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6 Preadaptation and the Puzzles and Properties of Pleasure

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Sensory pleasures derive primarily from the contact senses that cover the body surface and the body apertures. It is proposed that, by the processes of preadaptation and increased accessibility, the subjective and expressive aspect of this pleasure system is, in later evolution and development, extended to a wider range of pleasure elicitors, including aesthetic and mastery pleasures. Many basic principles of hedonic systems may be studied in the more primitive sensory pleasure system. These include the properties of context dependence and the mappings between remembered, experienced, and anticipated pleasures. Pleasure in the food domain is specifically considered, including the elicitors of pleasure, the role of context, and the acquisition of likes and dislikes (hedonic changes). Special attention is paid to hedonic reversals, in which innately negative sensory hedonic responses become positive (for example, the case of chili pepper). It is argued that on the appraisal side, basic sensory pleasures are qualitatively different from aesthetic pleasures (such as music), but that both feed into the same subjective and expressive system. Some basic features of sensory pleasures are listed.

THE HUMAN BODY is physically defined by a sheath of skin, penetrated by seven holes. The sheath and holes are a veritable playground of pleasure and pain. Virtually all of the sensation-localizable pleasures we have, and many of the pains, are generated along this surface. Most sensations that come to us from this perforated sheath are hedonically tinged. The apertures, the salient points of entry and egress from the body—the mouth, nostrils, and genital and anal openings—are foci of affect, perhaps because of their critical and ambiguous (inside or outside of the body?) positions (Rozin et al., 1995). The aperture exception to this principle is the external auditory canals, but these are the only apertures not involved in material exchanges between the outside and inside of the body.

The notion that the "contact" senses (skin, taste, and smell) differ from the others in their close link to affect dates at least from Charles Sherrington (1906) and was elaborated in detail by Leonard Troland (1928). (The sense of smell holds an anomalous position as a "contact" sense. In some ways, it is an exteroceptor, detecting properties of objects in the outside world. However, it resembles taste and skin senses in two important ways: in the experience of flavor, the sense of smell is reporting on substances in contact with the body, and like taste, the stimulus itself [that is, its molecules] is actually incorporated in smelling [Rozin 1982a].)

Troland (1928) divides sensory inputs into the body into beneceptive (beneficial), nociceptive (harmful), and neutroceptive (neutral). The nociceptive systems include pain, negative signals from "stressed" organs, such as empty lungs or a full bladder, and certain chemical inputs such as bitter tastes and repugnant odors. The beneceptive system includes erotic and a range of gustatory and olfactory stimulation. Troland leaves touch out of this system, but it seems to me touch is principally beneceptive, particularly as it pertains to contact-comfort. Troland's neutroceptive system includes our two major sensory inputs, vision and audition, and touch as well. The neutroceptive inputs, as a rule, are informative rather than directly evaluative.

Troland is aware that these are only approximations, but they are in fact good approximations. He notes a clear correlation between sense modality and affective "loading," while recognizing that the same input channel can carry both nociceptive and beneceptive inputs (as when low salt levels are pleasant, and high salt levels are unpleasant). He summarizes his view by the claim that the nociceptive and beneceptive systems are reporting, by

and large, on the state of the organism, whereas the neutroceptive systems are reporting on the state of the environment.

We can add to Troland's conception that while the surface and aperture inputs signal both positive and negative affect, the internal, evaluative inputs indicate primarily that something is wrong, that is, they give rise almost entirely to pain (from the viscera, joints, or muscles). In a way, this can be interpreted to mean that for the body interior the normal state is neutral and only malfunction is signaled. From the perspective of the body interior, "no news is good news." For receptors that line the interface between the body and the world, good news is transmitted as well as bad news; the neutral state is a midpoint. Good news often has behavioral and survival implications (approach) over and above neutral news.

The functional and direct link between the contact (surface and aperture) and visceral senses and survival is too clear to require comment. It is the premise of this chapter that hedonic experiences originate in these systems, both phylogenetically and ontogenetically. Insofar as nonhuman animals have a conscious "pleasure" experience, we presume that it is closely related, via sensory systems, to basic needs, such as maintaining adequate nutrients, oxygen, and temperature, avoiding bodily harm, and encouraging social contact and reproduction.

Our previous analysis of the emotion of disgust (Rozin, Haidt, and McCauley 1993; Rozin, Haidt, McCauley, and Imada 1997) provides evidence that disgust began, both phylogenetically and ontogenetically, as part of a food rejection system. In evolution and development, the expressive and output side of this system remains more or less intact, while the domain of elicitors expands, depending on the culture and historical time, to include reminders of our animal nature (such as gore and death), contact with most other human beings, and certain types of moral offenses. We identify the process through which this occurs as preadaptation in the domain of cultural evolution. In biological evolution, preadaptation involves the co-opting of a structure or system involved for one function to another function (Mayr 1960; Bock 1959), and is a major force in large changes in evolution. An appropriate example is the human mouth, evolved for food and fluid intake and air input and output, and co-opted in later human evolution as a vocal output. The tongue and teeth, critical for speech production, evolved for purposes of handling food.

In cultural evolution, through socialization, the range of elicitors that tap into a basic biological system can be extended. As this process occurs ontogenetically, whether programmed biologically or by culturally prescribed experience, systems initially limited in their inputs become more widely used and generalized. This process, in development, I have called increased accessibility (Rozin 1976). The same type of analysis holds for food itself (Rozin 1996): a nutritive and sensory pleasure function expands to include the social, moral, and metaphorical domains.

Along the same lines, our pleasure system may have its origin in, and derive its basic character from, the fundamental life-protecting inputs from the skin surface and apertures. If so, to understand both the function of pleasure and its nature, examination of its primitive roots would seem to be an opportune strategy. That is the approach taken in this chapter.

This inquiry into the fundamental nature and function of pleasure focuses on the food system, which is a very appropriate choice, on the following grounds:

1. The food (nutrient procurement) system is one of the most basic and fundamental of all biological/behavioral systems
2. The relevant behaviors (unlike sex) are exercised very frequently.
3. Food is the only biologically based system that has its own dedicated emotion (disgust) and its own dedicated sense modality (taste).
4. Given that the apertures seem to be foci for pleasure, it is of note that the food system is heavily involved with holes. It lays claim to one of the holes (the mouth), invokes two more intimately in detecting and experiencing food (the nostrils), and provides the materials that "supply" the two excretory holes.
5. Unlike many of the other "primitive" biological systems, such as the needs for air and appropriate temperatures, the food system relies heavily on experience and hence becomes highly elaborated in human cultures. Indeed, some of the greatest cognitive demands facing the human omnivore have to do with finding an adequate food supply (for extensions of this argument, see Rozin 1996).
6. The wide range of food metaphors in English testifies to the foundational (preadaptive) role of the food system. That is, we use food terminology to describe many aspects of our lives, as when I say, "I hope this article is in good taste," or, "I will soon get to the meat of this chapter," or, "I hope the reader can stomach my approach and digest my arguments" (for

a full discussion of metaphor in this context, see Lakoff and Johnson 1980.

7. I have been studying this system in one way or another (from its biological to its cultural aspects) for most of my research career, so I have the relevant information at hand.

Even if the ideas about preadaptation and accessibility fail to hold up with respect to the food system, we can rest assured that we will be at least setting out to understand one of the major sources of pleasure for the human race, and the aspect of life that commands more of our currency (across all cultures) than any other. So this is not like a *Drosophila* or *E. coli* model system, which depends almost entirely on its generality.

I have argued that the food system is a foundation system, and that many preadaptations for general human systems originate in adaptations to making optimal food choices (Rozin 1996). There is also evidence that at least some cognitive abilities emerge first, in human children, in the context of food choice problems (Siegal 1996). When food is the focus, children are more inclined to behave in an adult, logical manner in dealing with the issues of contamination, distinguishing appearance from reality, and distinguishing lies from mistakes.

Much of this chapter is a presentation of what we know about pleasure in the food system of humans. But first, as an appetizer, I want to raise some fundamental issues about the nature of pleasure and some of the basic questions any student of pleasure must face. In my discussion of pleasure and food, I refer to these basic issues. In the final section, I summarize what we know about pleasure and evaluate the extent to which what we learn about food can be applied in other pleasure domains, particularly to that special domain of exquisite positive affect, music.

Pleasure Preliminaries

Our Ignorance About Pleasure

We know very little about pleasure from a natural science perspective. Few have tried to answer the basic questions. Pleasure has been of great interest to lay folk, philosophers, and Wilhelm Wundt, the founder of experimental psychology. In the middle of this century, Paul Thomas Young (see, for example, Young 1948, 1959, 1961) devoted much of his distinguished career to the study of affective processes in animals, and J. G. Beebe-Center (1932) did much the same for humans. Both tried to create a science based on pleasure. The emphasis on pleasure by both introspectionists and psychoanalysts, the two bêtes noires of behaviorism, relegated pleasure to a minor place in the behaviorist psychology of the mid-twentieth century. And the pleasure-laden apertures, dear to the heart of Freud, were perhaps for this very reason pushed aside as foci of concern in the middle and late twentieth century. One might almost say there was a reaction formation to the study of apertures and pleasure.

The idea was that pleasure is either very difficult or impossible to measure, and anyway, it might be an epiphenomenon, with no significance for understanding behavior. It could be translated into terms like reinforcement, changed probability of response, or utility without any loss (see critical discussion in Kahneman, Wakker, and Sarin 1997). From our current perspective, neither the measurement problems (which can be solved in many ways on the model of the very successful field of psychophysics) nor the easy substitutability of behavior for mental events are substantial arguments.

As of 1919, Edward Titchener complains: "The reason then, that our descriptive psychology of emotion is schematic rather than analytical is, simply, that experimental psychology has so far found neither the time nor the courage to take emotion into the laboratory" (471–72).

The Definition of Pleasure

According to the first of many definitions in the *Oxford English Dictionary,* pleasure is: "1.a. The condition of consciousness or sensation induced by the enjoyment or anticipation of what is felt or viewed as good or desirable."

In the long list of *Oxford* definitions, it is striking that none refer to the dimension of pleasure, used frequently in American conversation and modern psychology (for example, in scales of pleasantness). Thus, pleasure, pleasantness, and happiness all stand for both a state of affairs and a dimension that they anchor. Note that the opposite end of the dimension is the negated form of the positive term (displeasure, unpleasant, unhappy). One can invoke opposites for these words (aversion/pain, aversiveness/painfulness, or sad) but none of these words can be negated to generate the positive. ("Unaversive," "unpained," and, "unsad" don't sound right.) In English, it is quite reasonable to ask someone, "How pleasant was this?" and reasonable answers include: "very," "ex-

tremely unpleasant," and "50-50." One study of how these evaluative terms are treated in many different languages with respect to the asymmetries in both negation and naming of the dimension confirms that English is representative (Rozin, Berman, and Royzman 1999).

