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Perceptual learning in flavor-aversion learning: Alternating and blocked exposure to a compound of flavors and to an element of that compound☆

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Abstract

Rats received different schedules of pre-exposure to a compound flavor (AX) and to one element of that compound (X). In Group ALT, exposure consisted of alternating trials with AX and X; Group BLK received a block with all AX trials before a separate block with all X trials (or vice versa). Discrimination between AX and X was assessed then by establishing an aversion to X and measuring the generalization of this aversion to AX. In Experiments 1A and 1B, generalization was less in Group ALT than in Group BLK. In Experiment 2, this latter result was confirmed and furthermore only Group ALT, and not Group BLK, showed less generalization than a group that received exposure to X alone. These results are discussed in terms of their implications for theories of perceptual learning.

Keywords: Perceptual learning; Flavor-aversion learning; Generalization; Rats

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It is well established that prior exposure to various stimuli, in the absence of reinforcement, is often sufficient to enhance their subsequent discriminability (see, Hall, 1991). Examples of this perceptual learning effect have been observed in experiments that make use of the flavor-aversion learning procedure. In this type of experiment, rats are given non-reinforced exposures to two flavored solutions, for example two compound flavors, AX and BX (where A and B represent distinctive features of the two stimuli and X represents an explicitly common feature). The ability to discriminate between these flavors is then assessed by establishing an aversion to one compound flavor (AX) and measuring the extent of generalization to the second compound (BX). It has been routinely found that the effect of such pre-exposure is to attenuate the extent to which the aversion established to AX is generalized to BX (e.g., Mackintosh, Kaye, & Bennett, 1991; Symonds & Hall, 1995). This result is consistent with the notion that pre-exposure to the stimuli enhances their discriminability. However, there is also an alternative explanation for this generalization-reducing effect in terms of latent inhibition (see Lubow, 1989). The generalized aversion shown to BX in the test will depend on the associative strength acquired by those features which this flavor has in common with AX (i.e., X). Pre-exposure to AX and BX may result in greater latent inhibition of the common X element than the unique A and B elements, because X is exposed twice as much as either A or B. Thus, relative to A and B, X may be less strongly associated with the aversion established during conditioning with AX, and generalization to BX will be reduced.

However, several studies have provided evidence suggesting that latent inhibition cannot be the only process underlying perceptual learning. It is well established that alternating exposure to AX and BX is more effective in reducing generalization between them than blocked pre-exposure, where all pre-exposure to AX precedes pre-exposure to BX (or vice versa) (e.g., Bennett & Mackintosh, 1999; Mondragón & Hall, 2002; Symonds & Hall, 1995). Since the total amount of pre-exposure to AX and BX is the same in both schedules, it is assumed that the difference between them is evidence for a perceptual learning effect that cannot be explained in terms of the degree of latent inhibition of the common X element. Mondragón and Hall (2002) have offered an explanation for these results in terms of the account of perceptual learning proposed by Gibson (1969). This explanation suggests that pre-exposure to the stimuli might bring into play a process that allows the animals to detect more easily the distinctive features of the stimuli, thus enhancing their discriminability and reducing generalization between them. This process of stimulus differentiation will increase the perceptual effectiveness of the unique features of the stimuli (A and B), will decrease that of their common features (X), and will occur more readily in pre-exposure conditions that allow the opportunity to compare the stimuli. Thus, in accordance with this proposal, the perceptual learning effect should be engaged more effectively by alternating than by blocked presentations of the stimuli.

