of 449 g (range: 375–500 g). They had previously served as subjects in an appetitive conditioning experiment but were naive to the current stimuli and training procedures. The subjects were first water-deprived and then assigned to two groups, matched for baseline levels of water consumption. Group 4AX/ 4BX received, over the next four days, alternating exposures to AX and BX, whereas group 8BX received repeated exposures to just one of the compounds. The elements of the compounds were presented serially. On a given preexposure trial, all subjects were first given access to a bottle containing 5 ml of flavour X. After 15 min this bottle was removed and replaced with one containing 5 ml of one of the other flavours. Access to this second bottle was again for 15 min.

There followed three conditioning trials in which flavour X was paired with an injection of 0.15 M LiCl. This was followed by a phase of six extinction test trials in which the subjects received nonreinforced presentations of flavour X. Any procedural details not specified are identical to those described for Experiment 2.

Results and Discussions

During each 15-minute preexposure session, the subjects nearly always drank all of the fluid offered. The data from the three conditioning trials with flavour X are displayed on the left of Figure 4. Both groups came to show a decline in consumption of flavour X, but as in Experiment 2, the acquisition of the aversion appeared to proceed marginally more

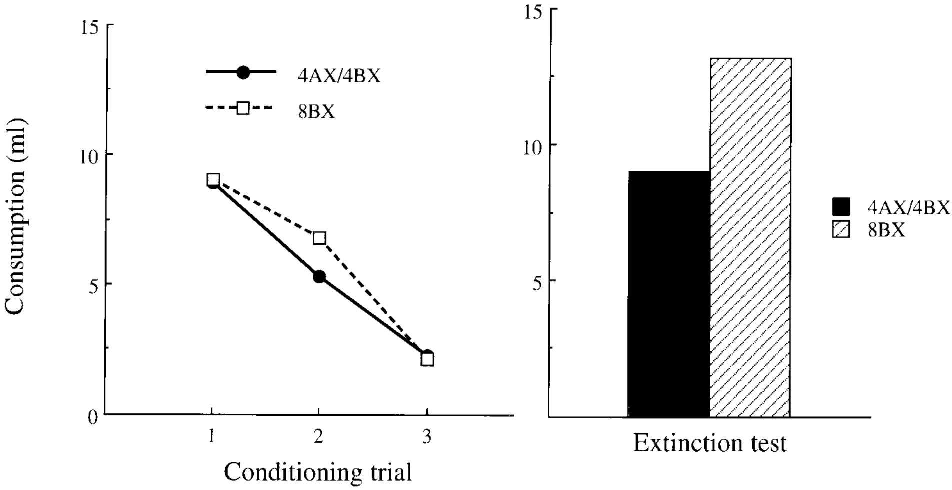

FIG. 4. Experiment 4: Left panel: Group mean scores for three conditioning trials on each of which presentation of X was paired with an injection of LiCl. Right panel: Total consumption (group means) over six nonreinforced test trials with flavour X. Group 4AX/ 4BX had received alternating preexposure trials with the serially presented A–X and B–X compounds; Group 8BX had received preexposure to just the (serially presented) B–X compound.

readily for subjects in group 4AX/ 4BX. Statistical analysis revealed, however, that the difference between the groups was not reliable. An ANOVA conducted on these data with group and trial as the variables revealed there to be no significant effect of group ($F < 1$), a significant effect of trial, $F(2, 28) = 124.19$, and no significant interaction between these two factors, $F(2, 28) = 2.26$.

Group mean overall scores for the extinction test trials are shown on the right of Figure 4. As in Experiment 2, consumption remained suppressed in group 4AX/ 4BX over the course of testing but recovered somewhat in group 8BX, suggesting that the aversion had been formed more readily in the former group. As in Experiment 2, the test data were subjected to a nonparametric analysis. This revealed the difference between the groups to be significant (Mann–Whitney $U = 13$).

This pattern of results serves to confirm the generality of the finding reported in Experiment 2, that a target flavour X will suffer less latent inhibition when it is experienced with inconsistent associates (in this case the flavours A and B) than when it is experienced in the presence of a constant associate. The serial mode of presentation of the flavours in this experiment makes it difficult to explain the results in terms of perceptual learning processes. In particular, it is difficult to see how there could be any scope for abstracting the elements of which the compounds are composed when such elements are already presented separately (unless, of course, the serial presentation allows for some residual taste that lingers from the first element to the second). Accordingly we conclude that these results are better interpreted as a demonstration that the latent inhibition suffered by a stimulus will be restricted when that stimulus is experienced along with inconsistent consequences (Pearce & Hall, 1980; see also Matzel, Schachtman, & Miller, 1988).

