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INFLUENCE OF TASTE AND COLOR CUES ON BATHING BY STARLINGS IN APPETITIVE AND ADVERSIVE CONTEXTS: IMPLICATIONS FOR ANIMAL DAMAGE CONTROL

J. Russell Mason
Monell Chemical Senses Center

Russell F. Reidinger
Monell Chemical Senses Center and Denver Wildlife Research Center

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J. Russell Mason
Monell Chemical Senses Center
Philadelphia, Pennsylvania
and
Russell F. Reidinger
Monell Chemical Senses Center and
Denver Wildlife Research Center
U.S. Fish and Wildlife Service
Lakewood, Colorado

ABSTRACT

The importance of color and taste in feeding and drinking by omnivorous birds is context-dependent and influenced by learning. Here, we report three experiments designed to assess the influence of such characteristics on starlings. In Experiment 1, eight starlings were given a choice between bathing in red or plain water and 0.15 M NaCl solution or plain water. The frequencies of bathing, drinking, and preening were recorded. Red water was avoided ($p < 0.05$), but no preferences were observed between NaCl solution and plain water ($p > 0.25$). That 0.15 M NaCl was not avoided is surprising, because it is rejected by starlings when drinking. Perhaps starlings do not taste substances while bathing but continue to ingest substances that they would otherwise reject.

In Experiment 2, we assessed these alternative explanations and also tested (a) whether starlings would bathe in colored water if plain water was unavailable, (b) whether starlings would show preferences among such colors, and (c) whether preferences could be altered by learning. Twenty-four starlings were assigned to three conditions. Birds in the first condition were presented with red and blue baths and relative preferences for bathing in these colors were assessed. Birds in the second condition were presented with a blue bath and intubated with methiocarb or propylene glycol. Birds in the third condition were presented with a saccharin bath and intubated with methiocarb or propylene glycol. On the four days following treatment, birds in the second condition were given two-choice tests between red and blue baths. Those in the third condition were given two-choice tests between bathing in saccharin solution and plain water. Birds readily bathed in red and blue water when plain water was unavailable. After treatment, however, birds avoided blue water ($p < 0.05$), but aversions dissipated rapidly. Learned aversions for saccharin were also obtained ($p < 0.05$); these remained strong over all tests.

Experiment 3 was designed to assess the differential importance of taste and color. Sixteen starlings were assigned to four groups. Two groups were food-deprived and then given dogfood in a red cup followed by a bath of 0.15 M NaCl or LiCl. The other two

groups were presented with a bath of 0.15 M NaCl or LiCl only, as a control. On the four days immediately following treatment, all groups were given two-choice feeding (red vs. blue food cups) and bathing (NaCl vs. plain water) tests. Aversions were expressed towards color in the feeding context ($p < 0.05$) but not taste in the bathing context ($p > 0.25$). We inferred that color cues in the feeding context overshadowed taste cues in the bathing context.

The present results may have implications for control. Starlings will bathe even under harsh environmental conditions, and one control strategy might be to pair livestock feed with distinctive colors and provide lithium-adulterated bathing stations nearby. Starlings eating feed and bathing in the solution might form color aversions and subsequently avoid the food. Also, the use of such techniques might enhance already existing control, such as the use of starlicide baits. Depredating starlings would be directed toward such baits as birds feeding in the laboratory are directed towards food color combinations not explicitly paired with lithium-induced malaise.

INTRODUCTION

Accounts of bathing by land birds usually describe casual observations of bathing (Pozanin, 1957; Strautman, 1958) or bathing techniques (Simmons, 1964). Few reports analyze bathing behavior in terms of functionally significant components (Borchelt, 1973, 1975; Borchelt and Duncan, 1974; Kniprath, 1969; Slessers, 1970); and, to our knowledge, no attention has been paid to sensory characteristics of the bath that could influence bathing. Here, we report the results of three experiments designed to assess the influence of such characteristics on male starlings (*Sturnus vulgaris*).

In the first experiment, the starlings were given a choice between bathing in colored and plain water or flavored and plain water. Our aim was to uncover whether starlings would attend to the color and/or flavor of the bath without prior training. Evidence collected in studies of feeding and drinking by omnivorous birds such as starlings suggested that the importance of color and taste might be context dependent and influenced by learning (e.g., Lett, 1980; Westbrooke et al, 1980; Martin and Bellingham, 1979).