An alternative explanation is suggested by an associative theory of perceptual learning (McLaren, Kaye, & Mackintosh, 1989; McLaren & Mackintosh, 2000). According to this account, pre-exposure to AX and BX will allow the formation of as-

sociations among the various elements of these compound stimuli. During alternating pre-exposure, initially within-compound excitatory associations will be formed between A and X and between B and X. Consequently, presentations of AX will be able to retrieve a representation of B by way of the X–B association; similarly, presentations of BX will retrieve a representation of A by way of the X–A association. According to the associative standard theory (e.g., Rescorla & Wagner, 1972; Wagner, 1981), these are conditions under which mutual inhibitory associations could be expected to develop between A and B, A being present in those trials when B is absent, but its representation being activated associatively, and vice versa. Thus, in the generalization test with BX, B will inhibit the activation of the representation of A, eliminating the source of the mediated generalization determined by the ability of X (by way of the X–A association) to activate a representation of the unconditioned stimulus (US). During blocked pre-exposure, within-compound excitatory associations between A and X and between B and X will be formed too. However, given that all pre-exposure to AX precedes pre-exposure to BX (or vice versa), there will be only one transition between the different trial types, and the formation of mutual inhibition between A and B will be reduced. There is no reason why any inhibitory association learning will occur during the first block of trials; during the second, the excitatory associations established during the first will be extinguished, and any inhibitory association established between A and B will probably be weaker than following alternating pre-exposure. Thus, in blocked pre-exposure, the source of mediated generalization will be prevented to a lesser extent, and therefore the response to BX in the generalization test will be greater than in the alternating pre-exposure (for direct evidence that alternating exposure to two compound flavors can produce inhibitory associations between their unique elements more readily than blocked exposure, see Dwyer, Bennett, & Mackintosh, 2001; Dwyer & Mackintosh, 2002).

The aim of the experiments reported here was to contrast predictions made by these two rival accounts. Previous demonstrations of the perceptual learning effect in flavor-aversion learning have been obtained in experiments employing two similar stimuli, each with a unique flavor, AX and BX (e.g., Mondragón & Hall, 2002; Symonds & Hall, 1995; Experiment 2) or A and B (Symonds & Hall, 1995; Experiment 3). Thus, in these previous experiments, the inhibitory learning mechanism proposed by McLaren et al. (1989) may have played an important role. Central to this mechanism is that each of the pre-exposed stimuli must have a unique element with respect to the other. In the experiments that follow, rats were given alternating or blocked pre-exposure to a compound flavor (AX) and to one of the elements of that compound (X). That is, one of the stimuli (X) was entirely a part of the other (AX), and therefore it did not have any explicit unique element with respect to the other. In consequence, the operation of the inhibitory mechanism proposed by McLaren et al. (1989) was precluded in our experiments. Nevertheless, if a stimulus comparison process plays an important role in the perceptual learning effect, alternating pre-exposure to AX and X should enhance the discrimination between them to a greater extent than blocked pre-exposure.

Experiment 1A

This experiment included two groups. Group ALT received alternating pre-exposure to a saline-sucrose compound (AX) and sucrose (X). Group BLK received all presentations of AX first and then X second (or vice versa). All rats then received aversion conditioning with X as conditioned stimulus (CS). Finally, generalization of this aversion to AX was measured. The question of interest was whether alternating pre-exposure would generate a perceptual learning effect of the sort that was obtained when two compound flavors, each with a unique flavor (AX and BX), were pre-exposed.

Method

Subjects and apparatus

The subjects were 20 experimentally naïve Wistar male rats with a mean ad libitum weight of 488 g (range: 453–529) at the start of the experiment. They were singly housed with continuous access to food in a room with a constant temperature (23 °C), humidity (50%), and a 12:12-h light:dark cycle with light on at 08:00. Access to water was restricted as detailed below.

Solutions were administered, in the home cages, at room temperature through 50-ml graduated cylinders. The following flavored solutions were used: 0.3% w/v saline (A); 5% w/v sucrose (X). Consumption was measured by weighing to the nearest 0.1 ml. The US for the conditioning trials was an intraperitoneal injection of 0.3 M lithium chloride (LiCl) at 10 ml/kg of body weight.