We will adopt a simple definition of pleasure: "a positive experienced state that we seek and that we try to maintain or enhance." Similarly, pain (or aversion) is "a negative experienced state that we avoid and that we try to reduce or eliminate."

These problems with the word *pleasure* may cause some to use the more precise but less familiar word *hedonic* or even Jeremy Bentham's (1789/1948) *utility*. I will continue to use the familiar word *pleasure* here, but will sometimes use the word *hedonic* to refer to the dimension.

The Types of Pleasure

There is no shortage of taxonomies of pleasure. Aristotle mentions two different aspects of pleasure: "Desire being appetite for what is pleasurable." (*De Anima,* 59); and "Pleasure perfects the activity" (*Nichomachean Ethics,* 595).

Karl Duncker (1941) deals with types of pleasure systematically in a thoughtful discussion of the nature of pleasure. He asks whether the object of pleasure is the wine, the drinking of the wine, or the sensory experience of drinking the wine. That is, respectively, the object, the communication with the object, or the experience of communication with the object. In the case of wine, the answer is clearly the last, the experience of the flavor. There is no such thing as free-floating pleasure; it must be "attached" to something. But that something need not be a sensory experience. Duncker develops a rich taxonomy at this point, and I will abbreviate and modify it here. There are three types of pleasures: sensory, aesthetic, and accomplishment pleasures. Sensory pleasures are tightly tied to sensory input and hence are physically localizable: we experience the pleasure of good food in our mouth. Aesthetic pleasures are more abstract, and not physically localizable, but linked to sensory input. Accomplishment pleasures derive from achieving something of value through mastery. (Some aesthetic pleasures may also involve mastery.) Duncker emphasizes the importance of such pleasures in terms of frequency and salience and describes this type of pleasure as hormic: "Hormism, then, is the theory that pleasure occurs when a conation, i.e., some striving for an object or goal, is being successful, while displeasure occurs when a conation is being frustrated" (392).

The focus of this chapter is on sensory pleasure because I suspect it is the most primitive and least complex. Also, in the phylogenetic or ontogenetic frame, it may be the anlage from which other types of pleasure are elaborated. Bentham (1789/1948) gives sensory pleasure a special, fundamental place. He holds that physical pleasure may operate independent of other pleasures (moral, political, and religious) and must be included in each of the other three. In short, he holds for the primacy of sensory (physical) pleasure.

The Temporal Frame of Pleasure

According to Aristotle: "What is pleasant is the activity of the present, the hope of the future, and the memory of the past" (*Nicomachean Ethics* Book 9, ch. 7). That is, at any point in time there are three temporal frames for pleasure. Troland (1928) sounds the same note, identifying three domains of pleasure: hedonism of the future, the present, and the past.

The attention of experimentally oriented students of pleasure has been almost entirely on the on-line, present experience of pleasure. However, in recent years Daniel Kahneman and his colleagues (Kahneman and Snell 1992; Kahneman et al. 1993; Kahneman et al. 1997; Frederickson and Kahneman 1993) have developed an analysis of pleasure (called utility by these authors) that incorporates the temporal frame. This distinction is also stressed by Jon Elster and George Loewenstein (1992) in their discussion of backward and forward consumption. The distinctions are between experienced (on-line, present) pleasure, remembered pleasure, and anticipated pleasure. Kahneman and his colleagues make a critical point: the mapping functions between experienced and either remembered or anticipated pleasure are complex and may be non-monotonic. For Kahneman, experienced pleasure is on-line and momentary, like brightness, and hence a sort of primitive. Integrated pleasure (the "experienced" pleasure of episodes) is a mentally constructed entity, which is accessed and/or reconstructed in remembered and anticipated pleasure. Experienced pleasure and pain, on this view, function to influence or guide the behavior of the moment; anticipated and remembered pleasure may guide ongoing behavior, but they also may participate in decisions and evaluations of future courses of action. Of course, a

remembered pleasure may be sufficiently vivid to function in many ways as an experienced pleasure.

In terms of real life, most pleasure may come from memory or anticipation, as opposed to online experience. The few seconds of experienced pain at a typical visit to the dentist are dwarfed by the displeasure of anticipation and by the frequent, frightful recalls of the experience after the fact. Although it may be most convenient to measure online pleasure, these measurements leave out a good part of the experience of pleasure. And it is critical to note that sensory pleasures remain sensory and localized in both memory and anticipation. We think we taste that delicious (or hopefully delicious) meal as we remember or savor it. The new line of work on pleasure from Kahneman and his associates opens up the temporal domain of pleasure, provides us with some experimental paradigms to explore it, and establishes an important theoretical and experimental agenda for an experimental hedonics.

One or Two Dimensions

In much of lay and experimental psychology, at least in the English-speaking world, the pleasure dimension is taken for granted. People easily use the hedonic dimension (for example, the nine-point scale anchored by "dislike extremely" and "like extremely"). However, these results indicate only that people are capable of combining or integrating experiences of varying hedonic qualities. There is abundant evidence that both people and animals can have simultaneous negative and positive hedonic experiences. Terms such as "bittersweet" applied to chocolate, or the simultaneous or near-simultaneous facial and bodily expression of pleasure and aversion in humans and laboratory rats (Berridge and Grill 1983), argue for co-occurrence. These behaviors are more easily interpreted as due to a simultaneous activation of two palatability dimensions than as a reflection of a neutral palatability. When increases in the magnitude of aversive responses are produced by increasing the bitterness of taste mixtures, there is not necessarily a reciprocal decrease in ingestive responses (Berridge and Grill 1983). This asymmetry supports the hypothesis of independent palatability dimensions. In the human domain, psychometric measures of positive and negative affect (as with the Positive Affect Negative Affect Scale [PANAS] are uncorrelated over short or long periods (Watson, Clark, and Tellegen 1988).

Christian Ruckmick (1925), in arguing for two dimensions of pleasure almost seventy-five years ago, notes that the pleasure/displeasure opposition is more logical than psychological. Hot and cold are opposites, but there is both psychological and physiological evidence that these two sensations are mediated by separate systems. The same may be true of pleasures. We should certainly not take for granted that pleasure is unidimensional.

The Purpose of Pleasure

It is easy to assign a function to pleasure as a guide for behavior: we behave so as to increase pleasure and remove pain (aversion). Such a function maps well onto the pleasures of eating or sex, and the avoidance of hunger for food or air or of extremes of temperature. Michel Cabanac (1971, 1985) has made this explicit and shows that in a number of systems, including temperature and food, pleasure covaries with departure from ideal physiological values, a phenomenon he calls alliesthesia.

Both instrumental and Pavlovian learning paradigms provide ways to accomplish the same ends without invoking the mental state of pleasure. Why not maintain the "easier" solution of just having mechanisms for increasing and decreasing the probability of behaviors? What Kahneman describes as "decision utility weighting" seems to do the job. This reasonable concern about the function of pleasure may be misplaced.

Although the decision utility account is more satisfying for behaviorally oriented scientists, it does not follow that such a solution is easier to instantiate in an actual organism: mother nature did not design animals and people so that they would be easy for psychologists to study (or hard for them to study either). Furthermore, there may actually be advantages to the experiential representation of utility.

First, even if pleasure is an epiphenomenon, some noncausal readout of the integrated utility function, it may be a powerful and useful indicator of the nature of that function. Second, pleasure as a mental event may function in the mental calculus of choice and decision-making. However, I must confess that none of the reasons I am about to propose are terribly convincing.

As systemwide experiences—that is, occupants of consciousness—hedonic experiences allow for translation into systemwide responses. In this sense, the general representation of hedonic state might function the way epinephrine functions as a hormone: it allows for a systemwide activation.

If the conscious system makes explicit and con-

sidered decisions, then the hedonic reports it receives become an appropriate condensed datum, in terms that influence conscious function.

To function well in any particular cultural context, humans have to learn a wide range of behaviors, values, beliefs, and so on. The investment of these values with affect, insofar as this is congruent with the cultural values, makes it easy for someone to function in the culture. That is, a properly enculturated person likes what his or her culture values, and dislikes what the culture shuns. Such a solution reduces conflict, allowing more time and energy for other life and social functions. Cultural values imply many positive as well as negative feelings. I have suggested elsewhere (Rozin 1982b) that these demands may account for the fact that humans have a strong proclivity to develop very strong, lifelong likings for all kinds of objects and activities. This may be a hedonic adaptation to culture; such strong acquired likes (outside of the human social domain) are very uncommon, so far as we know, in nonhuman animals.

Since humans plan for their future and use their past as a guide to their future, the instantiation of a salient, integrative representation of past and future experiences, that is, a remembered or anticipated and integrated hedonic value, may be a convenient shorthand for decision-making on-line (Kahneman et al. 1997). That is, the integrated affective memory or anticipation may be just what is needed to make sensible decisions now. If this is so, then there is substantial adaptive value in our mental representation of remembered and anticipated pleasure (utility).

These considerations are meant merely to raise the important issue of the function of hedonic experience. That function is still uncertain. Furthermore, certain features of hedonic experience, such as its presence or absence in particular activities, are extremely hard to explain functionally. An example discussed later concerns the fact that nausea produces food dislikes (a hedonic change), while other types of distress after eating produce avoidance but not dislike.

The Importance of Pleasure

How important is pleasure, and particularly sensory pleasure, in mental life? This has been a subject of dispute. From ancient Greece we have the opposed Epicurean and Stoic philosophies.

Perhaps the most famous quote, and the strongest position, comes from Jeremy Bentham (1789/1948): "Nature has placed mankind under the governance of two sovereign masters, *pain* and *pleasure*. It is for them alone to point out what we ought to do, as well as to determine what we shall do." And, later: "they govern us in all we do, in all we say, in all we think" (1).

It would seem fair to say that hedonic factors are clearly an important, that is to say, salient, and frequent part of human life. The normative side of this had best be left for others to discuss.

The importance of pleasure, especially sensory pleasure, no doubt varies across time and place. It is a feature of many of the philosophies from the Far East and South Asia that sensory pleasure is not very important, and that happiness comes from rising above it. For example, one of the sayings in the *Dhammapada,* the Buddhist prayer book, is "212. From pleasure comes grief, from pleasure comes fear; he who is free from pleasure neither sorrows nor fears" (34) (Babbitt 1936). These supposed differences refer, of course, not just to the experience of pleasure but to its motivational role, and the salience and frequency of remembered and anticipated pleasure in mental life. While it is clear that for Americans doing what is pleasant is a major part of living a successful life, this seems to be less the case for, among others, Hindus in India. Pleasure seems less important, and duty and tradition more important, in daily Hindu life. For example, in a questionnaire given to college students in the United States and India, 34 percent of Indian subjects and only 12 percent of Americans agreed with the statement "Whether or not an outcome of an action will be pleasant or unpleasant for me is not an important consideration." On the other hand, in evaluating the statement "Do your duty above all else," 86 percent of Hindu Indians expressed agreement, in contrast to 45 percent of Americans (Rozin, Grant, and Puhan 1997).