EXPERIMENT 1

Methods

The subjects were eight male starlings, decoy-trapped in Syracuse, New York during March 1980. The birds were individually housed (cage dimensions: 61 cm x 36 cm x 41 cm) and visually isolated in a room with an ambient temperature of 23ºC. The birds were permitted free access to apples and bird chow (Purina Flight Bird Conditioner).

Each starling was presented with two plastic tubs (28 cm x 17 cm x 12 cm) for 15 minutes on each of eight successive days between 1400 and 1600 hours. The tubs contained either (a) 500 ml of tapwater or 0.15 M sodium chloride solution, or (b) 500 ml tapwater or tapwater mixed with 0.1 ml red food coloring (McCormick Foods). Sodium chloride and red were chosen as stimuli, because both are readily avoided in drinking or feeding contexts (Kare, 1962; Mason and Reidinger, 1983). During the 15-minute period, the frequency and duration of bathing, drinking, and preening by each bird in each bath was recorded by two observers whose inter-rater reliability exceeded 0.95. After each period, the tubs were removed from the cages. The position of the tubs and the order of testing within and across days were completely counterbalanced.

Results and Discussion

The data from each observation period were converted into ratios of the frequency (or duration) of bathing, drinking, or preening in flavored or colored water versus the frequency (or duration) of these behaviors in tapwater and treated water combined. Two-way repeated measures analyses of variance were used to assess the ratios. One factor in each of the six analyses was flavored versus colored water ratios, and the other was successive tests. The birds preened more frequently and for longer periods of time when presented with sodium chloride than when presented with coloring (F (1,18) = 4.9, 5.2, $ps < 0.05$), although preening became more frequent and of longer duration over days regardless of the solutions presented (F (3,18) = 13.1, 10.9, $ps < 0.05$). There were also significant differences in drinking (F (4,24) = 25.9, $p < 0.01$) and bathing (F (4,24) = 3.93, $p < 0.05$), and Bonferroni tests (Games, 1971) were used to isolate significant differences among means. Given a choice between plain and red water, birds preferred to drink and bathe in plain water ($p < 0.05$). Such bathing increased over days ($p < 0.05$). Given sodium chloride, the birds showed no such differential drinking or bathing behavior (Figure 1).

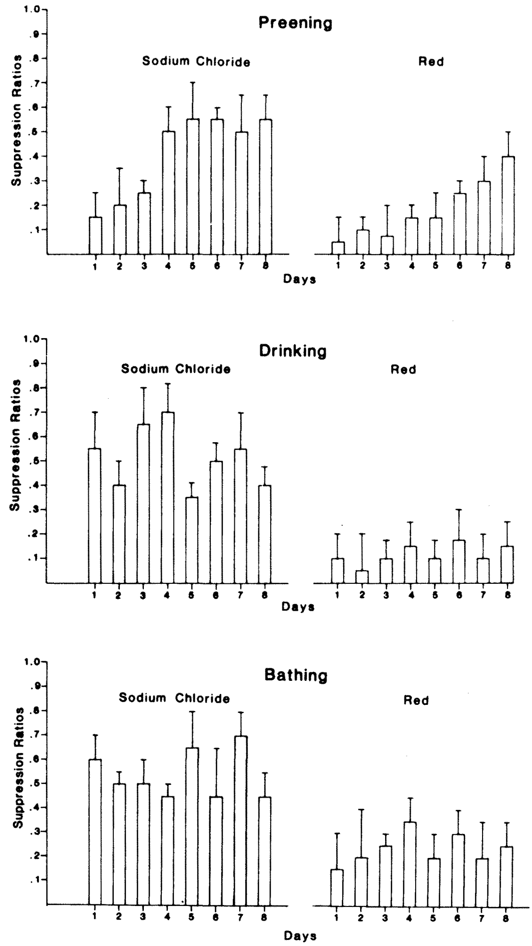

FIGURE 1. Mean suppression ratios of the frequency of preening, drinking, or bathing in flavored or colored water. Ratios were formed by dividing the frequency of behavior in flavored or colored water by the total frequency of behavior in both treated and plain water. The durations of bouts are not represented, since they merely reflected bout frequencies. Capped bars represent standard errors of the means.