Procedure

Water deprivation. The water deprivation regime was initiated by removing the standard water bottles in the morning. Over the next 4 days, access to water was restricted to two daily sessions of 30 min, beginning at 13:00 and 18:00. This schedule was in place throughout the experiment. The rats were then randomly assigned to one of the two equal-sized experimental groups matched for their consumption of water.

Pre-exposure. Over the next 4 days, all rats received eight pre-exposure sessions, two sessions per day, during which they were given 10 ml of either saline-sucrose (AX) or sucrose (X) to drink for 30 min. Animals in Group ALT were given access to the fluids in alternation. For half the animals in this group, saline-sucrose (AX) was presented during the first daily drinking period and sucrose (X) during the second; for the remainder the arrangement was reversed. Animals in Group BLK received the solutions in two blocks of trials. For half the animals in this group, saline-sucrose (AX) was presented on the first 2 days in both daily sessions and sucrose (X) on the last 2 days. The remaining animals in this group received the opposite sequence.

Conditioning. After pre-exposure, animals received two conditioning trials. During each trial, all subjects received a 30-min presentation of 10 ml of sucrose (X) followed immediately by an injection of LiCl. The conditioning trials took place in the first drinking period, with subjects having free access to water for 30 min in the second. Each conditioning day was followed by a recovery day on which the animals

had unrestricted access to water for 30 min in both the first and second drinking periods. After the second recovery day, a non-reinforced test trial was given in which all the subjects had free access to sucrose (X) for 30 min in the first drinking period. Water was available in the drinking period following this test.

Generalization test. On the next day, the animals received a single test trial in which the subjects were given unrestricted access to saline-sucrose (AX) for 30 min.

Results and discussion

During the pre-exposure phase, the rats almost invariably consumed all 10 ml of the fluid offered during each trial. Group mean amounts of solution X consumed during the two conditioning and the test trials were: For Group ALT, 9.8 ($SEM = 0.05$), 9.1 ($SEM = 0.32$), and 6.9 ($SEM = 1.27$) ml; for Group BLK, 9.7 ($SEM = 0{,}11$), 9.2 ($SEM = 0.20$), and 4.9 ($SEM = 1.27$) ml. Apparently, Group ALT showed less aversion to X than Group BLK during the test trial. However, an analysis of variance (ANOVA) conducted on these data with group and trial as main factors revealed only a significant effect of trial, $F(2, 36) = 16.53$ (here and elsewhere a criterion of statistical significance of $p < .05$ was adopted). There were no differences between groups, $F(1, 18) < 1$; nor was the interaction between the variables significant, $F(2, 36) = 1.24$.

Group mean amounts of AX consumed during the generalization test trial are depicted in Fig. 1. It is apparent that animals in Group ALT consumed more than those in Group BLK. An ANOVA conducted on these data confirmed this difference between groups, $F(1, 18) = 4.81$.

Our results provide a clear demonstration that alternating exposure to two stimuli results in less generalization between them than blocked pre-exposure. The important finding is that in our experiment the pre-exposed stimuli were not two compounds of two flavors each with a unique flavor. In the present experiment, one of the two stimuli was a compound of two flavors, AX (saline-sucrose) and the other was a flavor of that compound, X (sucrose). Moreover, there were no significant differences in the course of acquisition of aversion to X during conditioning, which suggests that the observed difference in generalization to AX between the two alternating and the blocked conditions cannot be explained by a similar difference in the level of conditioning to X.