Food: Pleasures and Aversions

The Framework of Food Choice

Human beings are quintessential omnivores or generalists. They consider almost anything as a possible food. They share this status with such other worthy species as rats and cockroaches. The generalist strategy has the advantage of lack of dependence on the availability of any particular food; blights or competitors are not usually serious threats for generalists. But being a generalist entails problems as well. Many potential foods are

toxic, and the multiple nutrient requirements of animals place constraints on acceptable mixtures and amounts of different foods. Basically, generalists learn what to eat, and this learning is produced, in large part, by delayed feedback from the consequences of ingestion (for a detailed treatment, see Rozin and Schulkin 1990). The momentary and medium-term health rewards of finding and consuming a nutritious food are great, as are the dangers of consuming something toxic. As a result, it is not surprising that a great deal of affect is invested in the process of food selection.

Pleasure and Food

Food is one of the major sources of pleasure for human beings. In different parts of the world, at different times, it is also a source of distress either because of a lack of food or a surfeit. It is not surprising that the major champion of hedonics in animal psychology, Paul Thomas Young (1948, 1959, 1961), focused on food choice, and sweetness in particular, in his research on rats. Carl Pfaffman (1960), in his important paper "The Pleasures of Sensation," chooses food and taste as the model system. Other leading investigators of food choice, including Eliot Stellar (1974), Michele Cabanac (1971), Herbert Meiselman (1996), David Booth (1994), John Blundell (1980), Barbara Rolls (Rolls et al. 1986), Rose Marie Pangborn (1980), and Richard Shepherd (1989), have devoted attention to the pleasure dimension. In the hands of all of these investigators and others, hedonic scaling of foods is a commonplace activity. (For broad reviews of food consumption and choice, see the edited volumes Barker [1982] and Capaldi [1996]; and Meiselman and MacFie 1996.)

Pleasure and the Gustatory System

There is abundant evidence for sensory pleasure in the food system. Pfaffman (1960) lays out the case that the gustatory sensory inputs are substantially correlated with hedonic variables (figure 6.1). The sweet system is innately hedonically positive for rats and humans. When small amounts of stimulus are used (forestalling satiation), gustatory afferent discharge and hedonic response increase with stimulus intensity. For bitter tastes, increases in afferent input covary monotonically with decreases in liking. For salty tastes, the relation is not monotonic. While the afferent discharge increases with concentration, the hedonic function rises at low concentrations, and then falls to unpleasant with higher concentrations (all of these results are determined by hedonic ratings in humans and by short-term preference tests and/or analysis of facial and bodily gestures in rats [see, for example, Grill and Norgren 1978]). In all cases, and for sour tastes as well, there is a distinct functional relation between stimulus intensity and hedonic response.

The functional value of the salt, sweet, and bitter systems is obvious. Sweet signals calories (via fruit) in nature, salt is a dietary essential but may be harmful at high levels, and there is a substantial correlation between bitter taste and toxicity in nature.

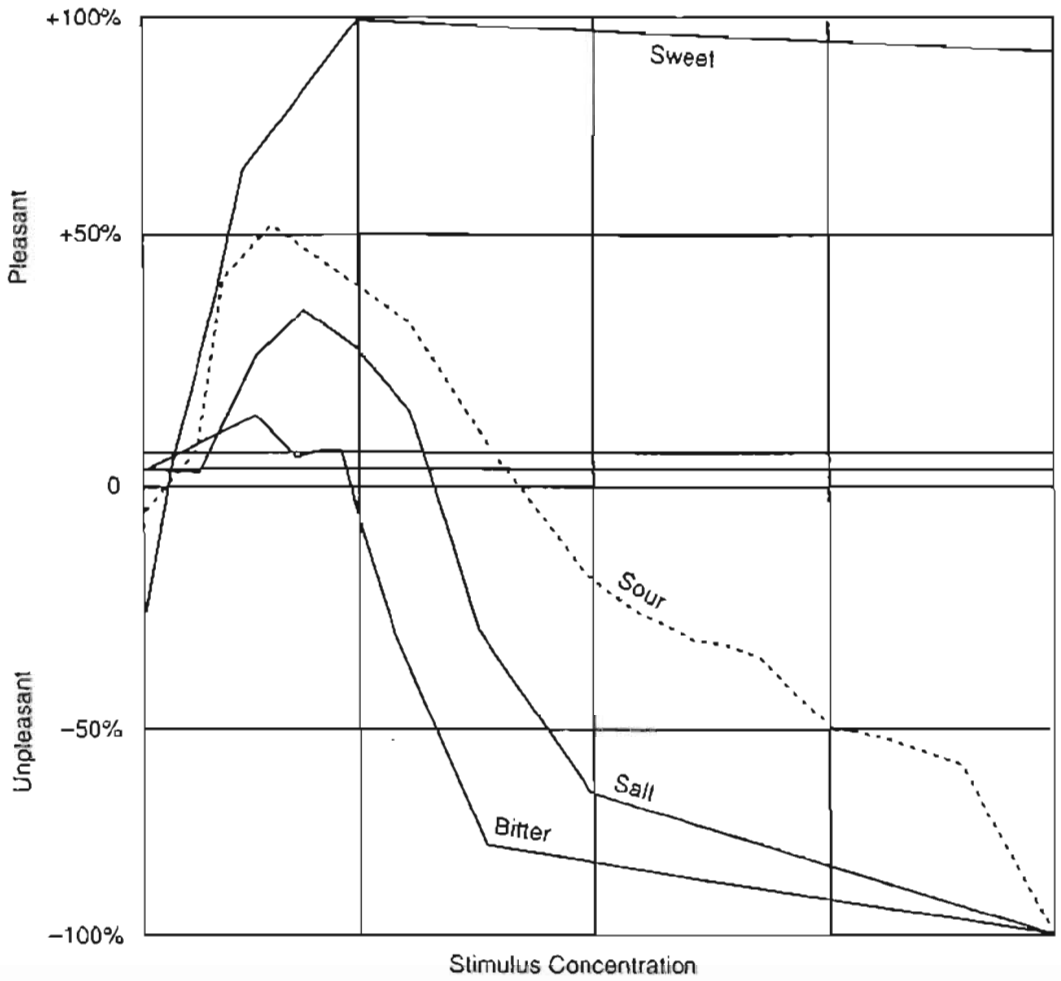
Jacob Steiner (1979; for confirmation with more objective techniques, see Rosenstein and Oster 1988) has demonstrated aversions to bitter and high levels of sour in human infants, and preferences (using facial expressions) for sugar. Humans probably also have an innate liking for the fatty texture (correlated in the real world with caloric value) and innate aversions for even low levels of irritating stimuli. Of course, fattiness and irritation are not transmitted by the taste system, narrowly conceived, but are food-relevant mouth sensations. Oddly, the biological significance of avoidance of sour (high-acid) or irritant foods (such as chili pepper or ginger) foods is not clear, since harmful concentrations of either of these stimulants do not exist in nature.

Hedonic response to mixtures of tastes is not predictable from algebraic combinations of hedonic ratings of the components. A particularly relevant example, for humans, is the complex palatability relationship between sweetness and fat. There is clearly an optimal combination, and it is far from maximal levels of each (Drewnowski and Greenwood 1983).

While much of the taste-related literature has explored solutions of pure chemicals and their combinations, real-world eating involves foods and beverages that are extremely complex in their gustatory and other oral and flavor properties. Rose Marie Pangborn (1980) pioneered the study of hedonic values in more complex stimuli (such as lemonade) and also demonstrated the wide degree of individual variation. For example, some people show monotonically increasing palatability with sugar concentration (depending on the vehicle); others, with the same vehicle, may show an inverted U or even a monotonically declining function (for a general review of sensory hedonic aspects of food choice, see Cardello, 1996).

The non-additivity of hedonic effects is abundantly clear when real foods are involved. For example, sugar may accentuate the palatability of

FIGURE 6.1 Pleasure Judgments in Relation to the Concentration of Taste Solutions



Source: Pfaffman 1960, 261.
Notes: The preponderance of "pleasant" or "unpleasant" judgments in relation to the concentration of taste solution. The ordinate gives percentage "pleasant" minus percentage "unpleasant." The abscissa is proportional to concentration, the full length of the baseline standing for 40 percent cane sugar, 1.12 percent tartaric acid, 10 percent sodium chlorine, and .004 percent quinine sulphate (by weight).

breakfast cereal, for Americans, but reduce the palatability of steak.

A Psychological Taxonomy of Foods

People eat foods, not nutrients (or pure substance solutions), so a psychological taxonomy of foods should not look at all like a nutritional classification. April Fallon and I (Rozin and Fallon 1980; Fallon and Rozin 1983) developed a psychological taxonomy of foods for Americans, by a process of interview and questionnaire. We believe the taxonomy that emerged holds for all cultures, although the foods that fall into the various categories will vary across cultures.

We begin with the set of all possible foods, then divide them, for any person, into accepted and rejected items. The results of the research indicate that acceptance or rejection can be motivated by three factors (see table 6.1): sensory-affective reasons (liking or disliking the sensory properties), anticipated consequences of ingestion (satiation, illness, and so on), and ideational reasons (knowledge of the nature or origin of the food). Only the first reason directly generates sensory pleasure (or displeasure).

The three reasons, alone or in combination, generate a set of relatively pure categories of rejection or acceptance. For rejection, there are four major categories.

TABLE 6.1 Psychological Food Taxonomy

Dimension	*Distaste*	*Danger*	*Inappropriate*	*Disgust*	*Good taste*	*Beneficial*	*Appropriate*	*Transvalued*
Sensory/affective	—			(−)	+			(+)
Anticipated consequences		—		(−)		+		(+)
Ideational			—	—			+	+
Examples	beer chili spinach	allergy foods carcinogens	grass sand	feces insect rotted foods	saccharine favorite foods	medicine healthy foods	ritual foods	leavings of heroes, loved ones, or deities

Source: Modified from Fallon and Rozin, 1983.
Note: Sign in parentheses indicates a statistical, but not a necessary relation, between a dimension and a food category.

Distastes are rejections based primarily on sensory properties. These include rejection of bitter foods and foods like broccoli or lima beans for those who reject them. Most within-culture individual differences in food choice result from differences in sensory/affective response.

Dangers are rejections based on anticipated negative consequences, short- or long-term. Rejection of tobacco, allergy foods, or fattening foods (for some) would fall under this category.

Inappropriates are rejections based on ideational grounds. The items in question are not considered a food, or edible, by the culture. Most objects in the world fall into this category, such as paper, pencils, rocks, and grass.

