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"Taste-smell confusions" and the duality of the olfactory sense

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In this paper, I argue that olfaction is the only dual sensory modality, in that it senses both objects in the external world and objects in the body (mouth). I suggest that the same olfactory stimulation may be perceived and evaluated in two qualitatively different ways, depending on whether it is referred to the mouth or the external world. I begin with a discussion of disparities in the affective value of odors and tastes of the same substance.

On eating a piece of Limburger cheese, a friend once commented to me: "I really love the taste, if I can only get it by my nose." The absurdity of this statement hit me head-on. Surely, the odor of the cheese is the primary cause of its repulsiveness. Yet, this same odor, which also constitutes the most distinctive aspect of its "taste," becomes pleasant when it is sensed in conjunction with ingestion.

This affect reversal is no rarity. I asked 42 undergraduates whether they disliked the smell, but liked the taste , of any foods. Specific categories were suggested (strong cheese, fish, eggs, vegetables, fruits, meat), although subjects were free to indicate items outside of these classes. More than half of the subjects (22) indicated such a response to strong cheese. The 42 subjects generated 72 instances, with fish (15) and eggs (11) following strong cheese in frequency.

The opposite affect reversal, liking the smell and disliking the taste, is yet more common. Black, unsweetened coffee is a common example. However, this type of reversal presents no interesting psychological problem. The taste (in the narrow sense) properties causing the dislike are never sensed in the external object. While the odor is shared by an object-at-a-distance and an object-in-the-mouth, the taste appears only with the latter. So, black coffee is disliked in the mouth because a bitter taste is added to a pleasant odor.

It is well known that affective responses are context dependent. The same foul odor can be pleasant if attributed to cheese, but unpleasant if attributed to decaying meat. But context effects cannot easily explain the positive affect shift for Limburger cheese and similar items. The disgust associated with putrid odors is most likely related to fear of oral incorporation of an offensive substance (Angyal, 1941; Rozin & Fallon, 1981). It seems unlikely that this disgust should attenuate as the offensive substance enters the mouth, the central focus of food-related affect. One would think that context would operate in reverse.

The explanation I suggest is based on the fact that olfaction is a dual sense: it functions both for sensing objects in the outside world and for objects in the mouth. This is an old distinction, described as contact and distance functions by Theophrastus (circa 320 B.C./1916, cited in Cain, 1978). I propose that the interpretation or perception of olfactory inputs depends on the contextual specification of internal or external. This position is compatible with Gibson's (1966) ecological object (as opposed to modality) oriented approach to perception. The idea is that the affect effect described above is based on a perceptual phenomenon: the same olfactory stimulus seems *qualitatively* different when referred to the mouth or the outside world. I shall review some relevant evidence on this point and present some hypotheses to explain the purported qualitative perceptual difference.

The olfactory system is the only major sense modality that is frequently confused with another sense modality (taste). Adults usually know (learn) what sensory system is being stimulated when they experience specific sensations. The most striking exception is referral to the mouth of the primarily olfactory sensations associated with substances in the mouth. There is little doubt that what we refer to as mouth-based taste, or (more properly) flavor, receives its principal distinctive properties from olfaction. This point was made by Titchener (1909), among others. The always-surprising loss of ability to "taste" or discriminate common foods when olfactory receptors are blocked by a head cold is everyday evidence for this, as are comments about this "illusion" by human subjects evaluating flavors under conditions of closed and open nostrils (Murphy, Cain, & Bartoshuk, 1977). In the laboratory, Mozell, Smith, Sullivan, and Swender (1969) have demonstrated major losses in the ability to identify otherwise easily identifiable flavors when a continuous airflow from nasal to oral cavities prevents access to olfactory receptors by materials in the mouth. Similarly, while subjects attribute little if any olfactory stimulation to relatively pure taste stimuli in the mouth (e.g., saccharine solutions), they attribute considerable taste to solutions of relatively pure odorants (e.g., ethyl butyrate,

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citral) in the mouth (Murphy & Cain, 1980; Murphy et al., 1977). That this taste attribution is actually caused by the odorant is indicated by the fact that the magnitude of the rated taste increases with the concentration of the odorant in the mouth. That it is caused by olfactory stimulation by the odorant is indicated by the fact that taste magnitude enhancement by the orally administered odorant occurs only with the nostrils open (Murphy & Cain, 1980; Murphy et al., 1977).