Experiment 1B

Prior to any discussion of the implications of these results, it may be prudent to replicate the findings of Experiment 1A. In Experiment 1B, a few variations were introduced with respect to the design and parameters employed in Experiment 1A. In order to demonstrate the generality of the effect, solutions A and X were counterbalanced. A subsidiary aim of this experiment was to obtain a more sensitive assessment of conditioning to X. The groups showed no significant differences during conditioning in Experiment 1A. However, the numerical difference observed in the test trial

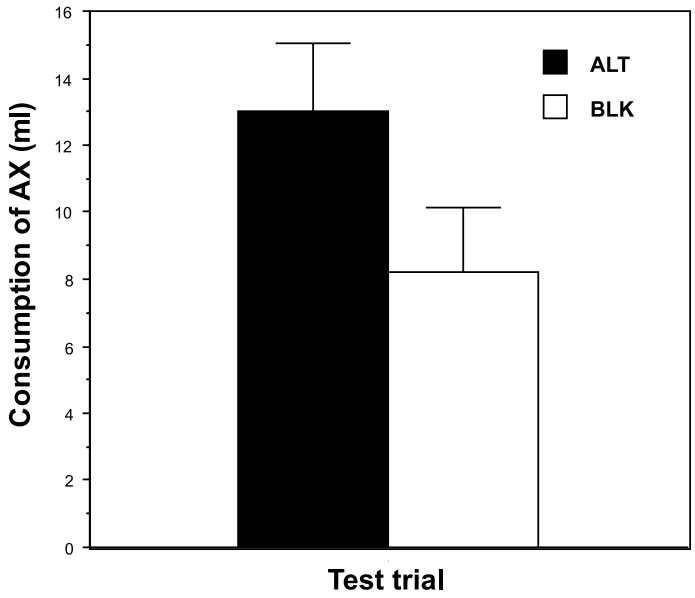

Fig. 1. Experiment 1A. Group mean consumption of AX in the generalization test trial. Group ALT had received alternating pre-exposure to flavors AX and X. Group BLK had received blocked pre-exposure. All subjects had received two reinforced trials and one non-reinforced trial with X. Error bars indicate standard error of the mean.

with X suggests that this flavor could have acquired less aversion in animals given alternating as opposed to blocked pre-exposure. It is possible that the difference between groups in their response to X may have become obscured in the conditioning trial carried out before the test by the fact that subjects received a fixed amount of X (10 ml). With the aim of obtaining a more sensitive test of the aversion acquired to X during conditioning, in the second conditioning trial of this experiment, similar to the subsequent test trial, the animals were given free access to X.

Method

Subjects and apparatus

The subjects were 48 experimentally naïve Wistar male rats with a mean ad libitum weight of 338 g (range: 300–372) at the start of the experiment. They were maintained in the same way as the animals used in Experiment 1A. The solutions were counterbalanced. For half the animals in each group, flavor A was 0.3% w/v saline and flavor X was 5% w/v sucrose. The remaining animals received the opposite arrangement.

Procedure

Rats were assigned to two equal-sized groups matched for their consumption of water. With the following exception, the procedure was exactly the same as that used in Experiment 1A.

Conditioning. During the second conditioning trial, the animals were given free access to X for 30 min prior to the injection (allowing a more sensitive assessment of the aversion established by the first trial than in Experiment 1A).

Results and discussion

The rats reliably consumed all the fluid offered during each pre-exposure trial. An aversion to X was readily established during the conditioning stage. Group mean amounts of solution X consumed during the two conditioning and the test trials were: for Group ALT, 8.9 ($SEM = 0.24$), 11.9 ($SEM = 0.64$), and 5.5 ($SEM = 0.75$) ml; for Group BLK, 8.3 ($SEM = 0.35$), 11.8 ($SEM = 0.37$), and 5.8 ml ($SEM = 0.6$). It is apparent that the two groups drank similar amounts of X. An ANOVA (group × solution × trial) revealed only a main effect of trial, $F(2, 88) = 62.81$. No difference was observed between groups as regards consumption, and there was no significant interaction between this factor and solution (sucrose or saline) or trial, Fs < 1.60. These results suggest that the alternating and blocked regimes of pre-exposure employed in this experiment generate equal levels of latent inhibition to X.