It should be acknowledged, however, that these results are not completely decisive. It is possible that, whatever may be true for serial compounds, the use of simultaneous compounds brings into play a comparison process that can act to modify the perceptual status of the common features of such compounds. This could be responsible for the effects observed in Experiment 2. But the Pearce–Hall (1980) model is also able to explain the results of Experiment 2, and parsimony would therefore dictate that we should prefer this as the explanation.

GENERAL DISCUSSION

The impetus for the experiments reported in this paper came from the finding (confirmed in the present Experiment 1) that preexposure is particularly effective in reducing generalization between stimuli when subjects have had an opportunity to compare the relevant cues. Generalization between the compound flavour stimuli AX and BX was reduced to some extent by preexposure to BX but to a substantially greater extent by preexposure in which AX and BX were given on alternate trials. There is, as yet, no well formulated proposal as to the mechanism by which the comparison process might operate. Nonetheless, it can be accepted that generalization from one stimulus to another will be importantly determined by the status of those features that they hold in common. It seems reasonable to suppose, then, that the opportunity to compare stimuli might have its effect because it is particularly effective in reducing the impact of features that are common to the target cues (such as the X element in the stimuli used in these experiments).

In Experiment 2 we attempted to determine whether the opportunity to compare the flavours afforded by the experience of alternating AX and BX trials during preexposure would result in more latent inhibition to the X element than would preexposure to just BX. It was found, however, that subsequent conditioning to X proceeded *more* rapidly in subjects given preexposure to both stimuli.

Two interpretations of this finding were considered. According to one (which we derived from Gibson's, 1969, account of perceptual learning), stimulus element X will be perceived less readily during preexposure in animals given both AX and BX than in animals given just one of these. There would thus be less opportunity for X to suffer latent inhibition in the former case, and conditioning to X would thus proceed more rapidly for subjects in Group 4AX/4BX than for those in Group 8BX. Experiment 3 tested this hypothesis by looking for evidence that the two preexposure procedures differed in the extent to which they allowed habituation to X, but no such effect was found.

The second interpretation assumes no change in the perceptual status of X during preexposure but offers an explanation in terms of a standard account of latent inhibition. To the extent that alternate presentations of AX and BX constitute a more uncertain outcome for X than does a series of exposures to BX alone, then the model developed by Pearce and Hall (1980) predicts that the associability of X would be more likely to be maintained in the former case. According to the theory, this outcome is just as likely to be found when the stimuli are presented serially (with X preceding presentations of A or B) as when they are presented as simultaneous compounds. Experiment 4 demonstrated such a result.

One implication of the results of Experiments 2 and 4 is that the source of the perceptual learning effect demonstrated in Experiment 1 (less generalization from AX to BX in group 4AX/ 4BX than in group 8BX) is unlikely to lie in changes to the extent to which common stimulus elements acquire associative strength during conditioning. Intermixed exposure to AX and BX appears to be particularly effective in reducing the generalization of associative strength between them (see also Symonds & Hall, 1995), yet it is also a particularly effective procedure for maintaining the associability of the common X feature—something that would be expected to enhance, rather than reduce, generalization between the target stimuli. We conclude that the opportunity to compare the stimuli must bring into play some other process of perceptual learning, one powerful enough to overcome the greater associability governed by common stimulus features following intermixed preexposure. Some alternatives are considered here.

One possibility emerges from the associative account of perceptual learning offered by McLaren et al. (1989). According to this analysis, generalization between two stimuli, A and B, will depend not only on the associative strength of their common (*c*) elements but also on associations formed between these elements and the unique stimulus elements, *a* and *b*. During conditioning with stimulus A, excitatory associations will form not only between A and the US, but also between the constituents of A (i.e. an *a–c* association will form). The ability of B to evoke a generalized response could thus be mediated in part by the fact that its *c* elements will be able to activate the representation of a feature (*a*) that was reinforced on the conditioning trials. Prior exposure to the stimuli will, according to McLaren et al. (1989), tend to eliminate this source of mediated generalization. The early trials of preexposure will allow the formation of the excitatory associations just described; but once these have been established, further trials will result in inhibitory learning. Presentations of A will be able to activate the representation of an absent *b*, via the route *a–c–b*; similarly, presentations of B will activate the representation of an absent *a* via the route *b–c–a*. These are conditions under which inhibitory links can be expected to form from *a* to *b* and from *b* to *a*. These inhibitory links will counteract the process responsible for mediated generalization in nonpreexposed subjects.

This account applies readily to the results of Experiment 1. An intermixed preexposure schedule, in which the subjects receive alternate trials with A and B, each presented in the presence of a salient common feature, X, will be the optimal arrangement for ensuring the development of mutual inhibition between the unique features of the stimuli. No such effect will be possible for animals exposed to the test stimulus alone (group 8BX).