The word "flavor" in English seems to capture best the mixture of mouth and olfactory sensations that we perceive with the ingestion of most foods. One of the definitions of "flavor" in the *Complete Oxford English Dictionary* is: "the element in the taste of a substance which depends on the cooperation of the sense of smell." The word has clear olfactory roots (old French, "fleur"; Italian, "flatore," or bad odor; and Latin, "flare," or to blow; *Webster's Unabridged* and *Complete Oxford English* dictionaries). The olfactory component in flavor, as opposed to the limited sense of "taste," is expressed in an imprecise way in common usage. Technically, the designation "taste" should be used as a total perceptual description for only the pure gustatory properties (e.g., sweet, salt, sour, bitter), for combinations of gustatory qualities, and for substances that produce these sensations in the absence of salient olfactory or nongustatory oral sensations. Examples would be sugar and salt.

Twenty-four native English speakers (none psychologists) were asked to indicate appropriate usage of the words "taste" and "flavor" in 16 sentences, using two sentence frames (see Table 1). One frame expressed the critical term in adjectival form (bitter, fruity, as in "This has a *bitter* _____"), and the other employed the critical term as a noun (substance; e.g., "I like the _____ of raspberries"). For each sentence, subjects were asked to indicate appropriate usage by choosing one of the following: (1) only "taste" appropriate; (2) both words appropriate, but "taste" fits better; (3) both words equally appropriate; (4) both words appropriate, but "flavor" fits better; and (5) only "flavor" is appropriate. It was emphasized that all of the sentences "refer to something (food) *in your mouth.*" Although there was considerable variation across subjects, it is clear that the basic taste qualities, and substances that instantiate them, are preferentially described in terms of "taste," while there is a tendency to use "flavor" more with mouth objects having a distinct olfactory component (meaty, fruity, coffee, wine). There is also an overall tendency to use the word "taste" for all mouth objects, as indicated in the table by the fact that, for 13 of 16 sentences, the mean rating was less than 3 (where 3 is the third choice: equal appropriateness). Thus, on the average, "taste" is considered more appropriate for raspberries, fruit, and meat.

We may conclude that there is a subtle and variable recognition, in the English language, of the olfactory component of some mouth objects, but the "mouth" word "taste" is the generally preferred form. It is possible that English is deficient, in comparison with other languages, in explicitly recognizing this distinction, but it appears that such is not the case. One native speaker of each of nine other languages was interviewed to obtain suggestive indications of this distinction. The informants, all bilingual English speakers, were first asked to provide synonyms for the English words "taste" and "flavor." They were encouraged to consult a dictionary in suggesting synonyms. They were then presented with six sentence frames (corresponding to the English sentences: "I like the _____ of raspberries") and were asked to indicate the most appropriate word from their language. Finally, I explained the issue of "pure tastes" vs. substances in the mouth that give rise to olfactory stimuli and mapped the English words "taste" and "flavor" onto this distinction. Subjects were again asked if there was any such distinction in their language. For seven of the nine languages, no flavor-taste distinction could be made, and the same word was appropriate for all six substances probed (raspberries, wine, coffee, meat, salt, and sugar). The words were: "sabor" in Spanish (Cuban); "geschmack" in German; "chuť" in Czech; "ta'am" in Hebrew; "svad" in Hindi; "ruci" in Tamil; and "wei" in Chinese (Mandarin).

Only for French and Hungarian did an informant suggest more than one word as synonyms for "taste" and "flavor." The words offered were then probed with sentence frames appropriate for each language,

Table 1
Appropriateness of the Words "Taste" and "Flavor" to Describe Substances in the Mouth, for 24 Native English Speakers

Sentence Frame	Mean Flavor-Taste Score
This has a BITTER _____.*	1.12
This has a SOUR _____.*	1.33
I like the _____ of SUGAR.*	1.50
This has a SALTY _____.*	1.58
I like the _____ of FRUIT.	1.62
I like the _____ of RASPBERRIES.	1.67
I like the _____ of SALT.*	1.83
This has a SWEET _____.*	1.88
I like the _____ of MEAT.	1.96
I like the _____ of GINGER.	2.38
I like the _____ of COFFEE.	2.38
This has a SPICY _____.	2.46
I like the _____ of WINE.	2.58
This has a FRUITY _____.	2.75
This has a MEATY _____.	3.67
This has a FRAGRANT _____.	3.70