Consumption of AX during the generalization test is shown in Fig. 2. It is clear that animals in Group ALT drank more than those in Group BLK. An ANOVA (group × solution) conducted on these data confirmed this difference between

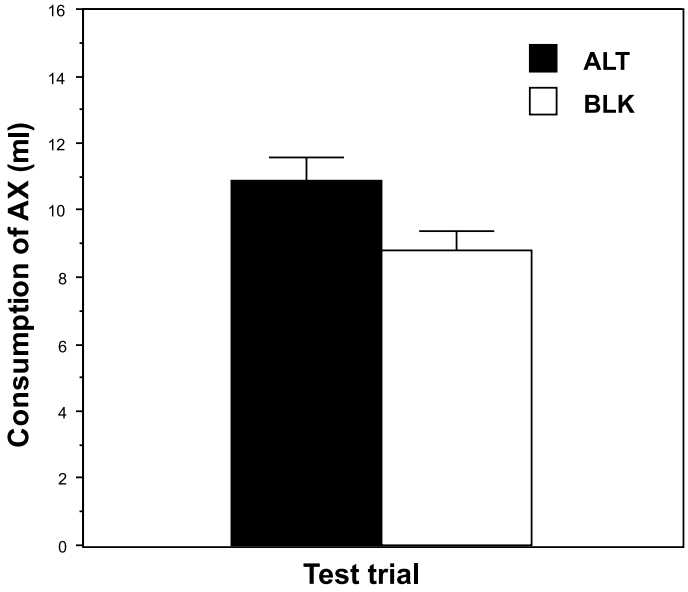

Fig. 2. Experiment 1B. Group mean consumption of AX in the generalization test trial. Group ALT had received alternating pre-exposure to flavors AX and X. Group BLK had received blocked pre-exposure. All subjects had received two reinforced trials and one non-reinforced trial with X. Error bars indicate standard error of the mean.

groups, $F(1,44) = 4.83$. No effect of solution was observed, nor was there any interaction between group and solution, Fs < 1.25.

These results confirm and extend those of Experiment 1A. Alternating pre-exposure to AX and X resulted in less generalization between the two flavors than blocked pre-exposure. Moreover, the absence of significant differences in the course of acquisition of aversion to X during conditioning suggests, similar to Experiment 1A, that the differential effect of the pre-exposure schedule cannot be explained by a similar difference in the level of conditioning to X.

Experiment 2

The purpose of Experiment 2 was to provide more direct evidence that it was not the latent inhibition to X that was responsible for the perceptual learning effect obtained. Thus, Experiment 2 included the two conditions from the previous experiments, Groups ALT and BLK. In addition, another group was included that received exposure to X alone (Group X). The aim was to assess the impact of latent inhibition to X on the generalization test in this latter group, and to compare this level of generalization with that resulting from the alternating and blocking pre-exposure to AX and X. If latent inhibition to X is not an important factor in producing the perceptual learning effect obtained in Experiments 1A and 1B, then Group ALT should show less generalization to AX than Groups X and BLK.

Method

Subjects and apparatus

The subjects were 24 experimentally naïve Wistar male rats with a mean ad libitum weight of 366 g (range: 308–399) at the start of the experiment. In this experiment, the solutions were not counterbalanced, given that no differences were found according to the solution employed in the previous experiment. As in Experiment 1A, flavor A was 0.3% w/v saline and flavor X was 5% w/v sucrose. All other conditions were the same as in the previous experiments.

Procedure

Rats were assigned to three equal-sized groups matched for their consumption of water. The procedure for Groups ALT and BLK was identical to that described in Experiment 1A, except that they received three conditioning trials (one more than in previous experiments with the aim of obtaining more sensitivity for detecting a possible difference between groups on latent inhibition to X) and that in the second and third of these trials, animals were given unrestricted access to sucrose (X). Group X received treatment identical to that received by these groups, except that subjects received eight presentations of X alone during the pre-exposure phase. All other details of the experimental procedure were as described in Experiment 1A.

