Physiological and Behavioral Aspects of Taste

Obesity and selection of a nutritionally adequate diet are human problems in many societies today. Restricted intake of feed has been established as advantageous to animal production and health. Various animals show deficiency-related specific appetites. In addition, gustatory stimuli can be powerful motivators for learning. The complex nature of the problems which the field of "taste" encompasses suggests that an interdisciplinary approach would provide wider perspective. On 27 and 28 June 1960, a Conference on Physiological and Behavioral Aspects of Taste, organized with the support of the National Science Foundation, was held at Cornell University.

The concept of senses was traced from its origin in Aristotelian philosophy by R. B. MacLeod. He argued: "There is no such thing as a sense." Rather, "We have dimensions and qualities of sensations, and these can be measured. . . . We [should] stop talking about taste and smell, audition and hearing as sensory systems, . . . look first at the dimensions of human sensory experience and then try to identify their neurological, their physiological, their anatomical, and their physical correlates." This questioning of a rigid categorization of sensory input into the usual modalities or senses was partially supported by neurophysiological data.

Human judgments of pair-mixtures of sodium chloride, citric acid, sucrose, and caffeine were reported by F. J. Pilgrim. Interactions were complex, with chemical composition and concentration of each component significant. The words *sour* and *bitter* were sometimes used interchangeably in describing these stimuli. Similar "quality confusion" was reported by R. M. Pangborn. In the light of these observations and other data, T. Engen questioned the validity of the classical four taste qualities.

In studying species differences in taste preference behavior, it is necessary to be free of preconceived ideas as to what chemical entities will be selected or rejected by each species. On the bases of several thousand trials with calves, pigs, chickens, and other animals it was obvious that man cannot use his taste reactions to predict the taste reaction of an animal. The unique individual taste behaviors described by M. R. Kare could not be related to any of a large group of physical or chemical variables incorporated into a systematic study. Further, the dozen taste buds in the fowl or the 25,000 in the ruminant could not be correlated with the distinctive taste behaviors of these two species. These data generally served to complement

the comparative studies of A. J. Carpenter.

Related electrophysiological data on chorda tympani and glossopharyngeal responses in chickens, goats, sheep, cats, monkeys, and human beings were reported by R. L. Kitchell. No two of these animals showed the same overall neural response pattern for the stimuli used.

Calves, rats, rabbits, and hamsters on adequate *ad libitum* diets will select a range of sucrose (glucose) solutions when offered a sucrose (glucose)-water choice. The relation between intake and sucrose (glucose) concentration is a function of the length of exposure to the choice situation: When both fluids are constantly available for approximately 24 hours, the preference function is roughly bell-shaped, with the maximum at about 10 percent (0.3*M*) sucrose. A choice period of 20 minutes or less results in a roughly linear and positive function. Postingestional factors, including all effects of the ingested material except the direct stimulation of taste receptors, are thought to underlie the differences. The osmotic dehydration effects of the ingesta have been emphasized in current research.

Experiments involving stomach loads, designed to test the osmotic dehydration hypothesis, were reported by H. L. Jacobs. In a 6-hour, two-choice situation, hypertonic glucose loads in non-water-deprived rats did not affect water intake, while water deprivation (16 hours), with or without glucose loads, significantly increased water intake. Glucose intake was reduced only by hypertonic glucose loads.

The location and functional characteristics of the thalamic gustatory relay in the rat were described by G. P. Frommer. Multiunit recording and adequate stimulation, combined with histological verification of electrode tracks, localized thalamic gustatory input in the medial portion of the tongue-like medial extension of the nucleus ventralis [according to DeGroot's terminology, *Trans. Roy. Netherlands Acad. Sci.* **52** (1959)]. Tactile and temperature inputs were localized laterally in the subnucleus. Thalamic response patterns were similar to those described in the chorda tympani (C. Pfaffmann) and in the medulla (B. P. Halpern).

This localization of the thalamic gustatory relay and the limited overlap of taste and somesthetic regions were verified by a series of lesion and recording studies described by R. M. Benjamin.

The procedures used in electrophysiological studies of neural responses to taste stimuli were discussed by R. L. Kitchell. Pre-stimulus treatment, solvent, temperature, method of applying fluids to the tongue, procedures for gaining access to the recording site, and electronic apparatus were all significant factors.

The development of brief-exposure preference testing methods (by P. T. Young) and data collected with an electronic preference tester were presented by K. Christensen. Sodium chloride-sucrose mixtures as acceptable as one of a series of pure sucrose solutions were determined for the rat on an *ad libitum* food and water regimen; for example, a 1-percent (0.03*M*) sucrose solution was matched by a 0.5-percent (0.1*M*) sodium chloride, 0.5-percent (0.015*M*) sucrose mixture.

Interactions between taste-determined behavior, nutritional state, and metabolic activity were discussed by J. Tepperman. Changes in any one of these may lead to alterations in the other two. The experiments of C. P. Richter were quoted as classic examples of these interactions. Recent experiments have demonstrated that modification of rate of lipogenesis, of catabolism of fatty acids, and of enzyme production can be a function of the metabolic mixture. Taste can determine the nature of the metabolic mixture.

A detailed example of interaction

between quality and quantity of ingested food and metabolism was presented by F. W. Heggeness. Weanling rats fed high carbohydrate diets ingested calories in excess of requirements and developed a transient, self-limiting elevation in metabolism. This could be prevented by initially presenting the diets in amounts just sufficient to maintain body weight. Modification of capacity for lipogenesis appeared to be the critical factor.

The 1960 Conference on Physiological and Behavioral Aspects of Taste brought together researchers from many disciplines: L. M. Bartlett (zoology), University of Massachusetts; R. M. Benjamin (physiology), University of Wisconsin; J. A. Carpenter (applied biodynamics), Yale; K. Christensen (psychology), University of Illinois; W. C. Dilger (ornithology), Cornell; T. Engen (psychology), Brown; I. Y. Fishman (biology), Grinnell; G. P. Frommer (psychology), Brown; A. Goldstein (psychology), Cornell; E. B. Hale (poultry husbandry and psychology), Pennsylvania State; A. E. Harriman (psychology), Franklin and Marshall; F. W. Heggeness (physiology), University of Rochester; H. L. Jacobs (physiology and psychology), University of Rochester; R. L. Kitchell (anatomy), University of Minnesota; R. B. MacLeod (psychology), Cornell; G. R. Morrison (psychology), McMaster; R. M. Pangborn (food technology), University of California; F. J. Pilgrim (food acceptance), Quartermaster Institute; M. W. Schein (poultry husbandry), Pennsylvania State; J. Tepperman (pharmacology), State University of New York, Upstate Medical Center; and L. F. Titlebaum (nutrition), Harvard.

The conference proceedings were recorded. An edited version is being prepared for publication.

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Forthcoming Events

February

1–3. Solid Propellant Rocket Conf., American Rocket Soc., Salt Lake City, Utah. (R. D. Geckler, Aerojet-General Corp., P.O. Box 1947, Sacramento, Calif.)

1–3. Winter Military Electronics Conv., 2nd, Inst. of Radio Engineers, Los Angeles, Calif. (A. N. Curtiss, IRE Business Office, 1435 S. La Cienega Blvd., Los Angeles 35)

1–4. American Physical Soc., annual, New York, N.Y. (K. K. Darrow, APS, 538 W. 120 St., New York 27)

2–4. Congress on Administration, 4th annual, Chicago, Ill. (R. E. Brown, Amer-