The Garcia Effect

A Tailored Taste for Survival

Chang Liu

On the surface, taste seemingly only serves as a factor of enjoyment in response to various foods, but it commands a much stronger persuasion on the human subconscious than any of the other four senses. Taste is the only sense that can unconsciously and permanently plant a memory of disgust and repulsion within animals without requiring any conscious thought or mental notation. This phenomenon is scientifically known as "conditioned taste aversion," and was first researched by Dr. John Garcia, a notable psychologist who conducted most of his studies during the 1950s at Hunter's Point Radiological Defense Laboratory in San Francisco. Garcia and his colleagues were originally studying the effects of ionizing radiation on the behaviors of laboratory rats when they stumbled upon the curious phenomenon of taste aversion (Garcia, 1988). They discovered that radiated rats would eventually stop drinking the saccharin solutions supplied to them for hydration during radiation tests, opting instead for thirst. Garcia switched his research to hone in on this peculiar finding and eventually demonstrated that it had a psychological basis. He postulated that the rats must have unwittingly attributed ingesting saccharin water—the only physical cue that they had—with the aversive symptoms that were actually due to undetectable radiation (Garcia, 1988).

A NOVEL IDEA

Garcia's discovery of taste aversion led to a plethora of questions from the scientific community. While the phenomenon seemed to follow a basic pattern of Pavlovian conditioning, it broke many of the key principles proposed by Pavlov and Thorndike regarding learning theory. For instance, the rats in Garcia's studies retained their distaste for saccharin-flavored water long after radiation was removed; also, they learned to avoid the solution despite the fact that they only drank the water sporadically while under radiation. All of these factors violate many key tenets of Pavlovian conditioning, such as the need to consistently pair a conditioned stimulus with a conditioned response over multiple trials in order to cement an association. Taste aversion also defies the "Law of Exercise" from Thorndike's learning theory, since the rats did not require repetition to learn or strengthen the association; in fact, the learning itself was spontaneous and the response lasted for much longer than it should have without the requisite practice. Psychologists noticed that a number of factors including sex, age, testing procedures, deprivation level, and drug history all affected the acquisition rate and terminal strength of taste aversion, but no one was quite able to put a finger on how the phenomenon could be implanted within an organism's memory so instantly and irrevocably (Parker, 2003). Furthermore, conditioned taste aversion is encountered at all levels of evolution, with similar forms of food aversion learning found in vertebrate and invertebrate species whose ancestral lines diverged more than 500 million years ago (Bures, 1998). Thus, the acquisition of taste aversion is not a simple Pavlovian-conditioned event, but a unique psychological phenomenon with deep evolutionary roots.

THE PSYCHOLOGICAL & PHYSIOLOGICAL BASIS

Many preliminary and subsequent in-depth studies were conducted in relation to taste aversion. While earlier studies aimed to uncover the physical effects of taste aversion, more recent studies are focused on the psychological framework and physiological mechanics behind the phenomenon. Linda A. Parker, a research psychologist at Wilfrid Laurier University in Waterloo, Ontario, discovered that the emetic system of the midbrain and brainstem was responsible for the nausea that results as a consequence of taste aversion. The emetic system is not a group of organs in the traditional sense, such as the digestive or nervous system. However, it is so named because "emetics" have traditionally been used as substances that induce vomiting to purge the body of toxins and harmful parasites; conditioned disgust reactions are established by the association between a flavor and the activation of the emetic system (Parker, 2003). Although rats are incapable of vomiting, they were observed to display conditioned disgust reactions such as gaping and chin rubbing when they were exposed to a flavor previously paired with drug-induced nausea. Time and the ability to form sensory memories play important roles in the acquisition of taste aversion as well. Baby rats could only acquire an aversion to a particular food if it was eaten within sixty minutes of nausea onset; the association failed to appear with longer time gaps (Stephenson, 2001). Baby rats also forgot taste information more easily than adult rats, pointing to the prominent tie between memory formation and taste aversion. Lastly, experiments showed that severing one of the vagus nerves in rats (see

Figure 1) increased the disappearance rate of learned taste aversions, likely because the vagus receives taste information and sends out parasympathetic signals to other organs in the digestive system such as the stomach and intestines. Scientists measured the frequency of electrical nerve impulses sent to the emetic system after vagus nerve severance in order to gauge the operation's effects on nausea. Thus, the vagus nerve may play a key role in the regulation of taste aversion alongside the emetic system (Kiefer, 1981). More recent research conducted on taste aversion uncovered a DNA-binding protein called HMGB-1 as a key factor in decreasing an organism's food intake upon its release into the cerebral ventricles. This protein can enter the cell nucleus and bind to DNA to regulate gene expression, ultimately influencing neurotransmitter release in the brain. HMGB-1 is now known to mediate taste aversion and interestingly, the development of anorexia (Agnello, 2002).

As mentioned before, taste aversion breaks many of the basic tenets of learning theory and Pavlovian conditioning. Particularly, taste aversion violates the typically impermanent nature of a conditioned learned response. In taste aversion tests of adult rats, hours can pass between a stimulus and an adverse reaction, yet an association can still be made if the ingested substance was the last notable event to occur before the onset of illness (Rusiniak, 1979). Additionally, test subjects can learn the connection after only a single experience, defying the laws of Pavlovian conditioning. Some novel traits of taste aversion include the following (Stephenson, 2001):

1. Taste aversion is not as strong if the subject is familiar with the taste prior to getting ill; the original, unbiased memory of the taste plays a factor in whether or not the subject will eventually be able to tolerate the food again.
2. A novel taste typically creates a lifelong disgust towards the particular food or beverage; it is almost impossible to convince the consumer that the food itself was not the direct cause of nausea or illness.
3. Taste aversion in humans is generally not considered debilitating, although the condition is sometimes associated with anorexia.
4. A common fallacy about aversions is that they are typically caused by eating contaminated food; in reality, the association of food with disgust or nausea cements taste aversion.
5. Conditioned taste aversion can be acquired while under deep anesthesia, which is incompatible with all other forms of learning.

