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Effects of Novelty and Familiarity on Illness-Induced Aversions to Food and Place Cues in Coyotes (*Canis latrans*)

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Two experiments investigated the effects of novelty and familiarity on illness-induced aversions to taste and place cues in coyotes (*Canis latrans*). Coyotes were made ill on familiar food laced with lithium chloride in a novel place and then received preference tests. In Experiment 1, coyotes avoided the previously poisoned familiar food in the novel treatment place but readily ate the same familiar food in a familiar safe place. In Experiment 2, the results of Experiment 1 were replicated, and it was found that coyotes would eat a different familiar food in the novel treatment place. On the basis of the results of this and other studies, a model for averting animals from places where they are not wanted is presented.

In spite of a long history of attempts to manage, and in many cases eradicate, coyotes (*Canis latrans*) in the American West by traditional techniques, their population has gradually spread across North America (Fisher, 1975). In addition, coyote sightings in urban and suburban areas have increased to the extent that they are considered by many to be a menace to the safety of humans, their pets, and livestock. It is our contention that learning to associate cues with the location of safe food is important in determining where coyotes forage. Many coyotes have found that areas associated with human population offer safe and efficient feeding in garbage cans and gardens, on small domestic prey, and often as a result of people's willingly feeding them. The general purpose of this study was to establish a spatial avoidance conditioning model, based on food aversion learning, that may be useful in such applied situations as in reversing the intrusion of coyotes into human population areas. Such a model must take into consideration the interaction of all factors that may affect coyote foraging behavior in the natural environment. These factors include the coyotes' capacity to associate food and place cues with illness or safety and the extent of the animals' prior experiences with those cues.

It has been found that coyotes readily associate salient tastes with subsequent illness (Gustavson, Garcia, Hankins, & Rusiniak, 1974), and field studies have shown that coyotes may associate nongustatory food cues with illness when these cues are presented in a stimulus compound with taste (Ellins & Catalano, 1980; Ellins, Catalano, & Schechinger, 1977; Gustavson, Jowsey, & Milligan, 1982; Gustavson, Kelly, Sweeney, & Garcia, 1976). After eating baits or carcasses laced with lithium chloride, coyote attacks on live prey of that species are suppressed as a result of associating such cues as the odor and sight of the prey with illness. Taste-potentiated aversions to the odor of food have also been demonstrated in coyotes by Ellins and Martin (1981), and the potentiation of food-related odor cues (Palmerino, Rusiniak, & Garcia, 1980) and visual cues (Galef & Osborne, 1978) has been demonstrated in rats. If coyotes associate nongustatory food cues with illness by taste potentiation, it is possible that they can form similar aversions to cues associated with the place in which the illness occurred. Lithium chloride baiting may then be successful in averting coyotes from areas where they are not wanted. Indirect evidence for place aversions in coy-

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otes has been reported by Gustavson et al. (1976), who observed that following LiCl baiting, general coyote activity in the research area decreased. In addition, Cornell and Cornely (1979) found that after feeding coyotes LiCl-laced foods, they no longer entered a campground looking for handouts.

Although studies of conditioned place aversions, that is, aversions to cues associated with objects other than the substance to be consumed, have not been performed with canids, related research has been performed with rats. It has been found that direct associations between place cues and illness can be produced in rats (Best, Best, & Henggeler, 1977; Best, Best, & Mickley, 1973; Garcia, Kimeldorf, & Hunt, 1957, 1961), although the number of trials required is typically greater than the number required to produce taste–illness associations. Mixed results have been reported, however, if the place cues are presented in a stimulus compound with taste. Best et al. (1973) found that a conditioned aversion to a place was reduced if during conditioning the rats also drank saccharin water. On the other hand, Cunningham (1979) reported that taste had no effect on the aversive conditioning of concomitant place cues.

