Acquired flavour preferences: Contextual control of adaptation-level effects

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Short article

Acquired flavour preferences: Contextual control of adaptation-level effects

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This experiment investigated the role of context in the expression of conditioned flavour preferences. Rats were trained on a mixture of almond and sucrose and were then given intermixed exposures to almond in one context (Context A) and to sucrose in a second context (Context S). Finally, choice tests were given in both contexts, with one group given almond-versus-water tests and the other almond + sucrose-versus-sucrose tests. Preference for almond over water was greater in Context A than in Context S. Conversely, preference for almond + sucrose over sucrose was greater in Context S than in Context A. These results suggest that the perceived sweetness of a flavour depends on the context in which it is presented and confirm that expression of a flavour preference depends on the type of test employed.

Keywords: Adaptation level; Conditioned flavour preference; Context; Rats.

A variety of procedures can result in animals acquiring a preference for a flavour (Sclafani, 1991). One of the simplest is to provide a thirsty rat with access to a sucrose solution that contains a flavour such as almond (A). Acquisition of a preference for almond alone is usually then assessed by giving the rat a two-bottle choice between almond and water (A-vs.-W). Although the procedure is simple, the properties of such acquired preferences are relatively complex. Like flavour preferences produced by other procedures (e.g., Drucker, Ackroff, & Sclafani, 1994), those resulting from exposure to a flavour–sucrose mixture can be remarkably resistant to extinction, at least as measured in a flavour-versus-water test (e.g., Albertella & Boakes, 2006; Harris, Shand, Carroll, & Westbrook, 2004). However, when a somewhat different test is used, one that pits sucrose solution to which the target flavour has been added against unflavoured sucrose—for example, almond + sucrose against sucrose alone (AS-vs.-S), repeated exposure to almond can reduce preference for the almond mixture. Conversely, postacquisition exposure to sucrose can reduce preference for A over W, but leave preference for AS over S unchanged (Boakes, Albertella, & Harris, 2007).

We have proposed that this double dissociation between postacquisition treatment (almond...
exposure vs. sucrose exposure) and type of test results from a shift in adaptation level, whereby a rat’s recent experience of sweetness sets the level for its subsequent sensitivity to sweetness. Thus, repeated exposure to almond allows the rat to adapt to low levels of sweetness, with the result that it can discriminate between water and the low level of perceived (conditioned) sweetness of A, but not between the high levels of sweetness of both almond + sucrose and sucrose alone. As a consequence, repeated exposure to almond will fail to reveal any apparent extinction effect, if an A-vs.-W test is given, but will result in such an effect if an AS-vs.-S test is given. On the other hand, repeated exposure to sucrose allows the rats to adapt to high levels of sweetness so that they now discriminate between A and A + S but have become insensitive to the low level of sweetness of A alone and no longer show a preference for this flavour over water (Boakes et al., 2007).

The above results were obtained under conditions in which the rats were group housed in a colony room and received daily sessions in individual drinking chambers in a separate laboratory. While in their home cages they had free access to food and restricted access to water a short time after returning from a daily session. It was possible that the rats’ adaptation level was specific to their experience in the drinking chambers and may have been little affected by what they consumed in their home cages. A long-term adaptation level effect in humans similarly suggests that these effects can depend on associations with specific cues. Vollmecke (1987) reported that participants' sweetness ratings for a range of sucrose concentrations presented in a distinctively coloured solution were lower if they had been given a range of stronger concentrations in the same coloured drinks a week or so earlier. Presumably her participants had experienced a range of sweetmesses in different foods and drinks in different settings during the period between the two tests.

The present experiment was designed as a direct test of the context dependency of adaptation level effects in the expression of learned flavour preferences in rats. It used a $2 \times (2)$ factorial design in which, following training on an almond-sucrose mixture in Context T, the rats were given repeated exposure to almond in Context A intermixed with repeated exposure to sucrose in Context S. They were then split into two groups, one group given A-vs.-W tests and the other given AS-vs.-S tests. The rats were given the tests in both contexts, so that Context A versus Context S was a within-subject factor. To the extent that adaptation level effects depend on the context, from our previous results we predicted that rats given the A-vs.-W tests would show a preference for A over W in Context A but not in Context S, while rats given the AS-vs.-S tests would show a preference for AS over S in Context S but not in Context A.