SURVIVAL THROUGH TASTE

Taste aversion also has a strong evolutionary basis. Animals have essentially evolved to be genetically hardwired to "learn" to avoid harmful foods quickly. Evolutionary psychologists were the first to posit that organisms are biologically prepared to acquire certain types of fears during their life span more readily than other types of fears (Riley, 1998). This general phenomenon has now come to be known as "prepared learning" or "biological constraints on learning." Prepared learning is based upon biological factors and will thus vary between different species of animals. Organisms will often employ other senses to amplify their sense of taste during eating; the pairing of senses is selective for each species (Baker, 1997). For example, rats more readily learn to associate an olfactory cue such as water sweetness than a visual cue such as pink water with illness. Birds, on the other hand, can associate visual cues with sickness with the ease that rats associate olfactory cues with nausea. Birds readily learn to avoid blue food pellets and eat red pellets instead if the blue ones induce illness. When presented with a novel pellet that is half blue and half red, the bird will peck at the middle, break the pellet in two, and then eat the red half (Carey, 2003). Thus, the very nature of taste itself was tailored for survival. Organisms need to quickly and efficiently learn what food sources are poisonous, harmful, or overall unpleasant to the body in order to thrive, and this is what provides taste aversion with its evolutionary bias.

As briefly touched upon before, other senses are able to build off of and even amplify taste aversion. For example, an organism's olfactory and tactile senses can be employed along with taste to strengthen repulsion towards a certain food. In a study conducted to test the effects of combining weak almond odor with strong saccharin flavor for lithium chloride-induced taste aversion, the added odor significantly increased the animal's repulsion to the food as compared to standard taste trials. Interestingly, during tests conducted after the compound solution was paired with nausea, rats displayed a stronger aversion to the odor component than to the taste component, showing the amplification of taste aversion with the addition of smell (Rusiniak, 1979).

Thus, taste aversion is a unique and complex phenomenon strongly influenced by both evolution and psychology. Its closest cousin in the field of Pavlovian conditioning is probably "fear conditioning," where the learned fear response can also be acquired for long periods of time after only a single incident or trial. Although taste aversion in its purest form is no longer studied as widely in modern society, the solid groundwork laid down by Garcia's studies has supplied psychologists, therapists, and dieticians with crucial information for improving people's quality of life even today. For instance, aversion therapy is an unlikely offshoot that resulted from the knowledge gained from taste aversion studies. Many patients go through aversion therapy to overcome self-damaging habits such as nail-biting, overeating, and binge drinking; in aversion therapy, an unpleasant reaction is paired with the bad habit to wean the patient off of the harmful behavior, much like how laboratory rats can be trained to stop drinking saccharin-flavored water when it is paired with an emetic. From aversion therapy to mouthwatering eats, the effects of taste aversion quietly pervade everyday life, making its presence known when the most delectable-tasting dessert for one person initiates uncontrollable disgust in another.

References

Agnello, D., Wang, H., Yang, H., Tracey, K. J., & Ghezzi, P. (2002). HMGB-1, a DNA-binding protein with cytokine activity, induced brain TNF and IL-6 production, and mediates anorexia and taste aversion. Cytokine,18(4), 231- 236. DOI: 10.1006/cyto.2002.0890

Baker, L. J., Baker, T. B., & Kesner, R. P. (1977). Taste aversion learning in young and adult rats.Journal of Comparative and Physiological Psychology, 91(5), 168-178. DOI: 10.1037/h0077382

Bures, J., Bermudez-Rattoni, F., & Yamamoto, T. (1998). Conditioned taste aversion: memory of a special kind. Oxford, New York: Oxford University Press.

Carey, G. (2003). Principles of evolutionary psychology in Human Genetics for the Social Sciences (Chapter 16). Thousand Oaks: Sage Publications, Inc.

Garcia, J., Dess, N. K., Raizer, J., & Chapman, C. D. (1988). Stressors in the learned helplessness paradigm: effects on body weight and conditioned taste aversion in rats. Physiology & Behavior, 44(4-5), 483-490. DOI: 10.1016/0031-9384(88)90309-5

Kiefer, S. W., Rusiniak, K. W., Garcia, J., & Coil, J. D. (1981). Vagotomy facilitates extinction of conditioned taste aversions in rats. Journal of Comparative and Physiological Psychology, 95(1), 114-122. DOI: 10.1037/h0077751

Parker, L. A. (2003). Taste avoidance and taste aversion: evidence for two different processes. Learning & Behavior, 31(2), 165-172.

Riley, A. L., King, H. E., & Hurwitz, Z. E. (1998). Conditioned taste aversion: an annotated bibliography. Washington D.C.: University Press of America. Retrieved from http://www.american.edu/cas/psychology/psychopharmacology/

Rusiniak, K. W., Hankins, W. G., Garcia, J., & Brett, L. P. (1979). Flavor-illness aversions: potentiation of odor by taste in rats. Behavioral and Neural Biology, 25(1), 1-17. DOI: 10.1016/S0163-1047(79)90688-5

Stephenson, F. (2001). Toxic taste. Florida State University: Research in Review, Retrieved from http://www.rinr.fsu.edu/issue2001/taste.html

Image Sources

http://people.eku.edu/ritchisong/301images/rat_vagus.jpg
http://www.allaboutbirds.org/guide/house_finch/id
http://www.ncbiotech.org/