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Synthesizing complex sensations from simple components

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Abstract

The target article suggests that taste is not based on the traditional four basic tastes, but rather is a continuum subserved by cross-fiber integration. This commentary describes evidence indicating that the traditional concept is valid, and that with suitable precautions, it is possible to match natural substances using mixtures representing fundamental tastes.

Although the target article suggests an across-fiber model as an alternative to the widely held belief that there are four basic tastes, I believe that these two concepts are not incompatible.

Erickson states that his model is “based on Young’s theory of color vision.” Thomas Young reasoned that because there are a very large number of hues, it is almost impossible to conceive of a separate receptor for each of these hues, and that there may be only three types of “particles” (or receptors), each having a primary or greatest sensitivity to one hue, but also a broad but lesser sensitivity to the others.

Thus, according to Young’s theory, no single receptor can by itself provide information concerning a particular hue: He stated that a “blue” receptor could respond to the presence of a low level of blue light, as well as a higher level of light corresponding to other hues. As pointed out in the target article, in keeping with Young’s multisensitivity concept, neurophysiological measurements have shown that single gustatory nerve fibers and their associated receptor cells can respond to more than one of the putative primary or basic tastes, but with a different sensitivity to each taste. As with hues in vision, it is only by cross-fiber integration at higher levels of the nervous system that perception of basic tastes could emerge. Hence, the target article’s cross-fiber model does not rule out the concept of basic taste qualities.

In the “cross-fiber” quote from Young cited in the target article, it is stated that green light can stimulate two receptors with their primary sensitivities to yellow and blue light, respectively, resulting in the “cross-fiber” mixture being perceived as green. Young, despite his brilliance, was wrong, being misled it seems by the subtractive color mixture produced by mixing blue and yellow paints. As subsequently pointed out by Helmholtz, blue and yellow *lights* are complementary, and when rays producing these two hues are viewed separately, then mixed, pale yellow, pale blue, or white is seen depending on the relative proportions. The reason for pointing out Young’s mistake is not to show that even a genius can blunder, but rather to demonstrate that it is not always possible to analyze mixtures into their primary components through introspection.

Despite this inability to determine basic constituents, Section 7 of the target article reports experiments in which subjects attempted to describe complex tastes in terms of their components. In discussing the results in Section 7.6, entitled “An inconvenient truth,” it is stated, “After the experiments it became disconcertingly clear that the subjects were biased towards the idea that the four basic tastes should account for the Comparison stimuli.” It was concluded, “This unexamined bias may be unavoidable in all psychophysical studies involving the basic tastes.” However, the problems in these experiments do not invalidate the use of other means of supporting or refuting the concept of basic taste qualities.

There is another way to test the validity of the basic four-component theory of taste. This is to use a variant of the procedure employed by Helmholtz to confirm the validity of the trichromatic theory. If the theory of basic tastes is correct, it should be possible to match the taste of any substance by using a mixture of chemicals each representing one of the basic tastes. With your indulgence, I’ll explain why I believe that this can be done using appropriate conditions.

Back in the early 1950s, armed with a fresh PhD in organic chemistry, I was hired by a major food company, and given the assignment of preparing a survey of the literature on taste perception. After two years spent in New York City libraries, I prepared a 318 page monograph spanning the period from the mid-19th to the mid-20th centuries (Warren 1953). I became convinced (or biased) of the validity of the concept of basic tastes, and using this concept, set about trying to match the taste of the powdered “instant” coffee produced by the company.

Padded nose clamps were used to block the aroma, and food dyes were employed to match the appearance of coffee (as well as conducting the experiments in dim red light). Results obtained by a panel made it clear that the major components of the coffee taste were bitter and sour, but that using magnesium sulfate (called “bittersaltz” in German) and hydrochloric acid produced very different sensations than coffee because of the quick onset of their tastes; coffee had a much slower onset of sensation and a blending of components. The molecular weight of components appeared to determine the time course of their sensations. For example, bitter substances with high molecular weights (e.g., naringin, derived from the white pulp of grapefruit) and synthetic sucrose octaacetate had much longer onset times and persistence of their tastes, lingering even after rinsing with water. Similar time constraints based on molecular weight applied for sour substances. Despite the fact that coffee is a complex mixture of many sour and bitter components, presumably each with their own onset times, an acceptable match to the instant coffee was obtained when the representatives of bitter and sour components each had a molecular weight between 150 and 200.

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Reference

Warren, RM. Taste perception--Literature survey. Hoboken, NJ: General Foods Corp.; 1953. 318 p.monograph reproduced by General Foods