Results and discussion

During the pre-exposure phase, the rats almost invariably consumed all 10 ml of the fluid offered during each trial. Consumption decreased over conditioning trials. Group mean amounts of sucrose (X) consumed during the three conditioning and the test trials were: for Group ALT, 9.9 ($SEM = 0.05$), 9.7 ($SEM = 0.17$), 6.1 ($SEM = 0.68$), and 1.8 ($SEM = 0.90$) ml; for Group BLK, 9.9 ($SEM = 0.11$), 9.1 ($SEM = 0.46$), 5.5 ($SEM = 1.04$), and 2.2 ($SEM = 1.20$) ml; for Group X, 9.8 ($SEM = 0.09$), 9.1 ($SEM = 0.46$), 3.4 ($SEM = 1.05$), and 1.1 ($SEM = 0.68$) ml. An ANOVA conducted on these data with group and trial as the factors revealed only a significant effect of trial, $F(3, 63) = 111.12$. Neither the effect of group, $F(2, 21) = 1.55$, nor the interaction of group × trial, $F(2, 36) = 1$, was significant.

Fig. 3 presents the group mean amounts of saline-sucrose (AX) consumed during the generalization test trial. It is evident that animals in Group ALT consumed more than those in Group BLK and Group X. An ANOVA conducted on these data confirmed that there was a significant difference among groups, $F(2, 21) = 4.23$. Pairwise comparisons between the groups (using the Newman–Keuls test) showed that Group ALT differed significantly from Groups BLK and X and that these latter groups did not differ significantly from one another.

These results confirm the findings of Experiments 1A and 1B. Alternating pre-exposure of AX and X enhances the ease with which these stimuli can be discriminated

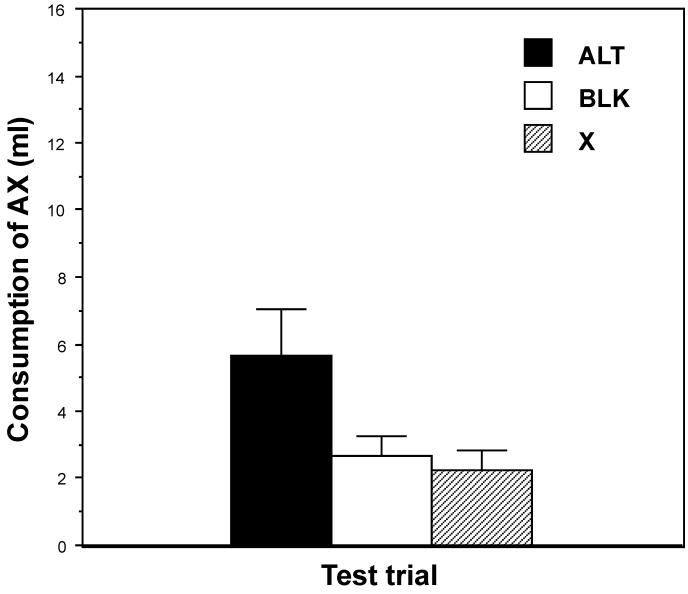

Fig. 3. Experiment 2. Group mean consumption of AX in the generalization test trial. Group ALT had received alternating pre-exposure to flavors AX and X. Group BLK had received blocked pre-exposure. Group X had received pre-exposure to flavor X. All subjects had received three reinforced trials and one non-reinforced trial with X. Error bars indicate standard error of the mean.