Note—Items arranged in order of increasing scores, i.e., increasing appropriateness of the term "flavor." Each rating category is assigned the number indicated in the text (1 = only taste is appropriate; 5 = only flavor is appropriate). **These items constitute adjectives or substances generally considered to have insignificant olfactory components.*

using the instances indicated in Table 1. In French, the word "gout" corresponds rather well to the English word "taste." The word "saveur" maps moderately well onto "flavor," with preferential usage for describing "spicy" or "meaty," and acceptability with "fruity." In addition, the French word "parfum" carries much of the meaning of flavor, but is limited in application to a narrow range of substances such as ice cream and confections. The Hungarian words "iz" and "zamat" map most directly, and better than English, onto the psychological distinction under consideration. "Iz" is used to mean "taste" in the narrow sense and applies primarily to sentence frames using the pure taste stimuli (sweet, bitter, sugar, salt, etc.). "Zamat" is used preferentially and sometimes exclusively when there is a significant olfactory input (raspberries, coffee, wine, fragrant, fruity). Both words were appropriate for meat or meaty and spicy. Interestingly, "zamat" was more appropriate for meat that was seasoned and cooked with some elaboration, while "iz" was more appropriate for plain, boiled meat.

Overall, the data from English and nine other languages indicate that distinctions involving olfactory input are not usually made in reference to mouth objects.

The psychological and linguistic phenomena under discussion are supportive of Gibson's (1966) ecological approach. The "objects" sniffed in the external world may be potential foods, but they also include other objects (predators, sex partners, etc.). We are basically dealing with two different perceptual systems, and olfaction happens to contribute to both. In Gibson's view, the modality source of any sensations or perceptions is learned; it is not obvious to the infant that the eyes are the source of visual sensations. Presumably, experiences with closing of the eyes provide information as to this channel of stimulation. However, by adulthood, all major modality channels seem to be identified, except for the flavor complex. This is somewhat surprising on a traditional learning view, because it is not obvious that there is less experience with the taste-smell separation than there is experience that would allow the inference that the ears are the source of auditory information. There are two general opportunities for learning about flavor: (1) We regularly smell foods (externally) before placing them in our mouths. We thus experience the pairing external-smell/internal-flavor complex. The powerful common olfactory input should be discernible, unless there is a psychological change in the quality of the olfactory sensation—perhaps a gestalt-like context effect, as we are postulating. (2) On particular occasions (most frequently head colds, but also holding one's nose), the olfactory input into flavor is eliminated. This remains a constant source of surprise to people, even those who have had many head colds (Murphy et al., 1977).

There seems to be some resistance to learning about the olfactory input into flavor, a resistance that is perhaps built into the system, as a perceptual unitary system for perceiving mouth objects.

An alternative description of this situation engages the "integral" concept (Garner, 1974). The complex of mouth-olfactory sensations associated with an object in the mouth (including touch, temperature, chemical irritation, taste, and odor) seem tightly linked. Even considering within-mouth sensations, the trigeminal vs. gustatory inputs are not separable in any distinct way. With development, many integral stimulus complexes seem to become distinguishable (separable), so that individuals can respond to specific components or features (Kemler, 1982). This general developmental trend does not proceed for all integral complexes and certainly does not seem to occur for the flavor complex.

The issues under discussion are illustrated and clarified by studies of conditioned taste aversions in animals. Rats rapidly learn to avoid a taste when it is followed by nausea and perhaps other, yet unspecified, internal aversive events (Garcia, Hankins, & Rusiniak, 1974; Rozin & Kalat, 1971). This learning is much less effective with conditioned stimuli outside the taste modality (Garcia & Ervin, 1968). There is currently a dispute about the effectiveness of olfactory stimuli, but, in direct comparisons, smells are not nearly as effective as tastes (Garcia & Rusiniak, 1980; Hankins, Garcia, & Rusiniak, 1973). However, the same "exteroceptive" ambient odor that shows poor illness conditioning will show a strong aversion if the illness pairing is accompanied by a taste (saccharine) in the mouth (Garcia & Rusiniak, 1980; Rusiniak, Hankins, Garcia, & Brett, 1979). Thus, odor of a mouth object, which might be the animal's interpretation of the odor in the presence of the tasty substance in the mouth, is effectively linked to internal events. Why, after all, should an animal associate an odor with gastrointestinal illness if it has not eaten anything? This shift in the conditionability of odor to illness supports the conception of olfaction as a dual sense.

I have discussed evidence for the duality and its reasonableness in an adaptive sense. I shall now consider explanations for the apparent psychological duality of olfaction. I will examine the hypothesis that olfactory stimuli arising from (or thought to arise from?) the mouth have different sensory-perceptual properties than those originating in the external world. This distinction is suggested by the affect shifts discussed at the beginning of this paper. It is also particularly salient in the experience of wine drinking; bouquet and flavor often seem very different, even to the extent that wines with minimal bouquet may have rich flavors.