The associability of food-related cues with illness is influenced by many factors, including the extent to which the subject is familiar with those cues. Cues associated with novel foods signal potential danger and typically result in neophobic avoidance (Barnett, 1958; Chance & Mead, 1955). However, if ingestion does occur, at least in rats, aversive consequences readily lead to conditioned aversions to cues associated with that food, whereas favorable consequences lead to associating those food cues with safety (Kalat & Rozin, 1973). Thus, many studies have found that if rats ingest a relatively novel food followed by illness, they are likely subsequently to avoid that food; however, increased familiarity with food cues signaling safety leads to difficulty in conditioning food aversions (e.g., Domjan, 1972; Kalat, 1974; Revusky & Bedarf, 1967; Rudy, Rosenberg, & Sandell, 1977). With regard to place cues, it has been shown again that rats respond to novelty with neophobic avoidance (Barnett, 1958; Mitchell, Scott, & Williams, 1973). In addition, rats learn to avoid novel place cues that are present during the ingestion of foods followed by illness, but they are less likely to associate illness with familiar place cues. Mitchell, Kirschbaum, and Perry (1975) gave rats a varying number of familiarization trials with two containers containing the same food, followed by LiCl-induced illness. The rats subsequently avoided eating from the relatively novel container and continued to eat from the familiar container. This suggests that if coyotes are presented with a choice between eating a familiar food in a familiar place or eating it in a novel place in which ingestion of that food is followed by illness, they will subsequently avoid eating that food in the novel treatment place.

Experiment 1

Method

Subjects The subjects were six coyotes (*Canis latrans*) ranging in age from 8 mo. to 2 yr. Four of the subjects (S1, S2, S3, and S4) were males, and two (S5 and S6) were females. All of the coyotes except Subject S1 were raised in captivity.

Apparatus The outdoor research facility was constructed of chain link fence and consisted of four kennels, a choice arena, and four goal boxes (see Figure 1). There was wire netting over the facility and under the dirt floor to prevent escape. Each kennel, 3.05 × 1.22 × 1.83 m high, had a concrete floor, a corrugated aluminum roof, and a chain link door that opened into the choice arena. The kennels were separated from each other by chain link fence with fiberboard paneling attached. Within in each kennel were two gray porcelain bowls, 27.5 cm in diameter, for food and water and a plywood dog house, 1.22 × .91 × .85 m high, positioned at the end opposite the door.

Of the four goal boxes, X and Y were similar in that each contained white plywood panels rising 45 cm from the ground and extending the length of three of its four sides. An automobile tire in the corner of each goal box served as a feeding bowl. Goal boxes A and B were similar in that each contained plywood panels painted in a red-and-white cross-hatched pattern which rose 45 cm from the ground and extended the length of each of its sides. A red aluminum trash can lid, 47 cm in diameter, in the center of each of these goal boxes, served as a feeding bowl. The distinctive panels and feeding bowls within the two sets of goal boxes served as nongustatory stimuli during the treatment and test phases of the experiment. When one set of goal boxes was being used, the entrances to the other goals were closed off with plywood

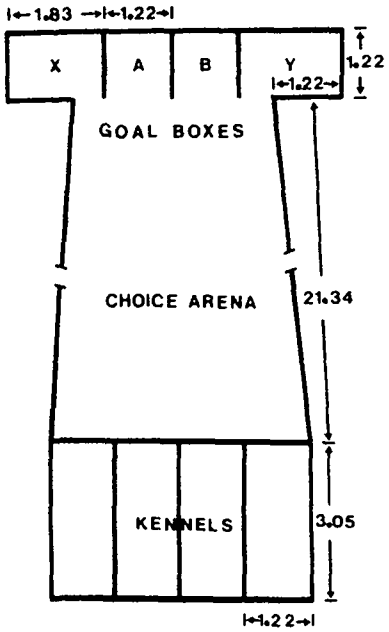

Figure 1 Outdoor research facility drawn to scale. (Units are in meters.)

so that the subjects could neither see into nor enter these areas. When a subject was released into the choice arena, the doors of the other coyotes' kennels were covered to preclude their observing the trial.

Procedure In each phase of the experiment, the subjects were run independently. Each subject was run for two trials. A summary of the procedure is shown in Table 1.

Trial 1 began with familiarization in which each subject was assigned to a home kennel where it received 20 consecutive daily events with a particular food. An event was defined as any amount of food eaten in a 24-hr period. For familiar foods, see Table 1.

