Journal of the Air Pollution Control Association

ISSN: 0002-2470 (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/uawm16

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Andrew Dravnieks , Thomas Masurat & Richard A. Lamm

To cite this article: Andrew Dravnieks , Thomas Masurat & Richard A. Lamm (1984) Hedonics of Odors and Odor Descriptors, Journal of the Air Pollution Control Association, 34:7, 752-755, DOI: 10.1080/00022470.1984.10465810

To link to this article: https://doi.org/10.1080/00022470.1984.10465810

Published online: 08 Mar 2012.

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Dr. Nochumson and Dr. Williams are with the Energy Technologies Group, Los Alamos National Laboratory, Los Alamos, NM 87545. This note manuscript was peer reviewed.

Hedonics of Odors and Odor Descriptors

Andrew Dravnieks
Institute of Olfactory Sciences
Park Forest, Illinois

Thomas Masurat and Richard A. Lamm
Warner-Lambert Company
Morris Plains, New Jersey

The hedonic tone (pleasantness-unpleasantness) of an air pollution odor depends on its character and influences how annoying the odor may be. In the context of air pollution, both unpleasant and pleasant odors may become objectionable, while this is less likely for hedonically neutral odors.[1] Methods exist to characterize odors through odor profiling,[2] and it might be that the values of the hedonic tones of odors could be derived from such profiles. In the present study, we searched for such a derivation.

A profile of an odor consists of a list of odor descriptors and ratings of the applicabilities of each of the descriptors to the odor being characterized. Our working hypothesis was that each of the descriptors can be assigned its own hedonic connotation (tone) from very pleasant, through neutral, to the very unpleasant. The hedonic tones of the descriptors could then be combined with the descriptor applicability percentages over the entire profile, producing a profile-derived hedonic index.

The data that were needed are profiles of odors and the hedonic ratings of the same odors made directly upon smelling these odors, preferably obtained independently of profiling studies.

Data from Experiments and Literature

Odor Profile Data

Odor profiles for odors for which hedonic ratings were available in literature were obtained using data collected in a cooperative exercise conducted by American Society for Testing and Materials Sensory Evaluation Committee E18. The procedure has been described earlier.[2] Briefly, it consisted of smelling solutions of odorants (on balsa wood chips) and evaluating their odors using a list of 146 descriptors. The number of panelists was 120–150, with 10 panelists from each participating organization.*

Hedonic Tones of Descriptors

Hedonic tones of each descriptor were rated on a 1–9 scale, with a midpoint of 5, a value of 1 for the most pleasant, and 9 for the most unpleasant connotation. These were collected

* Candess Industries, General Foods, Hershey Foods Company, IIT Research Institute, International Flavors and Fragrances, Philip Morris, John B. Pierce Foundation, Procter and Gamble, Quaker Oats, Department of Food Science of Reading University (England), The Stroh Brewery Company, Swift and Company, Food Science Department of University of Georgia, Gulf Coast Hydroscience Center of U.S. Geological Survey, and Warner-Lambert.

Table I. Hedonics of descriptors.

