Illness-Induced Aversions in Rat and Quail: Relative Salience of Visual and Gustatory Cues

Abstract. Blue-white quail, like the rat, learn in one trial to avoid flavored water when illness is induced by a drug. Half hour after drinking. To contrast to rat, quail also learn to avoid water that is merely darkened by vegetable dye. The visual cue is even more salient than the taste cue in quail.

Earlier work on illness-induced aversions showed that eating and drinking showed rather clearly that the rat, at least, must have either a gustatory or an olfactory cue in order to learn to avoid ingesting a substance if the illness that follows ingestion is delayed by 1 hour or more. Visual, auditory, and tactile cues, even though, consistently present at the time of ingestion, do not become danger signals for the rat in such circumstances (1). On the other hand, blue and yellow crows (Corvus corone cornix) readily learn to reject toxic fruits such as butterflies (Danaus plexippus L., sub-family Danainae) on sight, although the model suggested for this learning gives semantic reinforcement of 'sick during illness a prominent, mediating role (2).

Impetus for our experiments came from the general view that the behavior of an organism, including what it can and cannot readily learn, is largely a product of its evolutionary history. In view of the rat's highly developed alimentary senses, nocturnal feeding habits and relatively poor vision, its ability to learn to avoid acute substances on the basis of their taste or smell, rather than their appearance, is not surprising. But how general is this phenomenon? In the present study we test the hypothesis that, in situations involving long delay between the time of ingestion of some food and the onset of illness, can learn to avoid ingesting substances that are distinguishable in appearance only.

We report here two experiments which show that blue-white quail (Coturnix japonica) can associate a purely visual cue with a long-delayed, illness consequence. In the first experiment we investigated the relative salience of a visual cue and a gustatory cue in both rat and quail. In the second experiment, in which we used quail only, we controlled for two variables which, unless accounted for, might have allowed clear-cut interpretation of the first experiment.

Forty 90-day-old male Sprague-Dawley rats and 40 adult male bobwhite quail were the subjects in the first experiment. All were caged individually and had free access to food throughout the experiment. At the start, both species were transferred over a period of several days to drink all of their daily raw water from 10 ml pioneer bottles. Water was presented at the same time each day, and the time allowed for drinking was gradually reduced to a 10-minute period. Baseline drinking was then measured for 1 week, after which experimental treatments were imposed.

On treatment day, subgroups of eight species received an initial 10-minute exposure to water that was either dark blue (N = 8), and (N = 8), or both blue and sour (N = 24). Water was made less palatable by the addition of 3g of vegetable food coloring to 100 ml of water. Sour water consisted of a weak hydrochloric acid solution (0.5 ml per liter). One-half hour after removal of the distinction fluid all subjects were injected intraperitoneally with the illness-inducing agent, cyclophosphamide. The dosage for the rats was 60 mg/kg, a dosage known to be effective for establishing one-trial aversions to distinctive tastes in the rat. We used a much lower dose (1.5 mg/kg in quail), however, because exploratory use of the drug with the birds showed that the larger dose was necessary in order to produce the primary symptom of illness that rats experience, namely, extensive diarrhea.

For 2 days after treatment all subjects drank plain water at the regular (20-minute) daily drinking period. This allowed time to recover from the illness, as judged by remission of diarrhea and a return to baseline amounts of water consumption. Extinction tests were then begun to determine whether recovery conditioning had been established to the cues present in the water on treatment day. Five 20-minute tests were conducted, one every third day, with 2 days intervening between tests during which subjects were allowed to drink plain water to re-establish the baseline.

Animals that drank sour water 24 hours after treatment were tested with sour water only (S: S); those that drank blue water on treatment day received blue water in the extinction tests (B: B). However, the 24 animals of each species that had drunk blue-sour water on treatment day were divided into three subgroups for testing. One group of subjects was no longer given blue water (B: B), another on sour water (S: S), and the third on blue water (B: B).

Figure 1 shows a comparison of the amount of water drunk by rats on the first extinction trial over the first five extinction trials for each of the five treatment tests conditions. Differences between means drinking trends on treatment day and the first extinction trial (t0) were assessed for statistical significance by the two-sample t-test. As predicted, the 5:5 condition show that the four treatment by drug was the effective cue for avoidance (p < .05). Only the quail, however, showed reduced drinking (p < .01) of water that was colored blue on treatment and test days (B: B). The BS: B condition, both species drank less water than those reduced drinking in the S: S (p < .001).