Treatment began 24 hr after the end of each subject's 20th familiarization event when the coyote was allowed to leave its home kennel and eat the now familiar food laced with LiCl in a novel goal box (see Table 1). The subjects had neither entered nor seen into the novel goal boxes prior to this time. For the subjects familiarized on chicken, whole plucked chickens were sliced in numerous areas and soaked in a solution of 11.36 liters of water and 450 g of LiCl for 30 min. For the subjects familiarized on dog food, 6 g of LiCl was blended into 454 g of dog food. After the subject left the home kennel, the kennel door was closed to prevent the subject from returning to the kennel following the treatment. The remaining goal boxes were also closed during the treatment. The treatment session was ended for each subject when the LiCl-laced food was eaten in the goal box and subsequent vomiting occurred. All subjects vomited on their respective treatment days.

Testing began 24 hr after treatment when each subject was simultaneously presented with three conditions (see Table 1); the familiar food in the familiar place—the home kennel, the familiar food in the previously novel treatment place, and a novel food in a novel place—a previously unused goal box. At the beginning of each test, the subject was released in the middle of the choice arena, and the first, second and third choices were recorded. A choice was defined as a subject's eating any amount of food in any of the three goal boxes within 30 min of its release.

Table 1
Summary of Foods and Places Paired During Sequential Phases of Experiment 1

	Familiarization		LiCl treatment		Test condition					
Subject	FF	FP	FF	NP*	FF - FP		FF - NP*		NF - NP	
					Trial 1					
S1	Ch	H	Ch	X	Ch	H	Ch	X	Bk	Y
S2	Ch	H	Ch	X	Ch	H	Ch	X	Bk	Y
S3	Ch	H	Ch	X	Ch	H	Ch	X	Bk	Y
S4	Vr	H	Vr	B	Vr	H	Vr	B	Bk	A
S5	Vr	H	Vr	B	Vr	H	Vr	B	Bk	A
S6	Vr	H	Vr	B	Vr	H	Vr	B	Bk	A
					Trial 2					
S1	Vr	H	Vr	B	Vr	H	Vr	B	Bl	A
S2	Vr	H	Vr	B	Vr	H	Vr	B	Bl	A
S3	Vr	H	Vr	B	Vr	H	Vr	B	Bl	A
S4	Vc	H	Vc	X	Vc	H	Vc	X	Bl	Y
S5	Vc	H	Vc	X	Vc	H	Vc	X	Bl	Y
S6	Vc	H	Vc	X	Vc	H	Vc	X	Bl	Y

Note FF = familiar food; FP = familiar place; NP* = novel treatment place; NF = novel food; NP = novel place; Ch = chicken; H = home kennel; X, Y, B, A = goal boxes; Bk = beef kidney; Vr = Vets regular canned dog food (454 g); Bl = beef liver (454 g); Vc = Vets chicken canned dog food (454 g).

Each subject began Trial 2 24 hr after completing Trial 1. The procedure was the same as in Trial 1 except that the foods and the goal boxes in which they were placed were changed as indicated in Table 1.

Results

A summary of the results of Experiment 1 is shown in Table 2. On Trials 1 and 2, the subjects tended to select the familiar food in the familiar place as their first choice and the novel food in the novel place as their second choice. The familiar food in the novel treatment place was not selected by any of the subjects as their first or second choice. On only one of the 12 trials was the familiar food in the novel treatment place selected as a third choice; on the other 11 trials the subjects did not take a third choice, the familiar food in the novel treatment place remaining uneaten. The coyotes occasionally demonstrated stereotyped approach–avoidance behavior when nearing the treatment goal box during testing, but ultimately never entered the goal box. However, the familiar place containing the familiar food was entered without hesitation, and all of the food there was readily eaten on every test trial. The coyotes frequently entered the novel place containing novel food, although cautiously. A Friedman test for matched samples (Mendenhall & Ramey, 1973) indicated that the three choices differed significantly with regard to the number of times each was chosen first ($Fr = 66.76$, $p < .0001$). These results indicate that coyotes form an aversion to eating a familiar food in a novel place in which that food was eaten followed by illness but will eat the same food in a familiar place associated with safety. In fact, the coyotes even preferred to eat novel food in a novel place rather than eating the familiar food in the novel treatment place, a result indicating that the conditioned aversion was even stronger than their neophobia.