The results suggest that starlings detect both color and taste while bathing and show avoidance of red water without prior training. Such an interpretation is consistent with the finding that ducks are reluctant to cross red or orange water to reach food (Lipius et al., 1980). A surprising result was that the birds showed no drinking or bathing preferences between tapwater and 0.15 M sodium chloride solution. Sodium chloride at that concentration in a drinking context is avoided by starlings (Mason and Reidinger, unpublished observations) and other birds (Bartholomew and Cade, 1958; Bartholomew and MacMillan, 1960; Hanrum, 1953; Kare and Pick, 1962). One possible explanation for the result is that the starlings ingest substances in the bathing context that they would otherwise reject. That would be roughly analogous to the observation that rats groom tastants from their fur that they would not ingest in feeding or drinking contexts (Reidinger et al., 1982; Pank, pers. comm.). Experiment 2 was designed to assess these alternative explanations and to test (a) whether starlings would bathe in colored water if plain water was unavailable, (b) whether they would show preferences between such colors, and (c) whether such preferences, if any, could be altered by an aversive bathing experience.

EXPERIMENT 2

Methods

The subjects were 24 adult male starlings, trapped and housed in our laboratory as previously described. The birds were visually isolated and then randomly assigned to one of three treatment conditions (eight birds/condition). The birds assigned to the first treatment condition were tested before those in the other conditions to assess for preferences between bathing in red or blue water.

The birds assigned to the first condition were presented with two baths, one red and the other blue. Such presentations occurred between 1400-1600 hours on each of four days. The frequency and duration of bathing in each bath was recorded during successive 15-minute observation periods, as described in Experiment 1. Drinking and preening were also recorded but are not reported here, as those measures merely reflected bathing, as in Experiment 1.

The birds assigned to the second condition were randomly divided into two groups. One group was presented with a blue bath followed by intubation with methiocarb (2 mg/kg), a bird repellent that reliably produces conditioned aversions similar to those produced by lithium chloride (Mason and Reidinger, 1983). The other group also was presented with a blue bath, but bathing was followed by intubation with propylene glycol, as a control. On each of the four days immediately following the day of treatment, all of the birds in the second treatment were given two-choice tests between red and blue baths (Dragoin et al., 1970); and the frequency and duration of bathing in each bath was recorded during 15-minute observation periods between 1400 - 1600 hours.

The birds assigned to the third condition were also randomly divided into two groups. One group was presented with a saccharin bath followed by an intubation of methiocarb, while the other was given a saccharin bath followed by an intubation of propylene glycol. On each of the four days following that of intubation, both groups were given 15-minute two-choice tests between saccharin and plain water baths. The frequency and duration of bathing was recorded for each bird.

Results and Discussion

Data from the birds in the first condition were assessed separately, using two-way repeated factor analyses of variance (ANOVAs). One factor in each analysis was the frequency or duration of behavior (i.e., bathing, drinking, or preening) and the other was the frequency or duration of behavior exhibited during successive two-choice tests. All birds in the first condition bathed readily in both baths. There was no difference in latency to bathe, nor in the frequency and duration of bathing, drinking, or preening in relation to each bath ($ps > 0.25$). As such, while birds will avoid bathing in colored water if given plain water, they will readily bathe in it given no choice. These results stand in contrast to those obtained from the birds in the other conditions.

For birds in the other two conditions, ratios were formed as in Experiment 1, and these ratios were assessed using three-way ANOVAs with repeated measures on two factors. The independent factor in these analyses was groups (methiocarb versus propylene glycol intubation), while the two repeated factors were identical to those described above. In each condition, there were differences between groups ($F\,(1,7) = 12.4$, $p < 0.05$), and, within groups, among successive tests ($F\,(1,6) = 9.6$, $p < 0.05$). Also, for both conditions, bath choices were influenced by group assignment ($F\,(1,6) = 10.1$, $p < 0.05$). Tukey *b* tests (Winer, 1962) were used to isolate significant differences among means. Birds intubated with propylene glycol bathed more often than birds intubated with methiocarb ($p < 0.05$) but showed no preferences between red and blue water, or saccharin and plain water (*p*s > 0.25). Conversely for birds intubated with methiocarb, blue or saccharin water was avoided (*p*s < 0.05).

For birds given tests with colored water, the aversion effect was strongest during the first two tests and had virtually disappeared by the fourth test. For birds tested with flavored water, strong aversions were observed during all preference tests (Figure 2). We took the results to indicate that birds could learn to avoid colored or flavored baths but that avoidance learning to flavor was stronger than that to color. This interpretation is consistent with findings that pigeons and chickens are more likely to associate sickness with color when feeding and taste when drinking. Experiment 3 was designed to assess the differential importance of color and taste.