Perhaps the most striking results
were shown by the last two subgroups for which the compound cue (BS) of the treatment day conditioning trial was split for separate testing of each component. In the latter two conditions (BS: S and BS: B) rats and quail showed a remarkable difference with respect to the salience of gustatory and visual cues. When the nose element of the compound conditioning stimulus was the test cue (BS: S), rats avoided it (P < .01) but quail did not. On the other hand, when the blue color was the element tested (BS: B), quail avoided it (P < .01) but rats did not. The behavior of the quail in these two conditions is especially informative. Although the quail avoiding the evasion to taste alone (S: S condition), normal of the visual stimulus from the compound conditioning stimulus (BS: S condition) apparently conferred such a visual change is unimportant for the fact that it rendered the remaining taste element ineffective. The results demonstrate, therefore, not only that quail can associate a visual cue with long-delayed illness, but also that a visual cue can be so salient as to overshadow taste when the cues are compound.

The most important result of this experiment is that we showed how to relate a visual cue with the use of a compound cue using the visual stimulus from the compound conditioning stimulus (BS: S condition) apparently conferred such a visual change is unimportant for the fact that it rendered the remaining taste element ineffective. The results demonstrate, therefore, not only that quail can associate a visual cue with long-delayed illness, but also that a visual cue can be so salient as to overshadow taste when the cues are compound.

The most important result of this experiment is, that quail were somehow able to associate blue water with a sub-sequent illness which we induced arbitrarily 1 hour after removal of the drinking tube. Failure of the rats used in our experiments to do so does not, of course, constitute a powerful argument that this species cannot associate a visual cue or a long delay. It is conceivable, although we think it unlikely, that rats see no difference between plain and blue water. At any event, Garcia and his co-workers (3) have reported much more convincingly evidence than ours that rats do utilize a visual cue in delayed
illness incidence learning. Thus, concerns after the first experiment was whether the results for quadrats were unrepeatable, rather than whether rats could actually see our visual cue.

In the second experiment we attempted to answer two questions: (1) could the rats have been relying on some subtle hue of the dyed water rather than solely upon its appreciation? and (2) was the effective chromatope that produced overtly to blue water readily the drug-induced illness, or was it the considerable training of being caught, handled, and injected?

Birds (none of the 80 earlier subgroups were assigned to one of two groups. Assignment being random except for the restriction that the groups be banded with respect to prior treatment and test conditions. Procedures were the same as in the first experiment.) On treatment day, however, both groups drank from tinted blue water, but not from the colored liquid to which they were accustomed. One group (N = 20) was then injected with saline (2 ml/kg body weight) hourly drinking. For the other group (N = 20) that injected with normal saline. Figure 2 shows the results. Birds that received the illness-inducing drug drank less from the tinted blue water than from the control food. As these injected with saline did not.

Although Figs. 1 and 2 show a clear picture of the relative changes in drinking occasioned by treatment-day and test conditions, they give no information on the absolute absolute ingestions of the degree of variability. Accordingly, means and standard deviations are shown in Table 1 for all groups each day from the last baseline day through the first extinction test. Comparisons of baseline scores with those of treatment day show that over water, whether blue or not, was somewhat better for both species at first encounter, that is, before induction of illness; blue water alone was not.

The amount of saline water drunk on the two recovery days after treatment shows a return to baseline levels. Effects of the delayed illness conditioning trial are seen best by comparing scores of treatment day with those of the first extinction test. Despite the controls introduced as the second experiment, it could be argued that the results represent not true associative learning but that the birds' increased willingness of attractive-looking foods as a result of recent illness. However, studies now completed in our laboratory show that, although such sensitization or heightened ingestive contributions at the effect, there is a significant associative learning component as well. We are confident, therefore, that at least one species can associate a purely visual cue with a delayed illness without mediation by means of peripheral mechanisms such as reinitiated taste. It seems transmissible to expect that this capacity will be widespread among animals whose visual systems are highly developed and whose eliciting demand great attention upon vision in foraging. If so, the implications for ecology, behavior theory, and evolutionary theory are of considerable importance.

Harley C. Wilcoxson
William R. Dragoon*
Per A. Krist
Department of Psychology,
George Peabody College for Teachers,
Nashville, Tennessee 37203

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Atmospheric Aerosol Background Level

In my report Porch et al. (1) consider the existence of a background level of atmospheric aerosol, in which they derived a "scattering component for aerosol (0.002)," from atmospheric turbidity measurements made with a Volta light-scattering photometer at McMurdo Station, Antarctica (2). They compare "normal" values with the present data due to air with no aerosol (3). The November-December 1966 data of this ratio at McMurdo Station, Antarctica, is 1.36, whereas the value for Mount Olympus, Washington, in February-March 1967 is 1.5 and for Point Barrow, Alaska, in March 1970 is 1.95 (11). Porch et al. speculate that the increase from 1965 to 1970 may reflect "apparition of a 60's type of aerosol production," but discard this hypothesis in favor of one involving a difference in altitude between the last two stations.