Table 2
Number of Food/Place Choices Made by Coyotes in Test Phase of Experiment 1

Test condition	1st choice	2nd choice	3rd choice	No take
FF/FP	9	3	0	0
NF/NP	3	9	0	0
FF/NP*	0	0	1	11

Note. FF = familiar food; FP = familiar place; NF = novel food; NP = novel place, NP* = novel treatment place.

Experiment 2

In Experiment 1, the coyotes ate the familiar food in the familiar safe place but would not eat the same food in the novel place in which the food had been previously laced with LiCl; these findings replicate the results of Mitchell et al. (1975) with rats. Since the coyotes ate the familiar food in the safe place, the conditioned aversion to the familiar food in the novel treatment place cannot be attributed to a conditioned flavor aversion for that food alone. However, it is possible that a conditioned aversion was established between the illness and the nongustatory cues associated with the novel treatment place, or between the illness and an interaction of the place cues and the flavor of the food. The purpose of this experiment was to determine whether in Experiment 1 the coyotes were averted from a place associated with illness regardless of what food was there or whether they would eat a second safe familiar food in the same place in which they had eaten poisoned food.

Method

Subjects The subjects were four coyotes (*Canis latrans*), approximately 15 mo old, all of which were raised in captivity.

Apparatus The apparatus used was the same as in Experiment 1 (see Figure 1).

Procedure. For a summary of the food and goal boxes used in each phase of this experiment across subjects, see Table 3. The procedure was the same as in Experiment 1 with the following exceptions.

Familiarization consisted of each coyote being presented with two foods (familiar $food_1$ and familiar $food_2$), each on alternate days in the home kennel (the familiar place). There were a total of 40 familiarization events, 20 with each food. The foods were independently run through a meat grinder and then molded into 454-g patties.

Treatment occurred 24 hr after the end of each subject's 40th familiarization event when it was allowed to leave its home kennel and eat familiar food, containing 6 g of LiCl in a novel goal box (see Table 3).

There were two test conditions, the first occurring 24 hr after treatment and the second 24 hr after the first test condition (see Table 3). In Test Condition 1, each subject was simultaneously presented with two

Table 3
Summary of Foods and Places Paired During Sequential Phases of Experiment 2

	Familiarization			LiCl treatment		Test condition							
						1				2			
Subject	FF_1	FF_2	FP	FF_1	NP*	FF_2 – NP*		NF – NP		FF_1 – NP*		NF – NP	
						Trial 1							
S1	Ch	Bl	H	Ch	A	Bl	A	Fi	B	Ch	A	Vr	B
S2	Bs	Bk	H	Bs	A	Bk	A	Fi	B	Bs	A	Vr	B
S3	Bs	Ch	H	Bs	A	Ch	A	Fi	B	Bs	A	Vr	B
S4	Bk	Bl	H	Bk	A	Bl	A	Fi	B	Bk	A	Vr	B
						Trial 2							
S1	Bk	Bs	H	Bk	Y	Bs	Y	Po	X	Bk	Y	Vr	X
S2	Bl	Ch	H	Bl	Y	Ch	Y	Po	X	Bl	Y	Vr	X
S3	Bl	Bk	H	Bl	X	Bk	X	Po	Y	Bl	X	Vr	Y
S4	Ch	Bs	H	Ch	X	Bs	X	Po	Y	Ch	X	Vr	Y

Note. FF_1 = familiar food paired with illness; FF_2 = familiar food; FP = familiar place; NP* = novel treatment place; NF = novel food; NP = novel place; Ch = chicken (whole); Bl = beef liver (454 g); H = home kennel; A, B, Y, X = goal boxes; Fi = fish (454 g); Bs = beef steak (454 g); Bk = beef kidney (454 g); Po = pork (454 g); Vr = Vets regular canned dog food (454 g).

choices; familiar $food_2$ (a familiar food not previously paired with illness) in the novel treatment place and a novel food in a different novel place. In Test Condition 2, each subject was simultaneously presented with familiar $food_1$ (familiar food that had been previously paired with illness) in the novel treatment place and a novel food in a different novel place. The purpose of Test Condition 2 was to replicate the results of Experiment 1 with the subjects in Experiment 2.

Each subject was run through each of the two test conditions twice, for a total of eight trials with familiar $food_2$ and eight trials with familiar $food_1$ (see Table 3).

