Psychological Qualities of Odor I: Profiling Systems

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The past century has seen the appearance and disappearance of many systems for odor description. Almost a century ago, Zwaardemaker (1895) proposed a system of 39 categories with further subcategories. In the 1920s, at Arthur D. Little, Inc. in Cambridge, the flavorist Crocker and his associates worked out a four-quality system (fragrant, acid, burnt, caprylic) which was meant to provide numerical signatures to a large range of odorants. The system, later called the Crocker/Henderson system (Crocker and Henderson, 1927) was a very simple one with which to work, and was followed two decades later by the Odor Directory (Crocker and Dillon, 1949). The Odor Directory listed the quality "signatures" of several hundred odorants, in terms of how much of each of the four components every odorant possessed. Still later, Harper and his associates (1968a) published a scholarly review on various types of odor classification, and later developed their own system of 44 descriptor words to classify odorants (Harper et al, 1968b). These approaches, and the spin-offs they engendered, will be discussed.

Rationale and philosophy of odor description

It has been claimed by various researchers that the number of possible odor perceptions ranges into the millions. No two odorants are ever exactly alike. This is in contrast to taste, where two acids (especially the mineral, or nonorganic acids) can be equivalently strong in sourness, and sensorially indistinguishable from each other. In odor perception, no such simple sensory equivalence exists. Each odorant provokes its own unique set of perceptions which differentiates that odor from all others.

How then can we characterize odors, if each odorant is truly different from every other? The problem is like one faced by linguists. In English, every word differs from every other word, although some words are synonymous. Each word has its own nuances, never completely shared by any other word. How then can one teach English, and convey the precise nuances behind each word to the student? Perhaps a recognition of the problems of teaching language will help us to understand the problems of odor description.

English has an alphabet from which words are constructed. Odor may also have an alphabet—but the exact structure of that alphabet is not known, nor are the characters as yet determined. Amoore originally postulated 7 primaries, or 7 letters. All other odor qualities could be derived from combinations of these primaries (Amoore, 1952). Subsequently, he increased the number of possible odor primaries to 32+ (Amoore, 1969), and specified some of the chemicals which correspond to these primaries. (See Table I.) Other theories, such as Beet's profile functional group theory rely upon the shape of the molecule, as well as upon specific chemical groups which provoke a specific odor quality. Whichever theory is true, and however each theory accounts for data, we should remember that there is still no rational system for accurately combining elements or odor qualities to produce new, unexpected qualities. Thus, odor science may not possess a distinguishable alphabet in the same way as a language possesses an alphabet.

As a result of the failure of researchers to find a workable set of primaries and a set of rules for combining these primaries, odor science must rely on other techniques. At present, there is no possible recourse to such systems as the XYZ or CIE* color primary systems, in which mixtures are well defined, and with which one can mathematically construct desired colors by mixing together the primaries. Researchers in odor science have instead attempted to develop representative lists of descriptors. Failing to determine odor primaries, they have had to settle for adequate odor description. With such descriptions they hope to capture the nuances of odor perception, if not the quantitative underpinnings of odor quality that allow experimenters to change quality at will, in a desired direction. They also hope to determine, from these lists of adjectives, the possible existence of underlying continua of odor quality which recur from one adjective list to another. Such a continually reappearing set of adjectives across lists, experimenters, cultures, and eras may indicate that we possess mental or psychological rules for odor classification which scientists can then uncover.

