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Review Article

Measurement of chemosensory function

Richard L. Doty [a,b,*]

[a] *Smell & Taste Center, University of Pennsylvania, Philadelphia, PA 19104, USA*
[b] *Department of Otorhinolaryngology-Head and Neck Surgery, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA 19104, USA*

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Abstract Although hundreds of thousands of patients seek medical help annually for disorders of taste and smell, relatively few medical practitioners quantitatively test their patients' chemosensory function, taking their complaints at face value. This is clearly not the approach paid to patients complaining of visual, hearing, or balance problems. Accurate chemosensory testing is essential to establish the nature, degree, and veracity of a patient's complaint, as well as to aid in counseling and in monitoring the effectiveness of treatment strategies and decisions. In many cases, patients perseverate on chemosensory loss that objective assessment demonstrates has resolved. In other cases, patients are malingering. Olfactory testing is critical for not only establishing the validity and degree of the chemosensory dysfunction, but for helping patients place their dysfunction into perspective relative to the function of their peer group. It is well established, for example, that olfactory dysfunction is the rule, rather than the exception, in members of the older population. Moreover, it is now apparent that such dysfunction can be an early sign of neurodegenerative diseases such as Alzheimer's and Parkinson's. Importantly, older anosmics are three times more likely to die over the course of an ensuring five-year period than their normosmic peers, a situation that may be averted in some cases by appropriate nutritional and safety counseling. This review provides the clinician, as well as the academic and industrial researcher, with an overview of the available means for accurately assessing smell and taste function, including up-to-date information and normative data for advances in this field.

* 5 Ravdin Building, 3400 Spruce Street, Philadelphia, PA 19104, USA. Fax: +1 215 349 5266.
E-mail address: richard.doty@uphs.upenn.edu.
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Introduction

Chemosensory disorders are common in the general population, impacting safety, nutrition, and quality of life. Persons who cannot smell or taste have less enjoyment from eating, drinking, and the natural environment, and are at higher risk from such dangers as spoiled foods, tainted water, fire, leaking natural gas, and toxic environments. Importantly, olfactory dysfunction can be an early sign of such neurodegenerative diseases as Alzheimer's and Parkinson's.[1] Since older persons with smell loss are three times more likely to die over the course of a 4- to 5-year period,[2,3] it behooves the modern physician to be aware of his or her patient's degree of smell function.

Unfortunately, quantitative testing of the senses of taste and smell is rarely, much less routinely, performed in the clinic. Without testing, the accuracy of a patient's chemosensory complaint cannot be definitively established. Indeed, most persons are inaccurate in assessing the nature and degree of their chemosensory problem and considerable return of function can occur, often without patient awareness.[4–7] In one study, for example, only 18% of patients with bilateral anterior tongue taste loss following sectioning of both chorda tympani nerves were aware of their deficit.[8] Without testing, it is nearly impossible to detect malingering,[9] and it cannot be determined whether a perceived decline in function is normal for the patient's age and sex.[10,11] Without testing, the efficacy of pharmacological, surgical, or other therapeutic interventions cannot be accurately ascertained.

As demonstrated by quantitative testing, smell disturbances are generally believed to be more common than taste disturbances.[12] In fact, most patients who complain clinically of a "taste" disturbance actually have altered smell function.[12] The flavor of foods, which is often interpreted as "taste", largely depends upon volatiles that reach the olfactory receptors via the nasal pharynx during deglutition.[13] Aside from sweet, sour, bitter, salty, savory ("umami"), and perhaps chalky or metallic sensations, nearly all "taste" sensations are olfactory sensations. This can be demonstrated by holding one's nose while drinking coffee or eating a piece of chocolate. Until the blockage of airflow is released, no coffee or chocolate "taste" will be perceived. Although meaningful decrements in the basic taste-bud mediated qualities can occur, this is relatively rare. The most common bona fide taste problems are dysgeusias or distortions of taste, or persistent phantogeusias, i.e., the presence of taste sensations in the absence of obvious taste stimuli. Salty and bitter phantogeusias are typical, often as side effects of medications.

This review provides up-to-date information on the types of smell and taste tests available for both clinic and laboratory applications. Recent advances in practical ways to test smell and taste function in the clinic are provided, along with normative data for some tests. The focus is on psychophysical tests - tests that quantify a subject's conscious perception of stimuli. Most such tests are based on 19th and 20th century concepts of Weber,[14] Fechner,[15] Thurstone,[16] Stevens,[17] Tanner and Swets,[18] and others (e.g., Peryam and Pilgrim)[19] and do not rely on complex equipment. Psychophysical tests are generally more sensitive and reliable in detecting and quantifying chemosensory disturbances than extant electrophysiological tests. The latter tests, unlike their auditory counterparts (e.g., auditory brainstem evoked response), cannot reliably identify the locus of pathology within the brain, although summated electrical responses can be measured from the surface of the tongue and olfactory epithelium. Such recordings are difficult to measure and olfactory responses are present long after death, making them a poor surrogate for conscious smell perception. More comprehensive reviews of olfactory and gustatory tests, including electrophysiological tests, are available elsewhere.[20–28]

Olfactory tests

Psychophysical olfactory tests can be divided into threshold and suprathreshold categories. Threshold tests establish the lowest concentration of an odorant that can be perceived (detection threshold) or recognized as a quality (recognition threshold). Detection thresholds are lower than recognition thresholds. Unfortunately, some investigators fail to instruct their subjects to make the distinction between detection (which does not require the perception of an actual odor, only some sensation being present) and recognition (which requires such a perception), thereby increasing the variability of their threshold measures. Suprathreshold tests include ones that assess the ability to discern subtle differences between above-threshold concentrations of a given stimulus (e.g., the difference threshold), as well as tests of quality identification, discrimination, memory, intensity, and hedonics (e.g. pleasantness/unpleasantness). Most olfactory tests are strongly correlated with one another, although exceptions exist.[29] When a correlation exists between two tests, its magnitude is largely dictated by the least reliable test. Despite different names, chemosensory tests often measure the same underlying physiologic processes. In the case of olfaction, for example, this can reflect the degree of damage to afferent pathways, including the receptor cells within the olfactory epithelium.

Odor threshold tests

A number of odor threshold tests have been developed. Their popularity is due, in part, to the fact that they are akin to pure-tone auditory hearing threshold tests - tests which are familiar to most physicians. Odor detection threshold tests have achieved the most widespread use, given their relatively high reliability and amenability to forced-choice testing. Nowadays, phenyl ethyl alcohol (PEA) is the most commonly employed odorant in clinical threshold testing, given its relatively low propensity to stimulate intranasal trigeminal afferents, its relatively wide dynamic perceptual range, and its pleasant rose-like smell at higher concentrations.[30] Other odorants that have been used clinically include n-butanol (rancid sweet/alcohol),[31] amyl (pentyl) acetate (banana-like),[32] phenyl ethyl methyl ethyl carbinol (pleasant and mildly herbaceous),[33] γ-undecalactone (soft peach-like),[34] iso-valeric acid (putrid sweat),[34] skatole (vegetable garbage),[34] and methyl cyclopentenolone (burnt/caramel).[34]