Disgust involves complex motivations. Disgusting entities are always rejected because of their nature or origin (ideational). However, they are virtually always thought to taste bad (distaste) by virtue of their ideational origin, and they are often perceived as dangerous. Disgust constitutes the strongest affective reaction to foods (for more on disgust in the food domain, see Rozin and Fallon 1987).

With respect to pleasure, note that two of the categories, distaste and disgust, involve negative reactions to the sensory properties of the foods, whereas the other two (danger and inappropriate) involve a more cognitively based rejection.

On the positive side, there are comparable categories, though the ideational categories have little import in most Western cultures. The major contrast is between good tastes and beneficials, the former being, once again, an example of sensory pleasure.

Of course, many foods do not fall neatly into one of these categories. Milk is both a good taste and beneficial for most Americans. But many foods do fall naturally into one of the categories.

Context Dependence

Experimental psychology has generally adopted an abstractive, elementaristic approach to the analysis of phenomena, including pleasure. The interaction term of Analyses of Variance (ANOVAS) is the major concession to the fundamental gestalt ideas of contextual influence. Thus, in the history of studies of pleasure in the food domain, the work is dominated by the use of simple tastants in aqueous solution and rarely by combinations of these, or by more general contextual change. Yet, for any layperson, the roles of context in food pleasure are enormous, such that almost any food could be judged pleasant or not in some context. We divide contextual influences into three types: simultaneous internal, simultaneous external, and successive external (for a full discussion of context effects, see Rozin and Tuorila 1993).

Simultaneous Internal Context The principal internal state related to pleasure interpretations of food is hunger. Cabanac (1971, 1985), in particular, has demonstrated that the pleasantness of simple food stimuli is a function of food deprivation (hunger). His concept of alliesthesia captures that idea: "A given stimulus can induce a pleasant or unpleasant sensation depending on the subject's internal state." Cabanac invokes this idea to account for the adaptive value of pleasure. There is minimal work on how hunger may differentially affect the pleasure of different foods. (Perhaps, for example, desserts are more resistant to hunger decrease than other types of foods.) Other internal

states, such as nausea, clearly influence the hedonic evaluation of foods.

Simultaneous External Context Events simultaneous with the experience of a target food stimulus have major effects on the reported hedonic value of that stimulus. There are a wide variety of taste or flavor interactions, internal as it were, to the target stimulus. These effects are sensory, perceptual, and cognitive and include taste interactions (Rozin and Tuorila 1993; Bartoshuk and Gent 1984) and culturally induced preferences (for example, salt taste is appropriate in some contexts [meats in the United States] and not in others [desserts in the United States]).

Construals of the nature and origin (ideational issues) of a potential food may dominate its sensory qualities. Subjects will rate the same odor as very unpleasant if they think it is from cat feces and as very pleasant if they think it comes from cheese. A buttermilk drinker will dislike the flavor and odor of what is construed as buttermilk if informed that it is actually spoiled milk (that is, spoiled in an unintentional way, as opposed to the intentional "spoiling" of buttermilk).

At the level of normal eating, where individual foods (spinach, or spinach soufflé) are the "units," there are a variety of cultural rules of "appropriateness" that determine acceptable (and hence pleasant) combinations. This idea has been developed by Howard Schutz (1989). Thus, in American culture, steak and ice cream are not eaten together and offer an unpleasant prospect. Similarly, occasions dictate the appropriateness of certain foods, so that for most Americans dry cereal is presumably liked more for breakfast than for dinner.

Successive External Context There are two extremely important aspects of successive or temporal context. One refers to the recent food experience environment of a person. The other refers to the interplay of remembered, experienced, and anticipated pleasures.

As with sensory phenomena, there is a great deal of adaptation in sensory pleasure. Some of this stems directly from sensory adaptation, which is extensive in the olfactory and some of the oral somatosensory (for example, irritation) systems. In a sense, the sensory pleasure system is doubly sensitive to sequence; the receptor input itself shows adaptation, and the central processes that "generate" pleasure are also inclined to adapt or habituate and to be sensitive to temporal context. Pleasure systems, like sensory systems, tend to be sensitive to change and to adapt to baselines. Harry Helson's (1964) ideas about adaptation level apply here, particularly as modernized and formalized by Allen Parducci (1995). Parducci has shown that the strong tendencies of humans to adjust to baselines and distribute evaluations in accordance with the range and frequencies of experiences shown in sensory systems also hold for the hedonic/happiness dimensions.

However, range-frequency effects do not account for the simplest of all exposure sequences—repeated responses to the same stimulus. Here, adaptation or habituation seems to occur. At least under some conditions (including moderately palatable foods and frequent exposures over periods of minutes to hours), repeated exposures to an already familiar food produce a nonpermanent decline in liking for that food. This phenomenon, originally described in animals by David Katz (1937) and Jacques LeMagnen (1956), has been studied extensively in the laboratory, with human subjects, by Barbara Rolls and her colleagues (Rolls et al. 1986). It is appropriately called sensory-specific satiety. The effect is usually modest in size and has been measured in terms of both reduced intake and reduced ratings of liking. One reason that sensory-specific satiety is very sensitive to the particular local conditions is that it is opposed by another basic process, the mere exposure effect (discussed later in the chapter), which generally produces increased liking with exposure.

A second basic temporal contextual feature, observed in the food as well as other systems, is the affective primacy effect. Under an as-yet-unspecified range of conditions, other things being equal, two primacy relations may hold: the stimuli at the beginning of a sequence are more potent in overall hedonic effect than those same stimuli at the end; the earlier in a small set of food stimuli will yield a more positive hedonic response. Norman Anderson and Ann Norman (1964) read the names of six foods/dishes to subjects and asked them to rate their liking for a meal composed of these foods in the specified order. Subjects rated meals that began with three liked foods, followed by three disliked foods, higher than meals presented in the reverse order. In paired comparisons involving actual sampling of either food or beverage products, Michael Dean (1980) found, with an appropriately counterbalanced design, that the item sampled first tends to be preferred. The resilience and size of affective primacy effects in the food domain have yet to be determined.

My own experience in talking to eaters suggests

that scaling and framing effects are very important in determining the pleasures of consuming a specific dish or meal. For example, in establishing the range of judgment, people have framing options with respect to unusual experiences. Having had a superb experience of a great red wine, some find that the subsequent very good wines pale in quality; they have anchored their scale with a very rare and high-quality experience. Others seem able to frame such very special culinary experiences "out of bounds" and are not so negatively affected following a great experience.

Most of humanity consumes most of its foods in the form of meals. Meals are culturally prescribed eating bouts, and they often include multiple dishes. The order of dishes is often culturally prescribed. More than one dish may be available at any given point in a meal. If so, individuals have some options as to how to temporally structure their own meals. Thus, a survey of American college students (Rozin 1998) indicates that faced with a typical main course of two to four items, some people complete their favorite item first, then finish each of the other items in turn. Others also eat one food at a time, saving the best for last, and still others systematically rotate through the available foods. About half of the respondents do not subscribe to any of these patterns and report no habitual pattern of which they are aware. Each of these patterns presumably generates different experienced and remembered pleasure.

There has been very little research on the experienced pleasure of meals made up of diverse food items. John Rogozenski and Howard Moskowitz (1982) obtained ratings of five-course meals (on a questionnaire) and modeled them with some success from weighted ratings of the individual foods made on a different questionnaire. The issue of remembered utility (pleasure) for meals has not been addressed, nor has the issue of hedonic contrast within a series of sampled foods or a meal. Along the lines suggested by Kahneman's experimental hedonics, it would presumably be possible to arrange a meal sequence (both the order of dishes and the style of consumption) that would maximize remembered pleasure.

The domain of food and eating is dominated by remembered and anticipated pleasures. The dinner reservation at a fine restaurant is an opportunity to savor for weeks (or months—or years for Girardet!) an experience that will last but a few hours. And the memories of a great, distinctive meal last a lifetime and fuel the anticipation of a return to the same site. (Unfortunately, regression to the mean usually intervenes.) This is the other side of the nasty visit to the dentist's office, where a few seconds of experienced pain gives rise to mountains of anxious anticipation and negative memories that are bad out of proportion to the actual experience in the dentist's chair.

Furthermore, meals are social events, in which eating is typically interposed with conversation perhaps about sports and politics and the like in the United States, and more likely about the food itself and the pleasure it induces in France. We have recently documented major differences in attitudes to food and eating in the French versus Americans: Americans tend to worry that they will eat too much of a really good meal, and the French tend to just anticipate it positively (Rozin, Fischler, et al. in press). So the general social context of a meal and cultural attitudes to eating will also strongly influence the sensory pleasure induced by the food. And of course, when it comes to fine cuisine, the line between sensory pleasure and aesthetics is often blurred.

The Acquisition or Change of Hedonic Value of Foods

Acquisition of Likes (Good Tastes) and Dislikes (Distastes) The catalog of innately liked tastes/flavors is very limited: there are biases toward liking sweet tastes and fatty textures, and biases toward avoiding irritation, bitterness, and strong tastes and flavors. In contrast to taste, the olfactory domain, while intensely "hedonic," comes with no innately hedonically valenced sensations (Bartoshuk 1991).

Almost everything an adult likes and dislikes is at least partly an acquired taste (distaste). What causes some things to become good tastes and others beneficials, or some things distastes and others dangers?

Research on acquired likes and dislikes focuses on humans because direct measures of pleasure can be obtained only from humans. However, principles borrowed from animal psychology, particularly the psychology of learning, have informed this work. Furthermore, the possibility of a parallel to human sensory pleasure in animals has allowed for tentative generalizations. The development of expressive facial/gestural measures of rat responses to food by Harvey Grill and Ralph Norgren (1978) provided a tool that licensed stronger inferences about experienced pleasure in laboratory animals.

The most robust procedure for producing he-

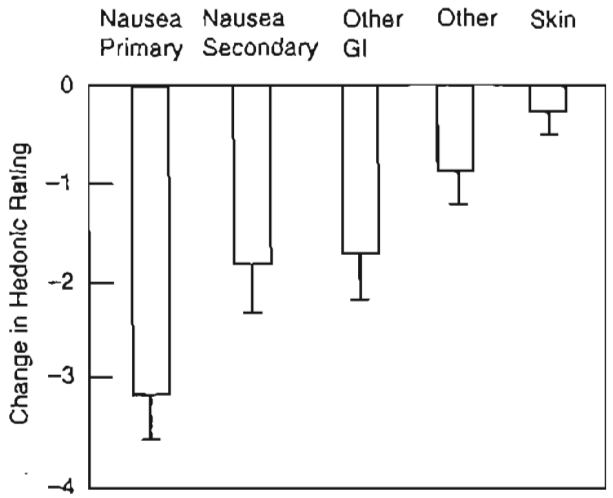
donic change in humans emerged directly from studies of taste aversions in the animal laboratory. The pairing of a preferred taste with any of a variety of negative events, including X-radiation and nausea-inducing drugs, led to a robust aversion (decrease in preference). These phenomena were known in the animal literature for a long time before 1966, when the classic demonstrations of John Garcia and his colleagues showed that aversions were learned with a long delay between conditioned stimulus (CS) and unconditioned stimulus (US) (reviewed in Garcia, Hankins, and Rusiniak 1974). The animal literature alone could not demonstrate that conditioned taste aversions involve a hedonic change—that the food CS now "tasted bad," that is, was an acquired distaste.