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Table I

Odor Classes: General

	Zwaardemaker 1895 30 (sub) classes	Linnaeus 1756 7 classes	Henning 1915 6 classes	Crocker & Henderson 1927 4 classes	Amoore 1952 7 classes	Schutz 1964 9 classes	Wright & Michels 1964 8 classes	Harper et al 1968 44 classes	miscellaneous additional
1	fruity						hexyl-acetate	fruity	
2	waxy							soapy	
3	ethereal				ethereal	etherish		etherish-solvent	
4	camphor				camphor			camphor; mothballs	
5	clove	aromatic						aromatic	
6	cinnamon		spicy				spice	spicy	
7	aniseed						benzo-thiazole		
8	minty				minty			minty	
9	thyme								
10	rosy								
11	citrous		fruity				citral	citrous	
12	almond					spicy		almond	
13	jasmine		flowery		floral			floral	
14	orange-blossom	fragrant		fragrant		fragrant		fragrant	
15	lily								
16	violet								
17	vanilla					sweet		vanilla, sweet	
18	amber							animal	
19	musky	ambrosial			musky			musk	
20	leek	alliaceous						garlic	
21	fishy							ammonia; fishy	
22	bromine								
23	burnt		burnt	burnt		burnt	affective	burnt	
24	phenolic							carbolic	
25	caproic	hircine		caprylic				sweaty	
26	cat-urine								
27	narcotic	repulsive							
28	bed-bug								
29	carrion	nauseous						sickly	
30	fecal							fecal	
31			resinous				resinous	resinous; paint	
32			foul		putrid	sulfurous	unpleasant	putrid; sulfurous	
33				acid				acid	
34						oily		oily	
35						rancid		rancid	
36						metallic		metallic	
37								meaty	
38								moldy	
39								grassy	
40								bloody	
41								cooked-vegetable	
42									sandal
43									watery
44									urinous
	(Non-olfactory)				(pungent)		(trigeminal)	(Pungent and 5 others)	

Representative systems of odor classification

Experimenters have developed their odor classification systems by different methods, including simple introspection, wherein the experimenter has considered his/her own range of odor quality perception, and has generated a series of apparently fundamental terms. Other methods include culling literature and previous reports to discern underlying trends and then presenting those trends as possible primary descriptors, or statistically analyzing data to find out how many independent descriptor terms are needed to account for odor quality perception.

Introspective systems Table I presents a list of such systems. Most of the descriptor systems were prepared before the twentieth century, often after an experimenter had had some experience with odors of various types. Foremost among these systems is Zwaardemaker's classification of odors into 39 discrete categories. There are others, however.

As Harper et al (1968a) noted, many of the systems that Table I shows, or indeed most odor classification systems, grow out of the personal experience of the compiler. A perfumer, for example, will select a different series of terms for classification than will a flavorist, because the two individuals have life-long experiences with different sensory attributes. A botanist interested in mushrooms, who is developing odor classification for plant smells, will focus on the smells typifying mushrooms and neglect or lump together differences and nuances which would seem critical to a perfumer or a flavorist.

Culled descriptor systems One of the most important contributions to odor description has been Harper's system of 44 descriptors, which he and his coworkers suggested in 1968 (Harper 1968a). (See Table II.) After a review of the extant literature, and after first-hand experience with a wide variety of pure chemicals and food aromas, Harper et al were able to distill the following general approach:

(a) No system was extensive enough to account for all odor nuances and yet be parsimonious. Classification systems which account for a large variety of qualitative nuances must be, by necessity, limited to one small region of the ol-

Table II

Odor Profiling Words (Harper Scale)

fragrant	oily, fatty
sweaty	like mothballs
almond-like	like gasoline, solvent
burnt, smoky	cooked vegetables
herbal, green, cut grass, etc.	sweet
etherish, anaesthetic	fishy
sour, acid, vinegar, etc.	spicy
like blood, raw meat	paint-like
dry, powdery	rancid
like ammonia	minty, peppermint
disinfectant, carbolic	sulphidic
aromatic	fruit (citrus)
meaty (cooked)	fruity (other)
sickening	putrid, foul, decayed
musty, earthy, moldy	woody, resinous
sharp, pungent, acid	musk-like
camphor like	soapy
light	garlic, onion
heavy	animal
cool, cooling	vanilla-like
warm	fecal (like manure)
metallic	floral

factory world. Otherwise, the classification system would be unwieldy.

