Learning About Foods and Locations

Anyone who has ever trained animals has wondered what animals learn from different experiences. For instance, a person walks into a pen of animals that have just been fed, catches a lamb or calf, and puts a balling gun containing a capsule with a toxin down its throat. Soon the animal will experience gastrointestinal illness, but will it associate the illness with the person who just attacked it or with the food it just ate?

Pre-eminent psychologist John Garcia pointed out that, "All organisms have evolved coping mechanisms for obtaining nutrients and protective mechanisms to keep from becoming nutrients" and that animals learn about the consequences of ingesting foods and being in a particular place through different senses. In many birds and most mammals, sight and hearing and feelings of pain and comfort are associated with the *skin-defense system*, evolved in response to predation. The taste of food and feelings of nausea and satiety are part of the *gut-defense system*, evolved in response to toxins and nutrients in foods. Odors may be associated with either the skin- or gut-defense systems. The smell of predators forewarns the skin-defense system, while the smell of food serves as a cue for the gut-defense system.

Skin and gut. The way skin- and gut-defense systems work is illustrated in trials with hawks fed colored or flavored mice. When hawks normally fed white mice were given a black mouse, followed by an injection of a toxin that caused gastrointestinal illness, the hawks would not eat black or white mice. They did not discriminate between mice as a food based on color alone because black and white mice taste the same. When a flavor was added to black mice, hawks learned to avoid black mice on sight after a single black mouse-toxin event. Hawks discriminate among food sources based on taste-toxicosis pairings first and then use color as a cue to discriminate black from white mice.

Thus, not all cues are readily associated with all consequences. Animals that get sick after drinking flavored water in a specific location show a strong aversion to the flavor but not the location where they drank. In contrast, if they received foot-shock while drinking, they show a stronger aversion to the location where they drank than to the flavor of the liquid.

Thus, toxins decrease palatability of foods, but they do not cause animals to avoid the place where they ate the food. Food aversions depend on the food and are generally independent of the location where the food was eaten. Conversely, an attack by a predator may cause animals to avoid the place where they were eating, but it does not necessarily decrease the palatability of the food they were eating when the attack occurred. Place aversions are specific to the site or to some physical attribute in the environment. For example, animals trained to avoid an electric fence will avoid the fence even if it is placed in a new location.

It's automatic. The formation of a food aversion is automatic and non-cognitive. That is, animals don't have to think about what made them sick to have an aversion to a food. Animals form aversions to foods even if they are under anesthesia when the illness occurs. Likewise, people acquire aversions to foods after gastrointestinal illness even when they are certain their illness was caused by the flu or motion sickness and not the food. Once the brain has paired the taste of the food with illness, trying to convince yourself that food really tastes good will not improve its flavor. Non-cognitive changes in palatability caused by postingestive feedback are similar to digestion. We don't need to think about which enzymes to release to digest food. Nor do we need to think about changes in palatability because of feedback. They result from the automatic pairing of postingestive effects of nutrients (satiety) and toxins (illness) with a food's flavor that occur because nerves for taste join nerves from the gut at the base of the brain.

Timing. Skin- and gut-defense systems operate in different time frames. For animals to learn from the skin-defense system, the event and the consequence must be paired closely in time. For example, animals learn that an electric fence produces a painful electric shock and should be avoided because touching the fence results in an immediate shock. Animals would never learn to avoid an electric fence if they touched the fence and were shocked five minutes later.

In the case of the gut-defense system, food ingestion and satiety or toxicosis can be separated by long time intervals. For example, sheep avoid foods that cause gastrointestinal illness up to eight hours after eating a food. The ability of the body to pair food ingestion with illness that occurs several hours after eating facilitates learning about foods because food related illnesses (allergies or poisoning) may occur long after the food was eaten. Digestion and absorption take place over long periods of time.

Conclusions. So what does an animal that has just eaten learn when a person walks into its pen, catches it, and gives it a capsule containing a toxin with a balling gun? The animal will associate the person with the attack on its skin-defense system and will avoid the person in the future, but it will associate the food with illness and will avoid the food in the future. The automatic, non-cognitive pairing of foods with postingestive consequences means that even if a person could explain to the animal that the toxin—not the food—was the cause of the illness, the animal would still be averse to the food. It is the same when we know that the flu or sea sickness, not the food, caused nausea—we still avoid the food even though we know it was not the source of nausea. The gut-defense system is designed to pair eating a food with gastrointestinal illness regardless of what the animal "thinks" caused the illness.

Additional Readings:

Provenza, F.D. 1995. Postingestive feedback as an elementary determinant of food preference and intake in ruminants. J. Range Manage. 48:2-17.

Provenza, F.D. 1995. Tracking variable environments: There is more than one kind of memory. J. Chem. Ecol. 21:911-923.

Funding provided by Utah Agricultural Experiment Station and USDA-IFAFS. Produced by Utah State University in collaboration with University of Idaho, University of Arizona, Montana State University and the National Wildlife Research Center with research conducted at Utah State University.

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