A number of questionnaire studies on humans (initially by Garb and Stunkard 1974) demonstrated by retrospective report a parallel phenomenon in humans, in which it was clear that illness following a food (especially a novel food) led to an acquired distaste for the food. Subsequent laboratory experiments on humans (for example, Bernstein 1978) confirmed this.

The next two steps in establishing taste aversion learning as the quintessential example of experimentally induced hedonic change were taken by my student, Marcia Pelchat, in her doctoral dissertation. A retrospective questionnaire indicated that only USs that had a nausea component reliably produced acquired distastes. Other negative consequences following ingestion, such as lower gut problems, or allergy symptoms such as skin eruptions or respiratory distress produced dangers (that is, avoidance), but not distastes (figure 6.2) (Pelchat and Rozin 1982). Nausea appeared to be the magic bullet that produced distastes.

This analysis was extended to laboratory rats, using Grill and Norgren's (1978) analysis of facial and bodily gestures associated with consumption of bitter and other aversive solutions. Assuming that these expressions indicated distaste, Pelchat and her collaborators (1983) monitored these responses in rats after Pavlovian pairings of sweet tastes with a variety of USs. The results were extremely clear, and very supportive of the nausea-distaste link. Sweet avoidance responses produced with intragastric lithium chloride, a substance that produces nausea in animals and humans, reliably induce aversion gestures (such as a gape) when the CS solution is offered post-conditioning. Strong avoidance (danger categorization) but rare aversion expressions occur when the US is either electric shock to the foot or intragastric lactose, which produces lower rather than upper gut distress (figure 6.3) (for related findings see Parker 1982).

FIGURE 6.2 Relation of Human Taste Aversions to Negative Events



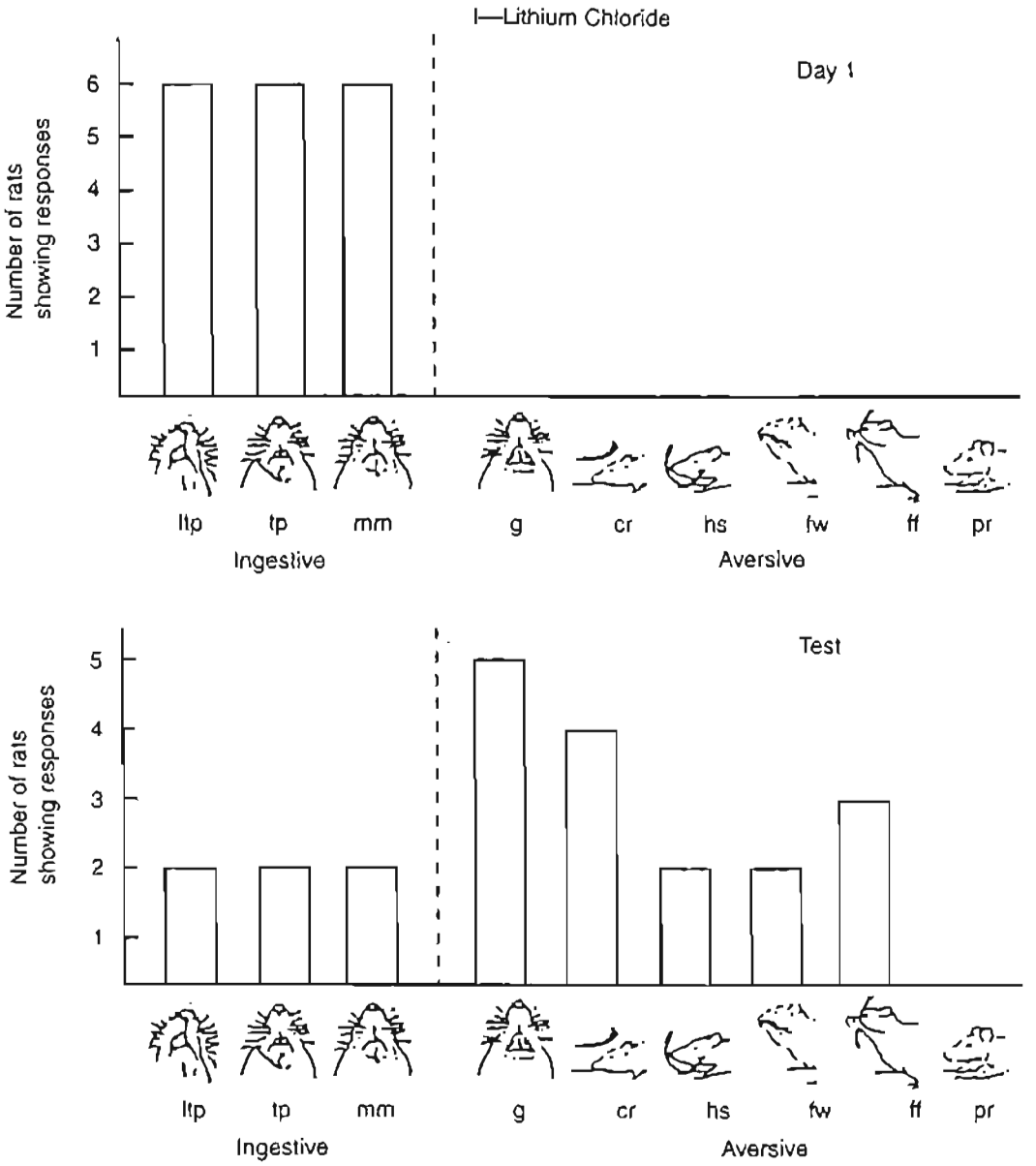
Source: Pelchat and Rozin 1982, 345.

Notes: Taste aversions in humans as a function of type of negative event. Subjects self-reported on experiences in which ingestion of a food was followed by a negative event. The food in question was rated on a 1 (extremely unpleasant) to 9 (extremely pleasant) scale for before and after the event. Subjects also indicated features of the negative event, designating one of these as the primary feature. The mean change in liking (rating-after minus rating-before) is presented as a function of type of negative event. Negative events are characterized, on the abscissa, as "Nausea primary" (nausea or vomiting is the primary feature), "Nausea secondary" (nausea or vomiting is a nonprimary feature), "Other GI" (gastrointestinal symptoms other than nausea or vomiting are primary), "Other" (items that did not fit in any of the other categories, such as respiratory distress, cardiovascular problems, systemic shock, or reception of very upsetting news, such as the death of a loved one), and "Skin" (skin symptoms, usually allergenic, such as rashes).

These nausea "magic bullet" experiments establish a Pavlovian pathway for hedonic change. The change is dramatic, occurs in one trial, and is the best experimental and real-world example of acquired hedonic change. Our recent evidence indicates that for both human taste aversions and phobias (with frightening USs) there are many occasions when the appropriate pairings occur in real life but hedonic changes do not occur (Rozin, Wrzesniewski, and Byrnes 1998). We do not yet know what contextual conditions promote or retard this type of hedonic change, but the novelty of the CS is surely important.

A second problem raised by the taste aversion studies has to do with the adaptive value of hedonic change, and of hedonic responses them-

FIGURE 6.3 Orofacial Responses of Poisoned Rats to Sucrose: Relation of Taste Aversions in Rats to Negative Events



Source: Pelchat, Grill, Rozin, and Jacobs (1983). Copyright 1983 the American Psychological Association.

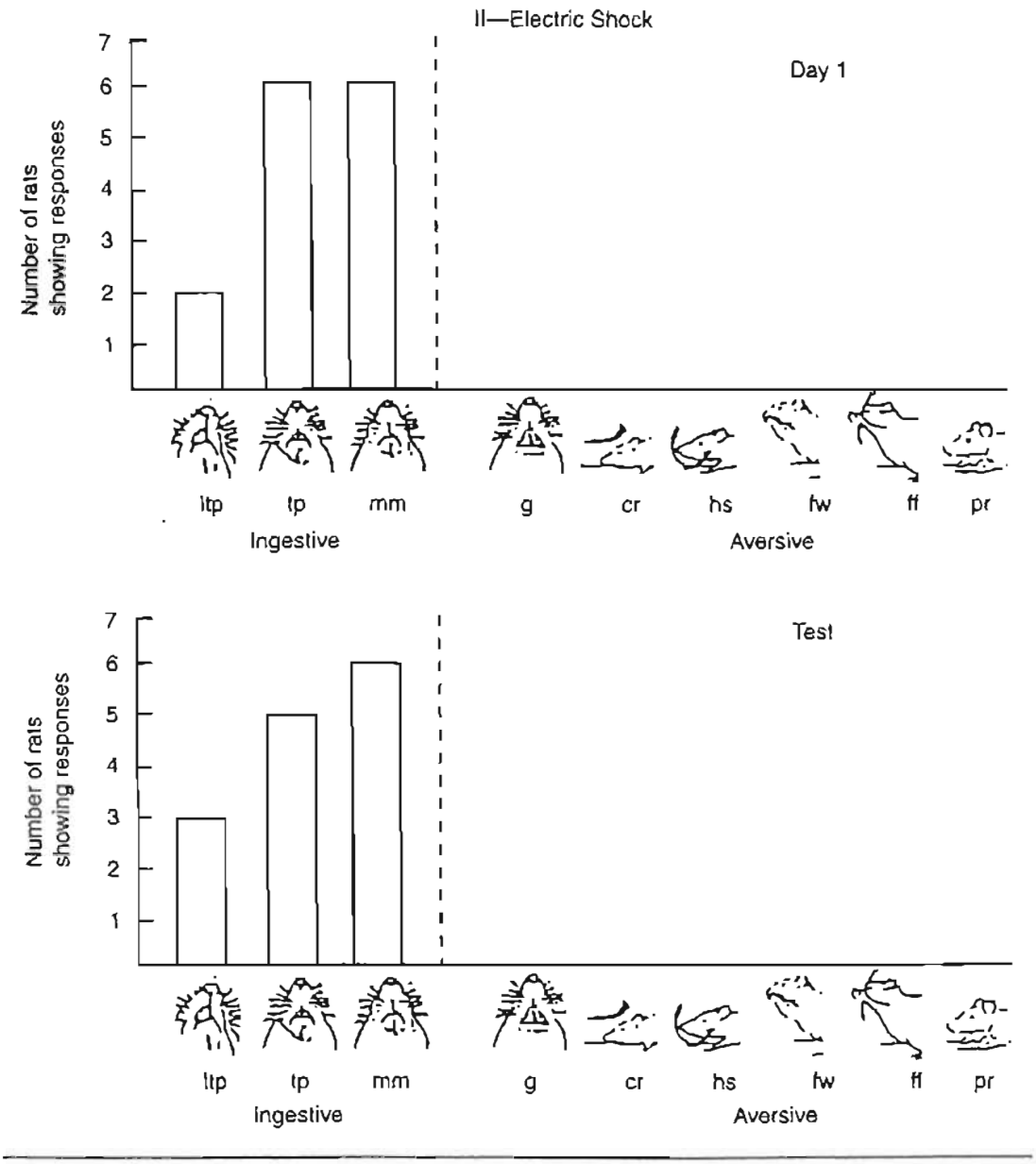
Notes: Orofacial responses of rats before and after exposure to pairings between sucrose ingestion and one of three negative events: (I) intragastric lithium chloride (LiCl) believed to induce nausea; (II) electric shock; (III) intragastric intubation of lactose, which induces lower gastrointestinal symptoms (such as cramps in humans) and diarrhea, but little nausea. Graphs show the number of rats (five or six per group, as indicated) who display the indicated behavior. The three positive followed by six negative orofacial responses are designated on the abscissa. ltp = lateral tongue protrusions, tp = tongue protrusions, mm = mouth movements, g = gape, cr = chin rub, hs = head shaking, fw = face washing, ff = forelimb flailing, pr = paw rubbing.