(b) The classification system must allow for intensity differences among odors. Two odorants might both be spicy and citrus. However, one odorant might evoke a strong spice note, and a light citrus note. The other odorant might evoke exactly the same notes, but in opposite proportions. Hence, the classification system must allow for odorants possessing identical attributes, but with differences in strength or degree of those attributes.

(c) The system must be capable of being used by both experts and novices alike.

The 44 descriptor system satisfied the foregoing requirements. 44 representative terms for the food industry were chosen but other terms could be added or deleted, and specific terms could be expanded, where necessary, to capture nuances as desired.

The 44 descriptor system or modifications thereof have been profitably used by various investigators. Table III shows the profiles for some pure chemicals, using the Harper system of 44 descriptors, and a 0-5 category scale (0 = not at all present, 5 = extremely strong). Scale values for the same chemicals, evaluated by novice sniffers and by experts, are shown. (Experts tend to be more parsimonious in their use of categories and descriptors than novices.)

Table IV shows the profiles for four fruit juices, as studied by Von Sydow et al (1974). The panelists in that study were asked to profile the flavor and taste qualities of juices by means of a 9 point scale, which expanded the 0-5 scale originally suggested by Harper et al. The descriptor list was modified, so that the original 44 descriptors were reduced to a core set that actually applied to fruit juices. Taste and fruit juice specific descriptors were added to the list, so

Table III

Odor and Taste Qualities and their Average Scores for two Reference Juices (Blueberry and Cranberry) and for Grape and Apple Juices

Attribute	Grape		Apple		Reference Blueberry		Reference Cranberry	
	'nose' N = 146	'mouth' N = 142	'nose' N = 153	'mouth' N = 153	'nose' N = 69	'mouth' N = 69	'nose' N = 108	'mouth' N = 109
Total odor strength	5.99 (.16)	5.40 (.17)	5.53 (.14)	4.75 (.14)	5.16 (.31)	4.15 (.25)	4.57 (.21)	4.12 (.22)
Apple-like	1.07 (.09)	1.36 (.12)	5.46 (.18)	5.11 (.19)	.77 (.16)	1.69 (.17)	1.43 (.15)	1.33 (.15)
Musty, mouldy	1.81 (.13)	1.68 (.11)	2.10 (.11)	1.92 (.10)	1.68 (.21)	1.46 (.19)	1.32 (.13)	1.03 (.13)
Sweet odor	5.13 (.13)	4.83 (.13)	4.31 (.13)	4.02 (.13)	5.23 (.21)	3.90 (.24)	2.56 (.21)	2.46 (.19)
Spicy	1.80 (.11)	1.77 (.10)	1.84 (.10)	1.72 (.09)	2.19 (.22)	1.58 (.18)	1.69 (.14)	1.61 (.16)
Fermented, wine-like	2.68 (.14)	2.51 (.15)	1.99 (.12)	2.04 (.12)	2.20 (.22)	1.83 (.19)	1.60 (.13)	1.62 (.15)
Blueberry-like	1.67 (.18)	1.73 (.19)	.13 (.03)	.23 (.05)	6.30 (.25)	5.00 (.27)	.20 (.05)	.29 (.08)
Estery (hard candy)	2.37 (.16)	2.54 (.17)	2.11 (.13)	2.08 (.13)	2.23 (.27)	2.04 (.28)	1.61 (.18)	1.81 (.20)
Aromatic	4.23 (.17)	4.07 (.17)	3.81 (.15)	3.67 (.14)	4.15 (.34)	3.67 (.31)	3.12 (.21)	3.01 (.22)
Sharp, pungent	2.31 (.13)	2.11 (.13)	2.61 (.12)	2.39 (.12)	1.88 (.21)	2.01 (.20)	3.46 (.20)	3.42 (.24)
Cranberry-like	.33 (.06)	.41 (.06)	.33 (.05)	.54 (.08)	.39 (.09)	.73 (.14)	5.98 (.20)	5.28 (.26)
Woody, sawdust-like	.81 (.08)	.75 (.07)	1.15 (.10)	1.09 (.11)	.59 (.13)	.59 (.12)	.77 (.11)	.80 (.13)
Floral	3.21 (.16)	3.20 (.15)	3.18 (.14)	3.05 (.13)	3.45 (.29)	2.77 (.26)	1.93 (.20)	2.00 (.21)
Grape-like	6.33 (.15)	5.89 (.15)	.50 (.06)	.63 (.07)	1.55 (.20)	1.59 (.22)	.56 (.10)	.64 (.10)
Resinous	1.54 (.12)	1.43 (.11)	1.54 (.11)	1.49 (.12)	1.57 (.22)	1.33 (.20)	1.24 (.16)	1.30 (.17)
Fruity, berry-like	3.57 (.19)	3.75 (.19)	2.32 (.17)	2.33 (.16)	4.52 (.30)	3.86 (.30)	2.69 (.20)	2.49 (.22)
Green, cut grass	.57 (.07)	.56 (.07)	1.13 (.10)	1.04 (.10)	.44 (.11)	.57 (.15)	.74 (.14)	.77 (.14)
Fragrant	4.84 (.14)	4.62 (.14)	4.13 (.15)	3.85 (.12)	5.12 (.22)	3.90 (.26)	2.93 (.21)	2.86 (.21)
Earthy	.82 (.09)	.87 (.09)	1.19 (.12)	1.33 (.13)	.68 (.17)	.64 (.15)	64 (.12)	.61 (.11)
Vinegar-like	1.50 (.12)	1.49 (.13)	2.16 (.11)	2.26 (.13)	1.22 (.08)	1.46 (.21)	1.90 (.20)	2.03 (.23)
Etherish, anaesthetic	.73 (.08)	.73 (.09)	1.31 (.12)	.94 (.11)	.48 (.12)	.61 (.13)	.69 (.11)	.66 (.10)
Pleasantness in odor	6.47 (.09)	6.38 (.09)	5.58 (.12)	5.59 (.10)	6.65 (.15)	5.43 (.22)	5.03 (.16)	4.82 (.15)