Results

The results of Experiment 2 are presented in Table 4. In Test Condition 1, the coyotes slightly preferred the familiar $food_2$ in the novel treatment place over the novel food in the novel place, although both were eaten on most trials. In Test Condition 2, however, the coyotes were much less likely to eat the familiar $food_1$ in the novel treatment place than the novel food in the novel place; the familiar $food_1$ was taken in the novel treatment place on only one of eight trials, and on six of the trials it was not taken at all. A Friedman test for matched samples (Mendenhall & Ramey, 1973) indicated that the familiar $food_1$ in the novel treatment place was significantly less likely to be eaten than the novel food in the novel place ($Fr = 41.25$, $p < .001$). The results of Test Condition 1 show that an aversion for the place in which the LiCl-laced food had been eaten was reduced when that food was absent. The results of Test Condition 2 replicate the results of Experiment 1 and indicate that the coyotes were averted by an interaction of the food and place cues.

Discussion

The present findings emphasize the importance of exteroceptive cues and degree of familiarity in food aversion conditioning. The results of Experiment 1 replicate, with

Table 4
Number of Food/Place Choices Made by Coyotes in Test Conditions 1 and 2 in Experiment 2

Test condition	1st choice	2nd choice	No take
	Test Condition 1		
FF_2/NP*	4	3	1
NF/NP	2	4	2
	Test Condition 2		
FF_1/NN*	1	1	6
NF/NP	5	1	2

Note. FF_2 = familiar food; NP* = novel place paired with illness; NF = novel food; NP = novel place; FF_1 = familiar food paired with illness.

coyotes, the findings of Mitchell et al. (1975). They found that following illness on a familiar food in a place having novel cues, rats avoid eating that food in the presence of those cues in favor of eating that food in a place having familiar cues associated with safety. These results indicate that coyotes can be averted from a place in which a food–illness pairing had occurred. However, the question arises whether they were averted to eating all foods in that place or only the food on which they had been made ill. The results of Experiment 2 replicate the results of Experiment 1 and indicate that the coyotes were not specifically averted from the place but would eat a familiar food not paired with illness in the novel place in which the LiCl-laced food had been eaten.

The above results suggest that to avert coyotes from eating all foods in a given place, illness should be paired with a variety of foods to create a generalized food aversion associated with that place. This technique proved to be effective when Cornell and Cornely (1979) laced several familiar foods that were typically used as handouts in a campground with LiCl, resulting in a reduction in foraging and coyote sightings in the campground during the study period. In addition, this finding supports the notion that cues signaling the presence of poisoned food result not only in an aversion to eating in that place but also in avoidance of the general area.

If food aversion conditioning, as described in the present study, is viewed in terms of the classical conditioning paradigm, then we propose that the conditioned stimulus would be defined as a stimulus compound consisting of all interoceptive and exteroceptive cues related to the food and the feeding environment that are perceived by the subject. Included in this compound is the taste of the food which, when paired with illness (unconditioned stimulus), potentiates associations between the unconditioned stimulus and the other cues in the compound. It has been postulated that this synergistic compound potentiation of associations between nongustatory cues and illness by taste may be the result of the taste cue's indexing the other relevant feeding cues in the compound in the subject's memory (Rusiniak, Hankins, Garcia, & Brett, 1979). Regardless of the mechanism, however, it is well established that taste potentiates aversions to nongustatory food-related cues when the compound of conditioned stimuli is followed by illness (Clarke, Westbrook, & Irwin, 1979; Ellins & Martin, 1981; Galef & Osborne, 1978; Palmerino et al., 1980). It is also well known that nonreinforced exposures to a stimulus prior to its pairing with an unconditioned stimulus will retard an animal's ability to associate that stimulus with an unconditioned stimulus, a phenomenon known as latent inhibition (Lubow, 1973; Lubow & Moore, 1959). Its analogue in taste aversion conditioning is referred to as the taste familiarity effect, which indicates that the more preexposure an animal has had to a taste the less the associability of that taste with subsequent illness (Rudy et al., 1977). In short, with increased familiarity an animal learns that a particular place and/or food is safe, and many illness pairings may be necessary to establish a conditioned aversion. Thus, on a novelty-familiarity continuum, the strongest aversion would be produced if a coyote was poisoned on a novel food in a novel place; given the availability of alternative food, the coyote would not be likely to return for a second meal of that food. At the other extreme, only a weak aversion would result if a coyote was poisoned on a familiar food in a familiar place; both are known to be safe, and several illness treatments may be necessary to produce an aversion to that food in that place.