**Method**

**Subjects**

A total of 32 experimentally naïve, male hooded Wistar rats were obtained from the School of Psychology breeding programme at the University of Sydney. They were approximately 130 days old, with a mean body weight of 200 g (range, 190–350 g) at the start of the experiment. Rats were housed in squads of 8 in large opaque plastic cages, $60 \times 37 \times 26$ cm high, in a colony room maintained on a fixed 12:12-hr light–dark cycle, with lights on at 0730. Each rat was handled for 3–5 min each day for 3 days before the start of the experiment. Food was continuously available in the raised wire-mesh lids but fluid access was restricted, as follows. Daily access to water in the colony room was progressively reduced from 4 hr to 30 min over a period of 4 days prior to the start of the experiment. Thereafter, supplementary water was provided for 30 min, starting 30 min after each squad was returned to the colony room. The rats were weighed at least twice per week to check against unanticipated weight loss. The experimental procedures were approved by the Animal Care and Ethics Committee of the University of Sydney and adhered to the ethical guidelines established by the American Psychological Association. Daily sessions were given during the early part of light cycle, approximately 0900–1100.
Apparatus and solutions
Three types of drinking contexts were used. The first was used only for the initial training stage for all rats (Context T). It consisted of a set of eight plastic buckets, 38 cm high and of circular cross section with a diameter of 20 cm. The outside of each bucket was fitted with a metal clasp into which an inverted 200-ml plastic bottle could be fitted with a bent stainless-steel ball-bearing spout protruding into the bucket. Shredded newspaper covered the floors of each bucket, and this was changed after every drinking session. The second drinking context, referred to as the wooden chambers, consisted of four wooden rectangular boxes, each box divided into two equal-sized compartments, $29 \times 29 \times 29$ cm high, with one painted black and the other white. The floor of each compartment was covered with cat litter. The third context consisted of a set of eight clear acrylic cages, $33 \times 21 \times 18$ cm high, which were fitted with steel wire lids and their floors covered with wood shavings. In both the wooden and acrylic chambers experimental fluids were presented in 200-ml plastic bottles fitted with straight stainless-steel ball-bearing spouts. The three solutions were made up with tap water and consisted of a 1% vol/vol imitation almond essence (Aeroplane, Sydney), an 8% wt/vol sucrose solution (SRC Queensland), and an almond (1%) plus sucrose (8%) mixture. All three drinking contexts were located in the same laboratory, which was air-conditioned and maintained under natural lighting conditions.

Procedure
Rats were assigned to two weight-matched groups ($n = 16$). Throughout the experiment daily sessions lasted 10 min and consisted of giving rats access to a single drinking bottle, except where specified below. Across 4 days of pretraining rats were given water in the buckets. During the training phase (Days 1–4), also carried out in the buckets (Context T), all rats were given the almond–sucrose mixture each day. In the following phase (Days 5–16) all rats received in double alternating sequence six exposures to sucrose in one context (Context S) and six exposures to almond in the other context (Context A). Contexts were counterbalanced across groups such that for half the rats in each group, the acrylic chambers served as Context S, and the wooden boxes served as Context A; for the remainder the wooden boxes served as Context S, and the acrylic chambers served as Context A.

Four 2-bottle tests were given on Days 17–20. One group was given a choice between A and W on each of these days, and for the other the choice was between AS and S. Each group was tested in both Context S and Context A in a double alternation sequence that was counterbalanced within each group. For example, half the rats in the A-vs.-W group were tested on Day 17 in Context A with almond in the left bottle and water in the right bottle, on Day 18 they were tested in Context S with almond on the left and water on the right, on Day 19 they were again tested in Context S but this time almond was on the right and water on the left, and finally on Day 20 they were tested in Context A with almond on the right and water on the left.