Some of my students and I attempted to directly demonstrate the major perceptual distinction under

discussion. Our thought was that if odor had different sensory properties in the mouth vs. in the external world, then, having learned to identify an external odor, a person should have difficulty identifying that same odor coming from the mouth. Of course, for familiar odor-flavor instances such as coffee, the pairing of external odor with flavor on many occasions may lead to the impression that the smell is like the flavor or may build a strong association between odor and flavor. We had to use unfamiliar odors and flavors, so we settled on mixtures of exotic fruit juices or exotic soups. We taught blindfolded subjects to identify by odor four juices or four soups. Each soup or juice was assigned a number, and the subject proceeded, as in a rote memory task, through sequences of 12 stimuli, with each instance presented on 3 of the 12 trials in random order. Immediate feedback was provided, and subjects continued until they completed two consecutive runs with, at most, one error in each. Then, to the subject's surprise, we asked him to next identify the tastes of these same substances, assigning one of the four numbers to each of 12 stimuli (again, three instances of four soups or juices) in a sequence of taste trials. The soups or juices were delivered directly into the mouth via a plastic tube attached to a syringe to limit exteroceptive olfactory stimulation. A separate syringe and tube were employed for each of the four stimuli in order to minimize mixing of tastes. On each trial, approximately 1.2 ml of the stimulus was delivered. Following these 12 taste trials, the subjects were run again on a sequence of twelve odor stimuli, again without feedback.

Although the juices and soups were made to be highly distinctive, most subjects had great difficulty in identifying the tastes, and many felt that they were guessing at random. In fact, 35 subjects averaged 6.7 correct on the juices, and 31 subjects averaged 7.5 correct on the soups, where 3 would be the score expected by chance. Subjects did better than they thought and well above chance, although their performance was well below their performance on the subsequent olfactory test (mean of 10.1 correct for the juices and 9.9 for the soups). On 7 of the 66 tests, a subject scored close to random on the taste test (less than or equal to five correct) while scoring very well (11 or 12 correct) on the subsequent olfactory test. The results can be taken to indicate that there is at least considerable difficulty in identifying the flavor of an identified odorant, suggesting a duality in olfaction. This is a preliminary study, done primarily to illustrate a methodology for testing for qualitative differences. It would have to be repeated with better control for external leakage of odors in the course of taste administration and with controls for the distinctiveness of the taste stimuli.

I now consider some possible mechanistic explanations for the purported olfactory duality:

(1) The olfactory input to the brain could be gated differently depending on whether the input is processed as in-mouth or out-there. The differential gating could lead to qualitatively different sensations. There would be two possible sources of information that might control such a gate. One is the presence of a palpable substance or taste in the mouth. The other is the direction of movement of odorants across the olfactory mucosa, or a cruder correlate of that, whether the odor is more salient on the inhalant (out-there) or exhalant (in-mouth) cycle. These distinctions could surely be tested experimentally.

(2) The olfactory input may not be gated but, rather, combined with available oral inputs into an emergent percept in which the olfactory component loses its separate identity. There is evidence for a number of possible neural substrates for convergence of olfactory, gustatory, and oronasopharyngeal cutaneous inputs (see discussion in Van Buskirk & Erickson, 1977). Alternatively, the presence of a cutaneous oral stimulus (food in the mouth) might cause referral of the olfactory stimulus to the mouth locus, with a consequent blending of sensations (Murphy & Cain, 1980).

(3) The stimulus input to the olfactory mucosa may be very different in the in-mouth vs. out-there situations. The intensity is likely to be much lower from the in-mouth source because of absorption or adsorption of odorants by the lungs and nasooropharyngeal surfaces. However, mastication might release higher concentrations of some odorants. Most critically, *selective* absorption and adsorption, or mastication, may affect the quality of the stimulus reaching the olfactory mucosa. The olfactory *stimulus* may differ qualitatively in the in-mouth and out-there cases. Such a qualitative difference would make it harder to learn the relation between the odor in the external world and in the mouth.

It seems very likely that the olfactory component of flavor differs markedly from the olfactory consequences of the same substance in the external world. The question is why—and, in particular, whether—there is something interesting for psychology in this effect. If it is entirely in the stimulus (Hypothesis 3), it is of little interest to psychology. The more central the effect, the more interesting it becomes. It is quite possible that more than one of the mechanisms suggested (or, perhaps, others) contribute to the duality of olfaction. But, whatever the mechanisms, we are still left with the surprising lack of awareness of olfactory input in the perception of flavor and some surprising affective shifts that seem to relate to this.

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