(*Figure continued on p. 122.*)

selves. Nausea USs lead to hedonic changes, and most other USs do not. Why? What is the adaptive value of endowing nausea with a qualitatively different (hedonic) change as opposed to other events including gut pain? We don't know and suspect that the answer to this question may tell us something about the functions of hedonic systems.

Taste aversions are an example of Pavlovian procedures that induce hedonic change. The general process has been called evaluative conditioning. It

FIGURE 6.3 *Continued*

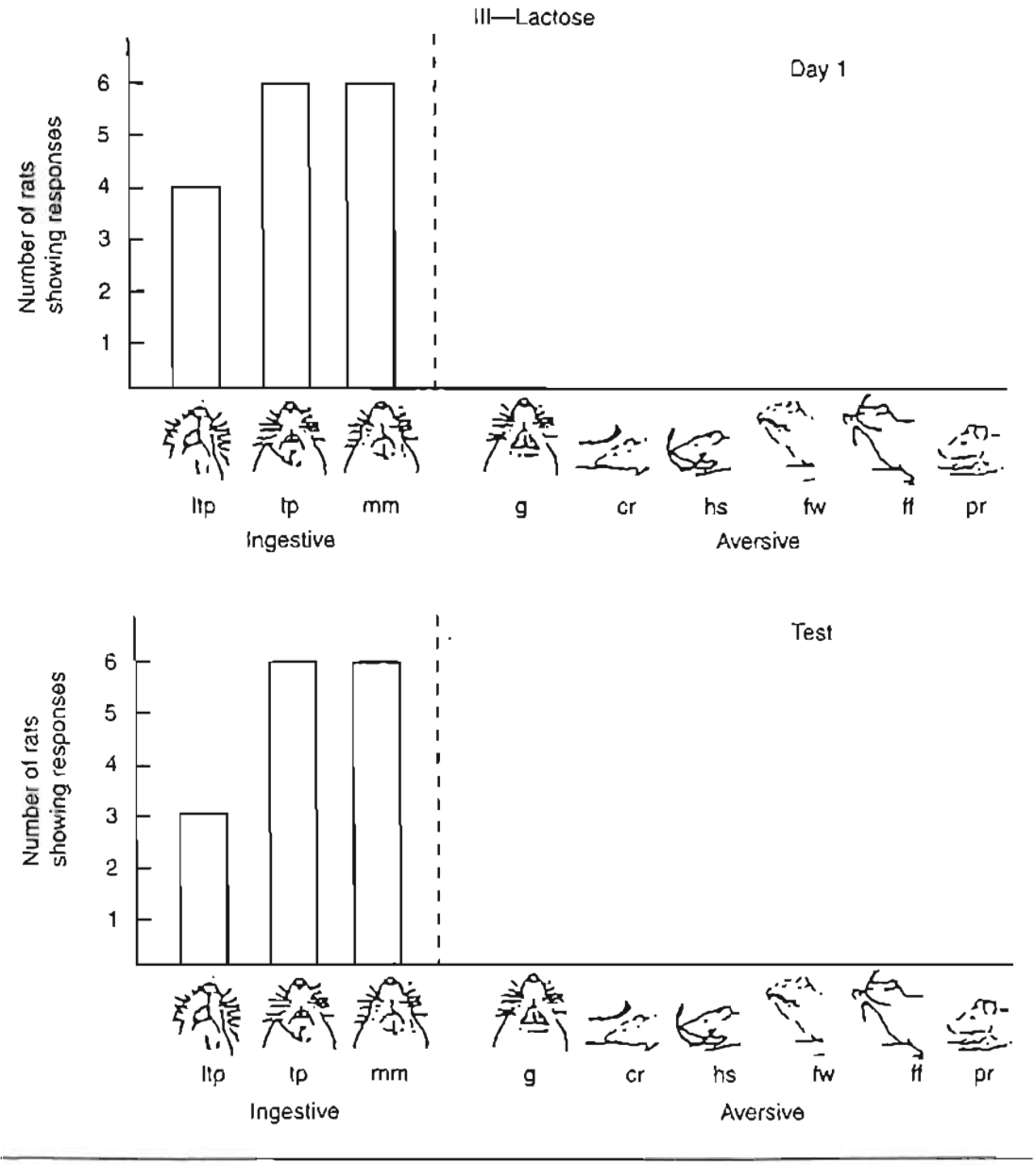


was originally described and named as a laboratory phenomenon by Irene Martin and A. B. Levey (1978), using visual stimuli of neutral and negative or positive valence as CSs and USs, respectively. Evaluative conditioning has been studied systematically by a group of Belgian psychologists under the leadership of Frank Baeyens. Both positive and negative evaluative conditioning have been demonstrated, using visual (Baeyens et al. 1988, 1991), olfactory (Todrank et al. 1995), and taste/flavor stimuli (Zellner et al. 1983; Baeyens et al. 1990; for a review of Pavlovian conditioning with respect to changes in food preferences, see Rozin and Zellner 1985).

Taste aversion learning seems somewhat atypical of other examples of evaluative conditioning. It occurs very rapidly, is a robust effect, and is not strongly resistant to extinction. Evaluative conditioning usually requires multiple trials, is a modest-sized effect, and is surprisingly resistant to extinction (Baeyens et al. 1988, 1991). In the food domain, aside from nausea-based taste aversions, the two major evaluative conditioning effects demonstrated prior to 1995 were increases in liking for flavors paired with a sugar US (Zellner et al. 1983) and decreases in liking for flavors paired with a disliked US (Baeyens et al. 1990).

Evaluative conditioning is one of the two well-documented models of hedonic change for foods and other stimuli. It is very likely that many common acquired likes, such as for coffee, occur

FIGURE 6.3 *Continued*



through a procedure like evaluative conditioning. When first introduced, coffee is often made very sweet, and the strong taste is softened with milk or cream. For many people, after many such experiences, the coffee flavor alone becomes liked, in the absence of milk or sugar.

Internal USs (such as relief of hunger) also function in evaluative conditioning (although we all know many highly nutritive foods that we don't like). There are surprisingly few studies on humans of satiation-induced liking, but David Booth and his collaborators have produced one empirical demonstration of enhanced liking, when the subject is trained and tested hungry, for a flavor associated with substantial caloric repletion (Booth, Mather, and Fuller 1982).

In the real world, it is likely that the most powerful US is social, perhaps the appearance of a respected other enjoying (or detesting) a particular event or food. Recently, Baeyens and his colleagues (Baeyens et al. 1996) have reported the first laboratory demonstration of a hedonic shift with a social US. Adult subjects watched videotapes in which a demonstrator person sampled various beverages in distinctive glasses and indicated pleasure or displeasure facially. Beverages varied in

color, and the glass shapes also varied. One of the glass shapes (with or without a "foot") was contingently paired with expressed pleasure, the other with expressed displeasure. Subjects showed a relative increase in liking for the glass shape paired with the pleasure expression. This is just the beginning of what should be some major investigations of hedonic shift in a social Pavlovian framework. Sylvan Tomkins (1963) raises the interesting possibility that observations of emotional expressions in others induces the parallel emotion in the observer. This internal representation can then serve as the US for evaluative conditioning.

The second well-documented mechanism for hedonic shift is mere exposure, a phenomenon that occurs in both animals and humans. As Robert Zajonc (1968) has forcefully shown from research covering a wide domain of stimuli and situations, exposure, in and of itself, tends to promote liking. This is a modest-sized effect that operates over a broad range of stimuli and conditions. It is limited by boredom effects resulting from high levels of exposure and/or very frequent exposure, but the basic effect is substantial and important (for a recent review of conditions that increase or reduce mere exposure effects, see Bornstein 1989). Mere exposure effects have been demonstrated in the laboratory with foods by Patricia Pliner (1982) and Leann Birch and Diane Marlin (1982), among others.

There are no doubt other pathways to hedonic change in the food domain, but none have been well documented. A variety of possible channels of social influence, besides Pavlovian conditioning, are likely to produce changes. Prominent among these are perceptions that respected others like or dislike a food, or value it in some other way (for reviews, see Birch 1987; Rozin and Vollmecke 1986). The literature in social psychology on intrinsic value (for example, Lepper 1983; Deci and Ryan 1985) offers evidence about what promotes and deters hedonic change. According to the "minimal sufficiency" principle, overt reward for consumption of a food may ultimately decrease the liking for it, while more subtle approval may promote liking or discourage a decrease in liking. Applications of this idea to the food domain have been reported (see, for example, Birch et al. 1982).

The Acquisition of Disgust The aversion to disgusting entities is based on ideational factors. We might find a food quite tasty and then, hearing that it was seal meat, find the taste repulsive. Because disgust is so strong and specific, it offers the prospect of being a natural arena in which to discover some general principles of hedonic shift (Rozin and Fallon 1987). Disgusting entities are so powerful that they are contaminants: contact between a disgusting item and an otherwise edible item renders that item inedible, and disgusting. Thus, one way to transfer negative affect to an object is to touch it to an already disgusting object. This affective route is captured in the sympathetical magical law of contagion, "once in contact, always in contact" (for a review, see Rozin and Nemeroff 1990).