Results
As shown in the top left panel of Figure 1, over the four test days the A-vs.-W rats drank more almond than water when in the context where they had previously been given almond, but less almond than water in the context in which they had previously been given sucrose. Conversely, the AS-vs.-S rats drank less almond-flavoured sucrose than unflavoured sucrose when in the almond context, but more almond-flavoured sucrose than unflavoured sucrose when in the sucrose context, as shown in the top right panel. Preference scores were calculated from the total amount of almond-containing solution over two tests of the same kind (one with almond on the left and the other with almond on the right) divided by the total fluid intake over these two sessions and converted into the percentages shown in the bottom panel of Figure 1. In a repeated measures $2 \times (2)$ analysis of variance (ANOVA) applied to these preferences there was neither a
main effect of group nor one of context, both Fs < 1, but there was a significant interaction between these factors, $F(1, 32) = 32.23$, $p < .001$. Subsequent repeated measure $t$ tests to investigate the source of this interaction confirmed that in group A-vs.-W almond preference was greater in Context A than in Context S, $t(15) = 2.50$, $p < .025$, and in Group AS-vs.-S preference for almond–sucrose over sucrose was greater in Context S than in Context A, $t(15) = 4.37$, $p < .001$. Note that these $t$ tests confirm that, in terms of the intakes shown in the top two panels, the interactions between type of solution and context were significant for both groups.

**Discussion**

These results confirm the double dissociation between type of test and postconditioning treatment previously obtained within a single context: Repeated exposure to almond reduced preference as expressed in an AS-vs.-S test, but not as expressed in an A-vs.-W test, whereas repeated exposure to sucrose produced the opposite pattern of results (Boakes et al., 2007). The new finding is that the effects of postconditioning treatment are specific to the context in which that treatment is given. Thus, this experiment lends further support to the proposal that prompted the present experiment, as described in the Introduction—namely, that expression of a sucrose-conditioned flavour preference depends on the extent to which the flavour is perceived as sweet and that this depends on the sweetness adaptation level controlled by the context.

There is another possible explanation for the double dissociation found previously within a single context, and it is of interest to examine how well it fares in the light of the present data. This “dual associations” explanation is based on a number of assumptions. The first is that experience by a thirsty rat of an almond–sucrose mixture promotes at least two kinds of association: One between almond and a stimulus-independent hedonic reaction, and the other between almond and sweetness. The second is that the A-vs.-W test is mainly sensitive to the strength of the almond–hedonic association, whereas the AS-vs.-S test is mainly sensitive to the almond–sweetness association. The third is that exposure to almond weakens the almond–sweetness association much more than it does the almond–hedonic association, whereas exposure to sucrose weakens the almond–hedonic association but not the almond–sweetness association. The present results are consistent with this alternative account, so long as one makes the further, and reasonable, assumption that “weakening” of an association results from inhibitory learning that is
context dependent (cf. Bouton, 1993; Harris, Jones, Bailey, & Westbrook, 2000).

Although the dual-association account can be made to fit the present results, it has difficulty explaining one previous finding. This was in a group that was first given postconditioning exposure to sucrose that reduced its sucrose-based preference for almond in an A-vs.-W test and that was then given exposure to almond prior to a further A-vs.-W test. The latter revealed that almond preference was now restored to its previous level, a result entirely consistent with the adaptation level account but difficult to explain in terms of the dual-association account (Boakes et al., 2007; Exp. 2).

Further evidence for or against the two accounts requires comparisons with procedures for producing flavour preferences that do not involve mixing with sucrose. For the present, we believe that the adaptation level explanation provides a better overall account for this complex set of results. Thus, casually speaking, in relation to the A-vs.-W test, if the context leads the rat to expect a moderate level of sweetness, then the conditioned sweetness of a flavour may be relatively so weak as to make it indistinguishable from that of water, whereas in a context in which a low intensity or no sweetness is expected the same conditioned sweetness will be detectable and give it stronger hedonic value than water. In relation to the AS-vs.-S test, however, in a context producing an expectancy of a moderate level of sweetness the aggregated sweetness of almond and of sucrose will be discriminably greater than the sweetness of sucrose alone, whereas in a context producing expectancy of a low level of sweetness—and hence producing high sensitivity to sweetness—due to a ceiling effect the difference between the sweetness of AS and S will no longer be discriminable.

Whatever theory turns out to be correct, the present results point to the following conclusions with respect to flavour preference learning. First, a posttraining treatment—such as “extinction” or “US-postexposure” (where US is the unconditioned stimulus)—applied within the training context is likely to change the value of this context, in the sense of signalling a decrease or increase in the likelihood of a US such as sucrose, but have little impact on the underlying preference. Second, the new value of the context will have a marked effect on how the preference is expressed.

REFERENCES