to a greater extent than blocked pre-exposure. Furthermore, these results suggest that latent inhibition to X is not an important factor producing this perceptual learning effect. The performance of Group X during the generalization test offers an assessment of the extent to which latent inhibition to X contributes to the reduction of the generalization between X and AX. Simply presenting AX and X in an alternating schedule, rather than in a blocked schedule, was sufficient to reduce generalization between these stimuli more than in Group X. These latter results support the suggestion that the significant factor producing this effect is the way in which the stimulus presentations are scheduled. However, it could be argued that the difference between Group ALT and Group X in their test performance might be explained in terms of differences in their degree of familiarity with the AX compound. The low level of test consumption shown by Group X would reflect a neophobic reaction to flavor A, encountered for the first time on the test. For animals in Group ALT, neophobia to A could become habituated during the four presentations of A in the pre-exposure trials with AX. On this hypothesis, therefore, neophobia would have been a critical factor contributing to the test performance of Group X. However, according to this assumption, Group X should also have shown less consumption of the test solution than Group BLK, which received the same amount of exposure to A as Group ALT. The absence of a reliable difference between Group X and Group BLK provides no evidence that a difference in the familiarity with A critically influenced subsequent generalization. Therefore, we do not believe that there are good reasons to suppose that the substantial difference between Group ALT and Group X might be attributed to neophobia in the latter group. Instead, the difference appears to reflect a decrease in generalization in Group ALT as a consequence of the pre-exposure schedule.

General discussion

Alternating pre-exposure to AX and X resulted in less generalization between the two flavors than blocked pre-exposure (Experiments 1A, 1B, and 2). Simply presenting AX and X in an alternating schedule, rather than in a blocked schedule, was sufficient to reduce generalization between these stimuli more than presenting X in isolation (Experiment 2). The demonstration of a perceptual learning effect under these conditions is not expected from the associative theory of perceptual learning proposed by McLaren et al. (1989). As outlined at the beginning of this paper, previous examples of perceptual learning have made use of a procedure in which two stimuli, each with a unique flavor, were employed. The inhibitory learning mechanism proposed by McLaren et al. (1989) can accommodate the results reported in these previous experiments but does not apply so well to the present experiments. According to this account, the reason why alternating pre-exposure reduces generalization is the development of the inhibitory associations between the unique features of the stimuli. The absence of a unique flavor in one of the two stimuli employed in our experiments would preclude the operation of this mechanism. Consequently, these results suggest that the inhibitory mechanism proposed by McLaren et al.

(1989) may not be the crucial (or at least the sole) process determining the different effects of alternating and blocked pre-exposure.

These results, however, are to be expected from the Gibsonian account outlined by Mondragón and Hall (2002; see also Hall, 2003). According to this account, alternating exposure to two similar stimuli (such as AX and X in our experiments) engages a learning process that enhances the perceptual effectiveness of the unique features (A) and reduces the effectiveness of features that the stimuli have in common (X). Any one of these changes in the effectiveness of the stimuli may be enough in itself to explain the perceptual learning effect found in our experiments.

If we assume that differences in the effectiveness of stimulus elements will be reflected in similar differences in the ease with which they are subsequently learned about (Mondragón & Hall, 2002), then in our experiments X should be learned about less readily after alternating than after blocked pre-exposure. The procedure employed in our experiments enabled an assessment of the effects of these two pre-exposure schedules on conditioning with X alone, and no differences were found in either of them. This absence of differences does not support an interpretation of our results in terms of a decrease in the effectiveness of X in alternating pre-exposure. Recently, Mondragón and Hall (2002; Experiment 2) have demonstrated that the common X element of two flavor compounds (AX and BX) acquired less aversion during conditioning in isolation after alternating than after blocked pre-exposure to AX and BX. Nevertheless, this difference was found by presenting X in extinction and not during the conditioning stage. It is therefore certainly plausible that in our experiments, similar to the experiment reported by Mondragón and Hall (2002; Experiment 2), conditioning was not a sensitive procedure to detect differences in the aversion acquired to X.