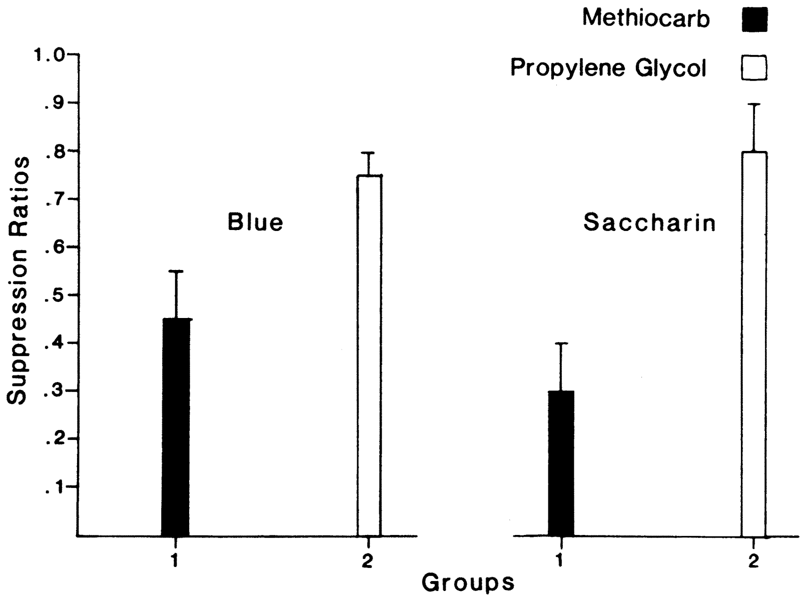

FIGURE 2. Mean suppression ratios of the frequency of bathing in colored or flavored water after intubations with methiocarb or propylene glycol. Capped bars represent standard errors of the means.

EXPERIMENT 3

Methods

The subjects were 16 male starlings trapped and adapted to our laboratory as previously described. The birds were visually isolated and randomly assigned to four groups ($n = 4$). On the next day, the birds in two groups were food-deprived for 30 minutes and then presented with 20 g of horsemeat dogfood in red food cups (7.5 cm diameter) for 15 minutes. When each bird had consumed at least 2 g of dogfood, the food cups were removed from the cages and a single plastic tub containing either 0.15 M lithium chloride (Group 1) or 0.15 M sodium chloride (Group 2) was placed in each cage. Birds in Groups 3 and 4 were only given a tub containing 0.15 M lithium chloride or sodium chloride, respectively (i.e., these birds were not first presented with dogfood). The frequency and duration of bathing was recorded for each bird. Two of the birds given 0.15 M lithium chloride showed typical symptoms of toxicant-induced malaise (e.g., bill-wiping), but the others did not. On each of the four days immediately following the day of experimental treatments, all of the birds were food-deprived for 30 minutes and then presented with two-choice feeding and bathing tests (Dragoin et al., 1971). During these tests, the birds were first presented with red and blue food cups, each containing 20 g of dogfood. After 15 minutes, the food cups were removed from the cages, and consumption was measured. Thirty minutes after the end of the feeding trial, during successive 15-minute periods over the next 2.5 hours, each bird was presented with two plastic tubs, one containing tapwater and the other containing 0.15 M sodium chloride. The frequency and duration of bathing in each bath was recorded for each bird. As in Experiment 2, drinking and preening were recorded but are not reported here.

Results and Discussion

Separate three-way analyses of variance with repeated measures on two variables were used to assess differential consumption and bathing. For analysis of consumption, the independent factor was groups; and the repeated factors were (a) consumption from the red versus the blue food dish and (b) changes in consumption among the four preference tests. For analyses of bathing, the independent variable was groups; the repeated variables were (a) the frequency and duration of bathing in water versus sodium chloride, and (b) changes in the frequency and duration of bathing among the four preference tests.

There was a significant interaction between groups and consumption from red or blue food cups ($F(1,8) = 6.5$ $p < 0.05$), but no overall differences between groups or among the four preference tests in the amount of food consumed (*p*s > 0.25). Bonferroni post-hoc t-tests (Games, 1971) indicated that the birds in Group 1 ate less from the red than the blue food cups ($p < 0.05$). The birds in the other groups exhibited no such differential consumption ($p > 0.25$). The analyses of bathing behavior indicated no significant differences between groups in the frequency and duration of bathing ($p > 0.25$) (Figure 3).