Table IV

Profile of Odorants using Harper System

EUGENOL (1.0%)

Experienced		Inexperienced	
Spicy	2.7	Spicy	1.8
Fragrant	1.4	Aromatic	1.6
Aromatic	1.3	Heavy	1.5
Sweet	1.1	Fragrant	1.4
Herbal	0.8	Sweet	1.4
		Etherish	0.9
		Oily, fatty	0.7

EXALTOLIDE (0.4%)

Experienced		Inexperienced	
Fragrant	1.9	Fragrant	2.6
Sweet	1.6	Sweet	2.6
Floral	1.2	Floral	2.0
Musky	1.1	Light	1.9
Light	1.0	Aromatic	1.4
		Fruity	1.1
		Sickly	0.7
		Vanilla	0.7

HEXYL BUTYRATE (10%)

Experienced		Inexperienced	
Fruity	2.5	Sweet	2.4
Sweet	2.2	Sickly	2.4
Fragrant	1.6	Heavy	2.0
Sharp	1.0	Aromatic	1.3
		Fragrant	1.3
		Warm	1.2
		Fruity	1.1
		Light	1.0
		Oily	0.8
			0.8

B IONONE (1.5%)

Experienced		Inexperienced	
Sweet	2.8	Sweet	2.9
Floral	2.7	Fragrant	2.9
Fragrant	2.7	Floral	2.2
Fruity	1.6	Aromatic	1.6
Light	1.2	Light	1.6
		Fruity	1.4
		Cool	0.9

that in the end the profile system comprised aroma descriptors, taste descriptors, and hedonic tone (or acceptability) descriptors.

The system proved sufficiently sensitive to pick up flavor perception differences for cranberry and blueberry juices which were sweetened by the addition of varying amounts of sucrose. Other studies by Von Sydow and his associates at the Swedish Institute for Food Preservation Research in Gothenburg, Sweden, focused upon the flavor changes in canned meat (Persson et al, 1973). These canned meat products were subjected to various treatments, and the sensory/flavor changes were quantified by means of the descriptor system.