Nevertheless, an increase in the perceptual effectiveness of the unique flavor A in alternating conditioning may be enough in itself to explain our data. When animals were tested with AX, A would remain more perceptually dominant or salient, and therefore better able to disrupt the aversive properties acquired by X during conditioning in the alternating than in the blocked condition. Blair and Hall (2003) have recently provided evidence that supports this hypothesis. In two experiments, rats received pre-exposure trials with three compound flavor stimuli, AX, BX and CX. Presentations of AX and BX were given according to an alternating schedule, and presentations of CX were given in a separate block of trials. Rats were then conditioned with the common element of these compounds, X (Blair & Hall, 2003; Experiment 5a), or with a novel stimulus, Y (Blair & Hall, 2003; Experiment 5b), as the CS. Then, in both experiments, the conditioned flavor was compounded on a generalization test with the unique flavor of a compound pre-exposed in an alternating schedule (B) and with the unique flavor of the compound pre-exposed in a blocked schedule (C). The results of these experiments revealed a similar effect, a greater aversion to the compound containing C than to the compound containing B. This outcome is not predicted by the inhibitory mechanism proposed by McLaren et al. (1989). This mechanism requires that the unique A element should undergo conditioning. Thus, the test stimuli must be able to activate the representation of the conditioned element A in the test stage. Conditioning to X or Y alone in these experiments precludes the operation of this mechanism. Blair and Hall (2003) inter-

preted these results by suggesting that the more salient B (distinctive flavor of a compound pre-exposed in an alternating schedule) interfered with the perception of the conditioned flavor more effectively than the less salient C (distinctive flavor of the compound pre-exposed in a blocked schedule).

Moreover, if pre-exposure to a pair of similar stimuli in an alternating schedule results in an increase of the effectiveness or salience of the distinctive features of these two stimuli, then not only the ability of these features to overshadow an aversive stimulus, but also the rate at which further conditioning to them occurs should increase. Hall (2003; Experiment 4) tested this hypothesis in an experiment in which rats received pre-exposure to two compound flavors (AX and BX) and to the common element of these compounds (X). For all the animals, the pre-exposure arrangement consisted of a block of BX trials (a version of the blocked schedule in our experiments) and a set of trials in which AX and X were presented in alternation (thus very similar to the alternating schedule in our experiments). Animals then received reinforced trials, half with A as the CS and the remainder with B. If pre-exposure to AX in alternation with X results in an increase of the effectiveness or salience of A (distinctive flavor of these two stimuli) the rate at which further conditioning to A occurs should increase. Although differences were not observed over the course of the conditioning trials, subsequent extinction proceeded more rapidly in subjects conditioned to B than in those conditioned to A, suggesting that stronger aversion was acquired to A than to B during conditioning. Hall (2003) concluded that this is the result to be expected on the basis of the hypothesis that pre-exposure resulted in A (distinctive flavor of the compound AX, pre-exposed in an alternating schedule) having a higher level of salience than B (distinctive flavor of the compound BX, pre-exposed in a blocked schedule) (for a similar result using a between-subjects design during pre-exposure, see Mondragón & Hall, 2002; Experiment 4).

In summary, the present data are to be expected from the Gibsonian account outlined by Mondragón and Hall (2002) but are not expected from the associative theory proposed by McLaren et al. (1989). Although experimental results have provided broad evidence supporting the establishment of inhibitory associations between unique elements during alternating pre-exposure (e.g., Dwyer et al., 2001; Dwyer & Mackintosh, 2002), our results suggest that this mechanism may not be the sole cause in producing the differential effect between alternating and blocked pre-exposure.

The above discussion focused on the two theories that explain the perceptual learning effect from an elemental perspective. Nevertheless, the proposal that alternating stimulus presentation is an especially effective form of pre-exposure because it allows differentiation to occur is not incompatible with a configurational perspective. Exposure might have led AX to be perceived as a compound, forming a new flavor configuration different from the mere sum of its elemental flavors. Perhaps alternating trials with AX and X enhance the perceptual effectiveness of this compound configuration. This, admittedly speculative, view would explain why animals in the alternating schedule of our experiments would have processed AX as a stimulus clearly different from X, thus resulting in less generalization at the time of testing. Conversely, in the BLK condition, AX and X would be less discriminable, supporting the generalization of conditioning.

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