Feces is a universal disgust substance. This reaction seems to be acquired, perhaps at least in part in the process of toilet training. It may be that affective displays by parents and others in the presence of feces help to endow feces with its powerful negative affective properties, but we really do not know how this process occurs. Disgust, as a powerful negative-affective force, becomes a principal instrument of socialization; a very effective way to enforce a cultural prohibition is to make the act or object disgusting.

Disgust is also a quintessential example of an affective-cognitive link, in which a cognition (for example, of a particular origin) produces a major hedonic shift. Discovery of the contents of an attractive-looking food morsel, or of the way a food animal was killed, can rapidly generate disgust.

We have been exploring some of these hedonic shifts in the context of the emergence of vegetarianism. It seems that disgust toward meat is promoted if a person holds to the immorality of killing animals, as opposed to the position that meat is just unhealthy (Rozin, Markwith, and Stoess 1997). That is, the involvement of a negative moral issue promotes the development of disgust, and disgust may further reinforce the negative moral response. Indeed, cross-culturally, disgust is an emotion that represents what the culture in question finds to be offensive. In the frame of preadaptation discussed earlier, disgust provides a prime example of how a food rejection system becomes co-opted and released by a wide range of meanings and elicitors, including death and a variety of moral violations (Rozin, Haidt, and McCauley 1993; Rozin, Haidt, et al. 1997).

The Reversal of Innate Aversions Human beings frequently, and uniquely, come to like objects and situations that innately give rise to fear or aversion. Roller-coaster riding and sad or horror movies are salient instances. The food domain is replete with examples: innately aversive oral experiences such

as coffee, beer, spirits, wine, tobacco, high levels of salt, carbonated beverages, and irritant spices (for example, chili pepper, black pepper, ginger) are among the most preferred foods and drinks on the planet. The irritant and bitter (or other strong) properties of these foods successfully deter other mammals from ingesting them, but humans have found pleasure where others find pain.

Hedonic reversals may be particularly informative, since the hedonic changes that occur are so large. There are almost no good examples of acquisition of likes for innately unpalatable substances in any nonhuman mammal. Extensive exposure of rats, in the food context, to either bitter tastes (Warren and Pfaffman 1958) or irritant sensations, such as chili pepper (Rozin, Gruss, and Berk 1979) does not induce a positive preference, or even any permanent reduction of aversion. Unlike their human owners, the animals in a Mexican village who regularly eat chili pepper on food in the garbage do not come to like it (reviewed in Rozin 1990). The only positive cases (presented and reviewed in Rozin and Kennel 1983) are a few pet primates and one pet dog, all of whom consumed "hot" food in the company of humans and developed actual likes for piquant foods.

We initiated studies of the acquisition of a liking for chili pepper as an example of hedonic reversal (reviewed in Rozin 1990). Chili pepper seemed like a good model system, since chili peppers are the most widely consumed spice in the world (well over one billion eager users), and they are neither harmful nor addictive, unlike some other innately unpalatable foods.

The situation, in brief, is as follows (for more details, see Rozin 1990). Chili peppers contain a set of chemicals called capsaicins, which cause irritation of mucus membranes; they cause pain. The peppers are actually harmless; the irritation is a sensory phenomenon, and any tissue damage that results from high levels of capsaicin on a sensitive surface results not directly from the stimulus but from the body's response to it.

The oral irritation produced by chilies is innately aversive. The evidence indicates that those who come to like chili pepper receive roughly the same neural signal from their mouths as those who do not. That is, the change is not peripheral; the same central input, once judged to be negative and painful, becomes pleasant after some substantial experience, often spreading over months or years. It is the very same sensory features of irritation that initially promote rejection, that later become attractive.

The strength of the attraction to the trigeminally mediated oral irritation experience is indicated by the wholesale adoption of chili peppers, especially in tropical Africa and Asia, when these became available after the discovery of the Americas by the European explorers of the fifteenth and sixteenth centuries.

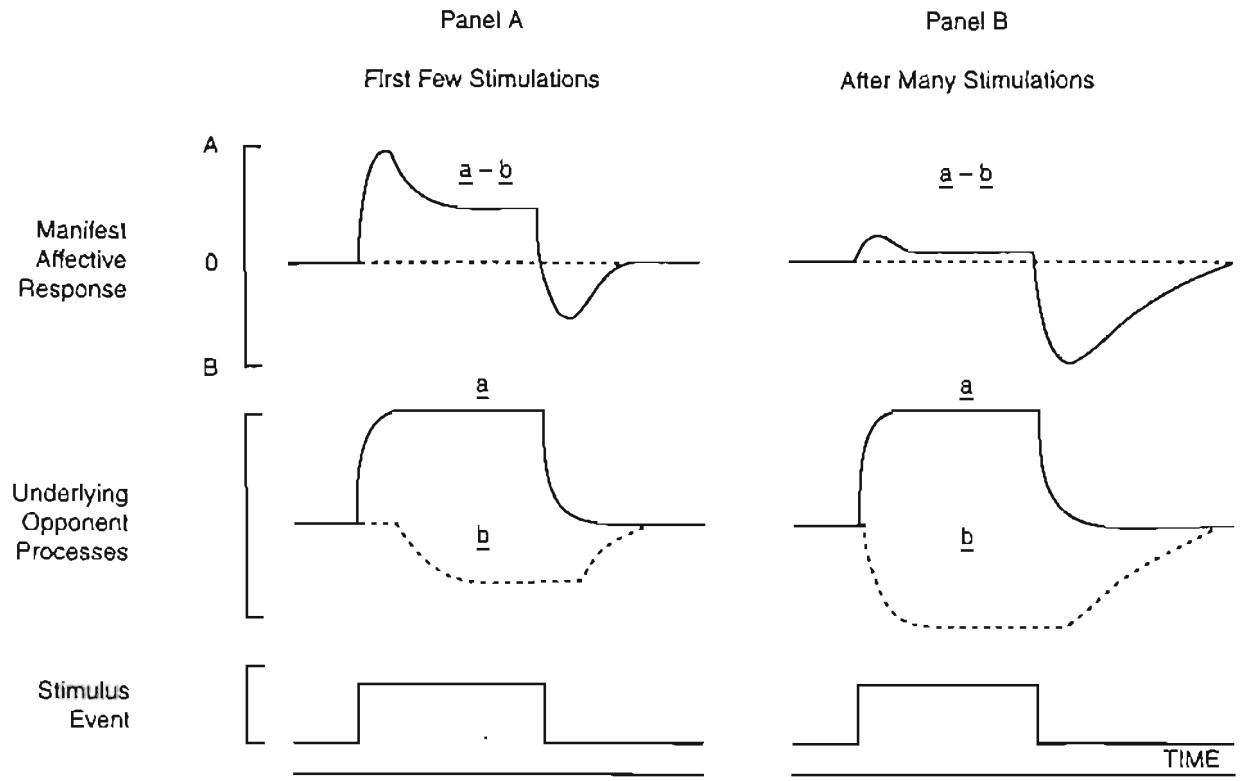
Mexican children come to like the burn of chilies sometime between four and seven years of age. This happens rather naturally in the course of eating with their families, observing their older family members eating and enjoying chilies and being offered mildly seasoned foods by their parents (Rozin and Schiller 1980). The hedonic reversal associated with chili pepper is "surface-specific." Getting to like the burn in one's mouth does not cause one to like the burn in one's eyes. We do not know whether exposure of only one part of the mouth to chili pepper would cause only that part to "like it."

The mechanism of the chili pepper hedonic reversal (or any other reversal) is not known. Mere exposure, evaluative conditioning, and a variety of social conditions already cited as promoting liking are present. But there are two other mechanisms of the hedonic reversal that require, as a precondition, an initial aversion.

First is the idea of opponent processes (Solomon 1980). According to this attractive view, the body achieves homeostasis, in part, by canceling out any departure from an optimal position (an A process) by generating an opposite, countervailing departure (B process). The opponent concept is embellished with three additional assumptions: (1) with exercise, the B process becomes larger in magnitude; (2) with exercise, the B process shows a more rapid onset and a much longer time course, which extends well beyond the termination of the stimulus-bound A process; (3) the changes described in (1) and (2) occur only when the A process is reinstigated before the prior B process has disappeared. The dynamics of the system are illustrated in figure 6.4. Solomon uses opiate addiction as a model system. By the opponent analysis, tolerance occurs because the building B process reduces the effect of the A process (assumption 1). Withdrawal follows from the second assumption; as the A process dissipates, what remains is a large, sluggish B process, which produces symptoms opposite to those induced by the A process.

The opponent model is about more than hedonic change, but it certainly encompasses hedonic change. For the case of chili peppers, the pain discomfort of the oral burn is the A process,

FIGURE 6.4 Opponent Process Theory



Source: Solomon 1980, 700. Copyright 1980 the American Psychological Association.
Notes: Schematic representation of opponent process theory. Panel A represents the balance of A and B responses for the first few exposures. Panel B represents the A and B responses after repeated exposures. The manifest response is the summation of the two underlying processes.

and a hypothetical compensating "pleasure" B process is generated in the brain. Over many experiences, the B process would come to dominate the A process. (In the original model, it was not assumed that the B process can dominate the A process while the A process is near its peak.) Thus, pain becomes pleasure, and there is a pleasant afterglow. The opponent model tracks the process of getting to like chili pepper rather well. However, there is minimal evidence for the opponent processes model other than that it tracks the sequence of either opiate addiction or chili liking. For example, there are no signs of a positive afterglow (B process) following an early negative hedonic experience with chili pepper (Rozin, Ebert, and Schull 1982).

The opponent model stands as an interesting, unproven account of hedonic changes. A second version of the hypothesis, put forth by Siegel (1977) and Schull (1979), holds that the B process, rather than being an innately determined part of the system, is a conditioned compensatory response. Siegel has accumulated evidence for the existence of such compensatory conditioning processes in drug addiction in both rats and humans.

Either opponent model requires multiple experiences in order to generate the full-blown opponent response. Normally when one encounters a hedonically negative situation, one subsequently avoids it. The multiple experiences, for drug addiction or chili use, are created by social pressures (from addicted companions or family members, respectively). Why else would one continue to assault one's mouth with something that burns?

For the case of chili pepper and other initially painful experiences, it is natural to assume that the B process is instantiated by the secretion of brain endorphins. Oversecretion of these, as a result of the augmenting B process, would be a natural channel for converting pain to pleasure. We have tried to demonstrate such effects with chili pepper, but with results that are only suggestive (see discussion in Rozin 1990).