With regard to food/place interactions, Rudy et al. (1977) stated that "the nature of the animal's exteroceptive environment can play an important modulating role in the development of acquired taste aversions." (p. 32) These researchers found, with rats, that the taste familiarity effect is disrupted when an animal is exposed to novel exteroceptive cues just prior to illness on a familiar food. Other researchers (Anderson, O'Farrell, Formica, & Caponigri, 1969; Lantz, 1973) have found that exposure to novel exteroceptive cues can disrupt the latent inhibition of a nongustatory cue

in a conditioned emotional response task. These findings led to the proposal of Rudy, Iwens, and Best (1977) and Rudy et al. (1977) that novel exteroceptive cues can disrupt the process that attenuates the associability of familiar cues with an unconditioned stimulus regardless of whether the familiar conditioned stimuli are interoceptive, as in the case of the taste familiarity effect, or exteroceptive, as in the case of latent inhibition. The results of the present study support this notion in that the cues in the novel treatment place retarded the effect of familiarization on the familiar $food_1$ and consequently resulted in avoidance of the familiar $food_1$ in the novel treatment place. (We know that the avoidance of the familiar $food_1$ in the novel treatment place was not due to an aversion to the novel treatment place per se because the familiar $food_2$ was readily eaten there.) It can be further assumed that if novel food were consumed in a familiar place, the novel food cues would retard the effect of familiarization on the place cues and result in an association between the place cues and subsequent illness and avoidance of that place.

The present research was intended to contribute to the establishment of a conditioned food aversion model that could be used as an aid in repelling coyotes and other animals from places in which they are not wanted. In that regard, the results of this study, along with those of other relevant experiments, can be summarized as follows: (a) The greater the familiarity of the food and place cues the more illness treatments necessary to produce an aversion to that food in that place: (b) In the case of an interaction of novel or familiar food and place cues, it has been demonstrated that poisoning of a familiar food in a novel place with one or few illness treatments results in a robust aversion to that food in that place. In addition, it can be assumed that poisoning of a novel food in a familiar place results in an aversion to that food in that place: (c) The greater the variety of poisoned foods consumed in a given place the greater the aversion to eating any food in that place. In addition, the strengths of food and place aversions are likely to be influenced by the intensity of the unconditioned stimulus. Although parameters for the effective strength of LiCl to be used on coyotes have not been established, Ellins and Martin (1981) suggested that approximately 2.1–2.5 g of LiCl in 454 g of food is the minimum quantity that will result in vomiting and should be sufficient to produce aversions following one or two illness bouts. It should also be noted that novelty and familiarity are relative terms that may be defined by the number of preexposures and/or the amount of time that an animal is exposed to place or food-related cues. Finally, it has been found that following two illness treatments on LiCl-laced food, coyotes will not eat any food containing LiCl, the presence of the LiCl being detected by its odor (Ellins & Martin, 1981). For the purpose of the model presented here, it is assumed that detection of LiCl in a food and consequent avoidance of that food is analogous to an illness treatment with that food. This assumption is based on the finding that animals that are averted by food cues often exhibit species-specific disgust reactions when subsequently presented with that food (Gustavson et al., 1974, 1976).

The above constitutes the first stage in establishing an illness-based place aversion conditioning model for repelling intruding animals. Although this model is supported by several well-established learning principles, it also includes predictions based on the results of experiments with a small number of subjects, as in the case of the present study, and includes some unverified but easily testable assumptions. With regard to coyotes and other species not typically studied in the laboratory because of space limitations and other factors, the present line of research is continuing. It should be emphasized, however, that the most important key in repelling coyotes and other animals is simply to make food unavailable to them. It is interesting that Cornell and Cornely (1979) discovered that volunteer workers had been feeding coyotes commercial dog food prior to their intrusion in large numbers into the campground under study. It is also important that the natural habitats and food sources of these

animals be preserved, as the availability of alternative food is requisite to the validity of the present model.

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