In a more recent contribution, Dravnieks (1977) has suggested that 44 adjectives are probably too few to be really useful in capturing nuances of odors. There are at least 800+ different adjectives which have been used to characterize odor, but this is too many. Rather, Dravnieks has suggested approximately 130 adjectives (see Table V). This wider variety of descriptors allows the experimenter to ascertain nuances not possible with the Harper system. In fairness to the Harper system, however, one must realize that it was aimed primarily at food users, whereas Dravnieks intended his system to be applicable to a wide variety of descriptor situations.

In a variety of studies, the Dravnieks system has shown some interesting properties.

(a) An index of odor similarity can be constructed for pairs of odors by determining the number of descriptors they share (independent of the strength of the descriptor for each odor). Odorants described by similar terms are more like each other than odorants described by nonoverlapping terms.

Table V

Odor Profiling Words (Dravnieks' Modification)

eucalyptus	strawberry-like
buttery	stale
like burnt paper	cork-like
cologne	lavender
caraway	cat-urine-like
orange (fruit)	bark-like, birch bark
household gas	rose-like
peanut butter	celery
violets	burnt candle
tea-leaves-like	mushroom-like
wet wool, wet dog	pineapple (fruit)
chalky	fresh cigarette smoke
leather-like	nutty (walnut etc.)
pear (fruit)	fried fat
stale tobacco smoke	wet paper-like
raw cucumber-like	coffee-like
raw potato-like	peach (fruit)
mouse-like	laurel leaves
pepper-like	scorched milk
banana-like	sewer odor
burnt rubber-like	sooty
geranium leaves	crushed weeds
urine-like	rubbery (new rubber)
	bakery (fresh bread)
beery (beer-like)	
cedarwood-like	oak wood, cognac-like
coconut-like	grapefruit
rope-like	grapejuice-like
seminal, sperm-like	eggy (fresh eggs)
like cleaning fluid (carbona)	bitter
cardboard-like	cadaverous, like dead animal
lemon (fruit)	maple (as in syrup)
dirty linen-like	seasoning (for meat)
kippery (smoked fish)	apple (fruit)
caramel	soup
sauerkraut-like	grainy (as grain)
	clove-like
crushed grass	raisins
chocolate	hay
molasses	kerosene

(b) Individuals use different strategies in describing odor. Some individuals use a wide variety of descriptor terms; others use a more restricted set. Similar individual styles in odor description have been shown in other studies of profiling. For instance, in a study by Moskowitz and Gerbers (1974), panelists were asked to profile 15 odorants on 17 descriptors. Over a period of several days, with a chance to repeat their ratings on a total of 4 different occasions, they showed shifts in the ratings. When an odorant showed a specific and dominant characteristic, such as the burnt quality which the odorant guaiacol provokes, untrained individuals first used many descriptors but soon restricted the number of attributes (from the list of 17) that they used to characterize guaiacol. Moskowitz and Gerbers labeled this effect "perceptual sharpening," but what it may indicate, in fact, is a different response strategy adopted by an experienced versus an inexperienced individual.

Outlook on profiling

In the future, we may expect to see additional refined descriptor lists. Experimenters will

probably tailor their lists to the specific category which they are investigating. No longer will all-encompassing lists of adjectives be used. This specialization should further isolate users of such descriptor systems from each other. Experimenters will also probably abandon the idea that odor perception can be modelled after color perception, wherein combinations of a few primary colors suffice to recreate the entire visual spectrum of colors. Hitherto, there has always been an underlying belief that descriptor lists could eventually get at the odor primaries. Such a belief is destined to fall by the wayside as experimenters try other psychometric methods besides odor description to arrive at psychologically relevant primaries.

Psychological Qualities of Odor II. Geometry of Odor Quality by Howard R. Moskowitz will be published in the Psychologist's Corner of the October/November 1977 Perfumer & Flavorist.

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