The final model for hedonic reversal is what we call benign masochism (Rozin and Schiller 1980; Rozin 1990). It holds that the whole range of human pleasures that derive from negative emotions or aversions is based directly upon the experience of negative sensations and experiences. We may

come to enjoy our body's negative responses to situations when we realize that there is no, or minimal, actual danger. In the case of the roller coaster, our body is scared, and sympathetically activated, but we know we are safe. Similarly for our crying in sad movies, and the burn we feel with chili pepper. Our mouth is saying, "Get this out of here," but we know it is safe. This type of enjoyment of constrained risk is related to Zuckerman's (1979) sensation-seeking. One appeal of the benign masochism model—mind-over-matter or -body model—is that it is the only one that neatly explains why hedonic reversals are common in humans but very rare in animals. (Can you imagine cats lining up to get on roller coasters or to do recreational parachute jumping?) The evidence for this model, in the domain of chili pepper, is that (1) the peak burn intensity preference for chili likers is often just below the level they claim is overtly painful and negative, and (2) many chili likers enjoy the body's defensive reaction to high levels of chili pepper: sweating, nose running, and eyes tearing (Rozin 1990).

Daniel Berlyne (1971) suggests a similar account for the many human hedonic reversals, or what I call the human proclivity to "play with fire." He assembles some quotes from major thinkers on this point. A. Doring (1890) suggests that there is pleasure in the inhibition of an aversion system, and that it is one of the properties of aesthetic systems. Closest to the mark of benign masochism is Edmund Burke's (1757) account of the sublime: "When we have an idea of pain and danger, without being actually in such circumstances" (quoted in Berlyne 1971, 94). Immanuel Kant (1790/1966) contributes a similar idea: the dynamically sublime "must be represented as exciting fear." It is identified as "might that has no dominion over us." Kant explains further that "there accompanies the reception of an object as sublime a pleasure, which is only possible through the medium of pain" (quoted in Berlyne 1971, 94). We presume that if there is truth in these accounts, it may be limited to *Homo sapiens*. They may all be linked to our enjoyment of arousal, within limits (Berlyne 1971).

Principles of Pleasure: A Comparison of the Domains of Food and Music

We can agree that:

1. Pleasure is a subjective (mental) experience.
2. Pleasure is a salient part of mental life.
3. Pleasure has a motivating function: we seek to maintain it or induce it, and to avoid its "opposite," pain.
4. Pleasures exist in three temporal frames: remembered, experienced, and anticipated.
5. There is something in common (at least items 1 through 4) for all the pleasures we experience, from a very wide domain of elicitors and activities.
6. There are at least three types of pleasures: sensory, aesthetic, and mastery.

Now we shall consider differences between two very different types of pleasures.

Differences Between Food and Music as Pleasures

Even for elaborated culinary experiences, the pleasures of food have a sensory quality, a palatability. We experience the pleasure as coming from the mouth, even as some of the experiences we have result from "palate training." Many of the pleasures of eating seem to involve little cognitive processing.

The pleasures of music are not localizable. They are not in our ear; they are generally not like the soothing sound of ocean waves at the shore. Stimulus "analysis" seems to be much more a part of music appreciation than of food appreciation. Chocolate and Mozart are not equally complex, and they are not complex in the same way. In the terminology proposed by Kubovy (this volume), chocolate is a pleasure of the body, and music a pleasure of the mind.

The most psychologically appealing account of the enjoyment of music comes from Leonard Meyer (1956). He holds an implication/realization model. As we listen to Mozart, we internalize the stylistic structure, develop expectations for the music, and get pleasure when they are realized. Until we have sufficient exposure to get a sense of the style, we cannot fully enjoy the music. On the other hand, a new piece of a familiar style fits our expectations in general but violates them in detail. It is the partial match that is pleasurable, and the lack of a complete match that keeps us from being bored. William Gaver and George Mandler (1987) build on Meyer's formulation, placing relatively more emphasis on the development of schemas of the musical structure, and less attention than Meyer on the importance of innate gestalt principles in providing the structure. Gaver and Mandler argue that discrepancy between the music and the schema is arousing, and that when this discrepancy is rather small and resolvable, there is the pleasure of a match energized by the arousal produced by the slight mismatch.

There is a serious problem with the Meyer formulation. Why do we continue to enjoy the same piece of music year after year? We know what is going to happen; we don't have expectations, we have knowledge. Meyer handles this problem in two ways: (1) in different performances, the music is actually subtly different; (2) because memory is less than perfect, we still get expectation/realization pleasure after many hearings. A much more satisfactory solution, and one that is of great psychological interest, comes from Meyer's former student, Eugene Narmour (1991).

Narmour holds that there are a set of innate expectations for sequences of auditory inputs. For example, we expect patterns to continue (a reasonable assumption about the world). We expect repetitions to continue, and we expect rising short intervals to be followed by more rising intervals. However, we expect a large change in tonality to be followed by a "corrective" movement, headed toward the original note. Narmour holds that these innate expectations are unbidden and unchangeable. This bottom-up expectation system has superimposed upon it a top-down, acquired style expectation system of the sort Meyer postulated. The result is that modest violations of innate expectations by composers continue to produce the arousal or tension that prevents boredom. And it is this tension resolution that would seem to be at least some of the source of the aesthetic pleasure of music. Such a formulation does not seem to capture anything of the pleasures of eating, even in the most exalted culinary contexts.

Appreciation of the spatial and temporal array of sensations produced by an excellent dish or wine requires experience, directed attention, and some familiarity and expectation with respect to the genre. Sensory pleasures can be complex and can seep into the cognitive domain. But the trained palate, it would seem, does not produce its pleasure principally by expectation and realization. Note that exquisite culinary experiences can well be assigned to aesthetic pleasures, but not to the same root cause as musical aesthetic pleasures. There seems, in the extremes, to be a qualitative difference between the pleasure derived from chocolate, building on a complex interplay of some innately pleasant textural, aromatic, and taste sensations, and the pleasure of Mozart. The Mozart is made up of sound "units" of no particular appeal; it is all in the sequence. But, of course, chocolate may be a poor representative of foods; it offers complexity but has innate appeal. Perhaps wine, an acquired taste, is a better example. Even here, however, though the pleasures may be aesthetic in some sense, they are tightly tied to the exact form of the stimulus.

The pleasures of the wine connoisseur and the lover of Mozart probably both include a touch of mastery pleasure (described as virtuosity by Kubovy, this volume)—the realization through experience, in both cases, of a rich structure of harmonies and sequences. The wine or music grows in appeal, perhaps from an initially unpleasant response. The Narmour bottom-up and top-down view parallels the benign masochism account of reversing innate aversions. In both cases, the accounts posit an interplay and opposition between an innate system that cannot be denied and an acquired, more sophisticated system that reinterprets or reevaluates.

Imagine a Mozartian symphony of sensations played out in the mouth, or on the skin. A gustatory theme, followed by systematic variations of the temporal sequence, tempo, and sensation qualities. Could this result in the type of aesthetic pleasure that we experience in music? We could surely mimic some of the structure of music. It may be that specifics of the auditory system, particularly tonality and the relations built into it, are essential for the type of structure that gives rise to the musical experience. Perhaps it is the fundamentally and deeply sequential nature of auditory input, illustrated so well in language, with the many brain adaptations to process it, that form a precondition for the musical aesthetic experience. An alternative account of pleasures of the mind (Kubovy, this volume) focuses on the necessary condition of an experience of a sequence of emotions. This criterion has much to recommend it but, like those offered here, founders on the classification of pleasures such as those derived from massage, wine, or the complex change of sensations of temperature, taste, texture, and flavor that accompany consuming a bite of ice cream.

We do not know whether a subtle aesthetic appreciation of food could ever be established in a nonhuman. Similarly, there is no evidence for an acquired liking for music in any nonhuman, in contrast to the ubiquity of music and musical pleasure in humans. We have no idea what the adaptive value of listening to music is. One possibility is that the enjoyment of music is a by-product of an organism built to be motivated to detect structure in the world, a clearly adaptive feature.

We can tentatively conclude that the aesthetic pleasures of music and the usually more sensory pleasures of food differ considerably in those pro-

cesses that mediate between perception and the ultimate pleasure experience. However, a sense of mastery may intrude into both experiences, sometimes nurtured by rising above an initial bewildered or aversive response to the stimulus.

Some Preliminary Principles of Pleasure

In this section, I offer a very preliminary set of principles about pleasure that may characterize sensory pleasures. If sensory pleasures are a model for others, such possible principles may have a wider domain.

1. Sensory pleasure (especially culinary and sexual) is extremely context-dependent. The context includes both the internal and the external (including social) environment.
2. In general, high levels of stimulation are negative, and often, middle levels are most pleasing. This probably links directly to the "Wundt curve," suggesting maximal hedonic effect for moderate levels of arousal.
3. Most sensory pleasure is experienced in the remembered or anticipated domains, as opposed to the online (experienced) domain.
4. Remembered pleasure departs from experienced pleasure and is much more sensitive to state changes. Thus, remembered pleasures show duration neglect and overemphasis on peaks, onset, and offset (Kahneman, Wakker, and Sarin 1997). There are probably also major order effects.
5. There are many positive-negative asymmetries:
   a. the body surface provides most of the positive hedonic inputs and many of the negative inputs.
   b. The body interior provides almost exclusively negative inputs.
   c. Most hedonically tinged sensory inputs are positive, but the negative inputs may be more salient.
6. Familiarity and complexity play important roles in adaptation and habituation to stimulation, but parts of the sensory pleasure system, especially those having to do with pain and some positive skin sensations, show remarkably little hedonic habituation.
7. Combinations of sensory pleasures do not obey any simple, hedonic algebra. This may result from large temporal context effects, limited attention, and specific interactions. As Duncker (1941) points out, it is not clear what we would even want to say about the pleasure of listening to Beethoven while eating our favorite food (and having a massage).
8. There is a large effect of experience on sensory pleasures. Hedonic shifts and reversals are common, and they may be very localized, so that only one patch of skin shows a change even though the effects are surely not at the periphery.

Preadaptation: Pleasure from Sugar to Mozart

I began this chapter with the suggestion that the various hedonic experiences are important and puzzling from a functional point of view. I suggested that the subjective and expressive side of the hedonic system may be quite similar across the different types of pleasures: sensory, aesthetic, and mastery. The principle of preadaptation suggests that the subjective and expressive system that originated for sensory pleasures is co-opted as the output system for the more complex mastery and aesthetic pleasures. Whatever the function and advantages of a salient subjective representation of sensory pleasures, the representation is there and can serve the same functions for more elaborated pleasures. This "model," then, holds for conservatism of the output side, with an expanding range and complexity of elicitors.

If this is so, then one can make some predictions about the neural representation of the various pleasures. In particular, one might predict that these very different types of pleasures (viewed from the input side) funnel together somewhere into a common neural substrate. A common neurochemical mediator, in the endorphin and/or dopamine systems, might be implicated. If that were true, and the phylogenetic and ontogenetic priority of the sensory pleasure system could be demonstrated, then the preadaptation and accessibility hypothesis would have much more force.

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