An alternative to this associative account can again be derived from Gibson's (1969) notion of stimulus differentiation. According to this, the subject comes to detect, through the experience of contrasted instances, unique features of stimuli that were initially not responded to. And although we have found no evidence that preexposure to AX and BX produces a change in the perceptual status of X, it remains possible that the perception of A and B is changed, and that the reduction in generalization between AX and BX depends on this. At the moment this is little more than a restatement of the facts that a theory of perceptual learning must explain. Nonetheless, a place for a more tightly specified theory of this sort may yet be needed if our associative theories prove inadequate as an explanation for all instances of the perceptual learning effect.

REFERENCES

Best, M.R., & Batson, J.D. (1977). Enhancing the expression of flavour neophobia: Some effects of the ingestion-illness contingency. *Journal of Experimental Psychology: Animal Behavior Processes*, *3*, 132–143.

Gibson, E.J. (1969). *Principles of perceptual learning and development*. New York: Appleton-Century-Crofts.

Hall, G. (1991). *Perceptual and associative learning*. Oxford: Clarendon Press.

Honey, R.C., & Hall, G. (1989). Enhanced discriminability and reduced associability following flavour preexposure. *Learning and Motivation*, *20*, 262–277.

Mackintosh, N.J., Kaye, H., & Bennett, C.H. (1991). Perceptual learning in flavour aversion conditioning. *Quarterly Journal of Experimental Psychology*, *43B*, 297–322.

Matzel, L.D., Schachtman, T.R., & Miller, R.R. (1988). Learned irrelevance exceeds the sum of CS-preexposure and US-preexposure effects. *Journal of Experimental Psychology: Animal Behavior Processes*, *14*, 311–319.

McLaren, I.P.L., Kaye, H., & Mackintosh, N.J. (1989). An associative theory of the representation of stimuli: Applications to perceptual learning and latent inhibition. In R.G.M. Morris (Ed.), *Parallel distributed processing: Implications for psychology and neurobiology*, (pp. 102–130). Oxford: Clarendon Press.

Pearce, J.M., & Hall, G. (1980). A model for Pavlovian learning: Variations in the effectiveness of conditioned but not of unconditioned stimuli. *Psychological Review*, *87*, 522–532.

Symonds, M., & Hall, G. (1995). Perceptual learning in flavour aversion conditioning: Roles of stimulus comparison and latent inhibition of common elements. *Learning and Motivation*, *26*, 203–219.

Swan, J.A., & Pearce, J.M. (1988). The orienting response as an index of stimulus associability in rats. *Journal of Experimental Psychology: Animal Behavior Processes*, *14*, 292–301.

Manuscript received 14 May 1997
Accepted revision received 18 June 1997

Préexposition aux stimuli, comparaison, et changement de l'associabilité des éléments communs

Dans quatres expériences des rats ont été exposés ou bien à deux composés de saveur (AX et BX) ou qu'à un seul composé (BX). L'expérience 1 a démontré un effet d'apprentissage perceptuel indiquant que pour les animaux ayant été préexposés aux deux saveurs, l'aversion conditionée à la saveur AX n'a que très peu généralisé à la saveur BX. Les expériences subséquentes ont évalué les charactéristiques de X, l'elément commun. L'expérience 2 a démontré que l'habituation de la néophobie évoqué par X était similaire dans les deux traitements de préxposition. L'expérience 3 a démontré que le conditionnement de X a progressé plus rapidement chez les sujets pré-exposés aux deux composés (AX et BX) que chez les sujets préexposés seulement qu'à BX. Dans l'expérience 4, un effet semblable a été observé lorsque les composés furent présentés en série. Il semble donc que l'effet d'apprentissage perceptuel démontré dans l'expérience 1 apparâit en dépit du fait que la préexposition aux deux stimuli tend à maintenir l'associabilité de l'elément commun.

Preexposición de estímulos, comparación, y cambios en la asociabilidad de las características comunes a los estímulos

En cuatro experimentos unas ratas tuvieron preexposición bien a dos sabores compuestos (AX y BX), o solo a uno de ellos (AX). El Experimento 1 demostró un efecto de aprendizaje perceptivo, ya que los animales que tuvieron preexposición a los dos sabores mostraron que la aversión condicionada a AX se generalizaba mal a BX. Experimentos posteriores evaluaron las propiedades del elemento común, X. El Experimento 2 mostró que los dos tratamientos de preexposición no diferían en la habituación que producía la neofobia provocada por X. El experimento 3 demostró que el condicionamiento a X procedía más deprisa en aquellos sujetos que habían tenido preexposición a AX y a BX que en los sujetos preexpuestos solo a BX. En el Experimento 4 se encontró un efecto similar presentando los elementos de los compuestos de manera serial. Se concluye que el efecto de aprendizaje perceptivo del Experimento 1 ocurre a pesar de que la preexposición a ambos estímulos tienda a mantener la asociabilidad de los elementos comunes.