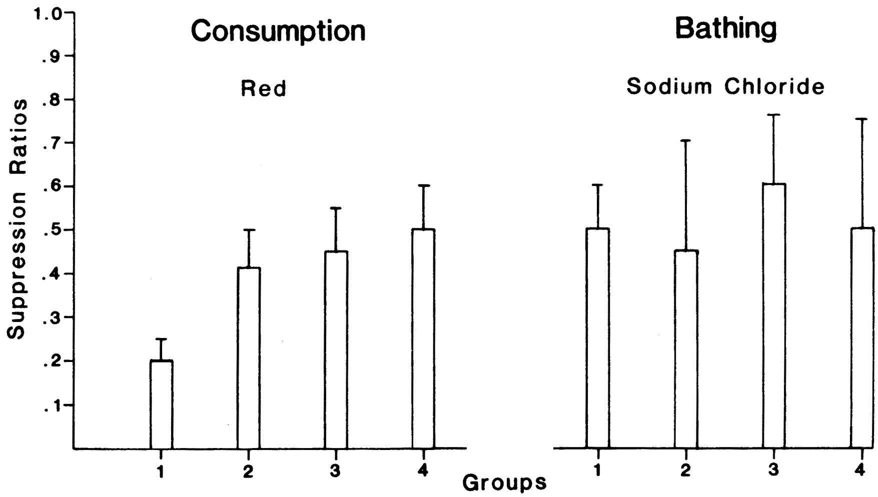

FIGURE 3. (Left) Mean suppression ratios of consumption from red food cups (i.e., consumption from red cups/total consumption). (Right) Mean suppression ratios of the frequency of bathing in sodium chloride solution (i.e., bathing in sodium chloride/total bathing). Capped bars represent standard errors of the means.

The results suggest that the starlings formed conditioned aversions towards color (red) in the feeding context but not toward taste (sodium chloride) in the bathing context. Such findings are inconsistent with the speculation that visual cues are less potent than gustatory cues in aversion learning (e.g., Czaplicki et al., 1976). Instead, the findings support the notion of color primacy in food aversion learning by starlings (Schuler, 1980).

Because 0.15 M sodium chloride is rejected by starlings (Mason and Reidinger, unpublished observations) and other birds (Bartholomew and Cade, 1958; Bartholomew and MacMillan, 1960, 1961; Hanrum, 1953; Kare and Pick, 1962) in two-choice drinking tests, we believe that the birds were able to detect the salt while bathing. Because there is reason to suspect that sodium and lithium chloride taste alike (Nachman et al., 1977), we also believe that the starlings tasted the lithium chloride and infer that if aversions had been formed to the taste of the lithium, aversions would have generalized and been expressed to sodium chloride. As such, the results support the possibility that taste cues in the bathing context were overshadowed (Westbrooke et al., 1980) by color cues in the feeding context, although taste aversions might have been expressed in the absence of explicit color cues, as in Experiment 2.

GENERAL DISCUSSION

Overall, the present results suggest that starlings attend to both visual and taste cues when bathing and that they show unlearned preferences among such cues. Moreover, the use of color and taste cues seems to be context specific and influenced by learning. When taste and color cues are confounded, as in Experiment 3, color overshadows taste, perhaps because color was appropriately presented (i.e., in a feeding context), while taste cues were inappropriately presented (i.e., in a bathing context).

While cautious about extrapolating from the laboratory to the field, we speculate that the present results may have significance for bird control. Extensive use of cattle feedlots by starlings during fall and winter months often results in meaningful economic loss to feedlot operators (Besser et al., 1968; Dolbeer et al., 1978; Levingston, 1967; Palmer, 1976). Toxicants (e.g., starlicide) are now used for control of depredating birds, but their use creates hazards both to livestock and non-target avian species. Because starlings will bathe under even harsh environmental conditions (Guarino, personal communication), an alternative strategy might be to paint or otherwise associate cattle food bunkers with a distinctive color and provide bathing stations available to depredating birds but not livestock. Possibly, starlings feeding from the bunkers and bathing in the stations would form color aversions and subsequently avoid food bunkers. Induction of such aversions could provide a relatively safe and selective form of damage control, since the lithium would be confined to small stations and not spread in or near feed troughs. If successful, the use of such a technique could enhance already existing means of control, such as the use of starlicide baits. Conceivably, feeding by starlings would be directed toward such baits as feeding in the laboratory is directed towards food-color combinations not explicitly paired with lithium-induced malaise.

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