Descriptors	Hedonic tones	Descriptors	Hedonic tones
Fruity, citrus	2.72	Soapy	0.96
Lemon	2.50	Leather	1.30
Grapefruit	1.95	Cardboard	−0.54
Orange	2.86	Rope	−0.16
Fruity, other than citrus	2.23	Wet paper	−0.94
Pineapple	2.59	Wet wool, wet dog	−2.28
Grape juice	2.07	Dirty linen	−2.55
Strawberry	2.93	Stale	−2.04
Apple	2.61	Musty, earthy, moldy	−1.94
Pear	2.26	Raw potato	0.26
Melon	2.41	Mouse-like	−2.20
Peach	2.67	Mushroom	0.52
Banana	2.00	Peanut butter	1.99
Floral	2.79	Beany	0.54
Rose	3.08	Eggy (fresh eggs)	0.45
Violets	2.68	Bark, birch bark	1.18
Lavender	2.25	Cork	0.19
Cologne	2.16	Burnt, smoky	−1.53
Musky	0.21	Fresh tobacco smoke	−0.66
Perfumery	1.96	Incense	1.01
Fragrant	2.52	Coffee	2.33
Aromatic	1.41	Stale tobacco smoke	−2.83
Honey	2.08	Burnt paper	−1.47
Cherry	2.55	Burnt milk	−2.19
Almond	2.01	Burnt rubber	−3.01
Nail polish remover	−0.81	Tar	−1.63
Nutty	1.92	Creosote	−1.35
Spicy	1.99	Disinfectant, carbolic	−1.60
Clove	1.67	Medicinal	−0.89
Cinnamon	2.54	Chemical	−1.64
Laurel leaves	0.97	Bitter	−1.38
Tea leaves	1.40	Sharp, pungent, acid	−2.34
Seasoning (for meat)	1.27	Sour, vinegar	−1.26
Black pepper	0.19	Sauerkraut	−0.60
Green pepper	1.39	Ammonia	−2.47
Dill	0.87	Urine	−3.34
Caraway	1.06	Cat urine	−3.64
Oak wood, cognac	1.23	Fishy	−1.98
Woody, resinous	0.94	Kippery (smoked fish)	−0.69
Cedarwood	2.11	Seminal, sperm-like	−1.04
Mothballs	−1.25	New rubber	−0.96
Minty, peppermint	2.50	Sooty	−1.69
Camphor	−0.55	Burnt candle	−0.08
Eucalyptus	0.99	Kerosene	−1.67
Chocolate	2.78	Oily, fatty	−1.41
Vanilla	2.57	Buttery, fresh butter	2.04
Sweet	2.03	Paint	−0.75
Maple syrup	2.26	Varnish	−0.85
Caramel	2.32	Popcorn	2.47
Malty	1.05	Fried chicken	2.53
Raisins	1.56	Meaty (cooked, good)	2.34
Molasses	1.00	Soupy	1.13
Coconut	1.93	Cooked vegetables	1.58
Anise (licorice)	1.21	Rancid	−3.15
Alcoholic	−0.47	Sweaty	−2.53
Etherish, anesthetic	−1.54	Cheesy	1.02
Cleaning fluid	−1.69	Household gas	−2.30
Gasoline, solvent	−1.16	Sulfidic	−2.45
Turpentine (pine oil)	−0.73	Garlic, onion	−0.17
Geranium leaves	0.57	Metallic	−0.94
Celery	1.36	Blood, raw meat	−1.64
Fresh green vegetables	2.19	Animal	−1.13
Crushed weeds	−0.21	Sewer odor	−3.68
Crushed grass	1.34	Putrid, foul, decayed	−3.74
Herbal, green, cut grass	2.14	Fecal (like manure)	−3.36
Raw cucumber	1.30	Cadaverous (dead animal)	−3.75
Hay	1.31	Sickening	−3.34
Grainy (as grain)	0.63	Dry, powdery	−0.07
Yeasty	−0.07	Chalky	−0.85
Bakery (fresh bread)	3.53	Light	0.91
Sour milk	−2.91	Heavy	−0.79
Fermented (rotten) fruit	−2.76	Cool, cooling	1.53
Beery	−0.14	Warm	0.78

by the Warner-Lambert Company using 429 subjects. For each of the subjects, the descriptors in the list were in a different computer-controlled order. Mean values were calculated for each of the descriptors. For convenience of use, data from the 1–9 scale were converted to a bipolar form, subtracting the mean value from 5, thus making unpleasant tones negative, and pleasant tones positive. Table I lists the resulting mean hedonic tones of all descriptors, arranged in an order such as used earlier for odor profile representation.[2] The highest possible absolute value of the hedonic tone would be 4.

A statistical analysis was conducted to explore if demographic factors—sex, age, and body weight—influence the hedonic ratings of the descriptors. Females, as compared with males, tended to be somewhat more extreme in such ratings, and heavier people tended to give less pleasant ratings. Age had no effect. When the raw data were normalized for the demographic factors, values in Table I changed only very slightly.

Hedonic Tones of Odors

Three studies reported in literature contained a sufficient number of hedonic ratings of odorants that our profile data also covered.[3–5] These studies differed in the methods of odor presentations and in the types of hedonic scales used.

In the present work, hedonic tones of odors were derived from profiles (obtained from the ASTM *Odor Profiling Exercise*) by multiplying the percent applicabilities for each of the descriptors by their hedonic tones (from Table I), and summing such hedonically-weighed applicabilities over the entire profile of the particular odor.

Table II lists the hedonic tones from the literature and those derived from the profiles. At the bottom of the table, coefficients of determination (squares of the coefficients of correlation) are shown for data from each possible pair of sets. Figure 1 gives graphic comparisons of correlations between the three literature data sets and the profile-derived hedonic tones of the odors.

The coefficients of determination in Table II changed by 0.01 or less when demographically normalized hedonic tones of descriptors were substituted for the values in Table I.

Discussion

The profile-derived hedonic tones of odors quite satisfactorily represent the hedonic tones of odors rated directly, as seen from Figure 1. Also, from an inspection of the coefficients of determination at the bottom of Table II, the agreement between the literature values themselves is not significantly better than between the literature data and the profile-derived hedonic tones of the same odors. Since profiles and the directly-rated hedonic tones of odors were obtained by different investigators using different panelists, different modes of odor presentations, and different hedonic rating scales, this finding should be on a very solid ground.

This finding opens a new way to estimating the hedonic impact of air pollution odors. An odor profile of an air pollution odor is relatively free from interference by subjective

Table II. Hedonic tones of odorants derived from profiles and from three literature sources.

Odorants	From profile	From Ref. 5	From Ref. 4	From Ref. 3
Amylbutyrate	0.12	−0.50		
Anethole	0.97		6.71	
Benzaldehyde	1.29	0.55	3.93	2.00
Butanoic acid	−1.77	−0.95	1.87	8.73
1-Butanol	−0.67	0.04	3.27	5.38
Cinnamaldehyde	1.31	0.45		
Citral	1.53	0.28	6.66	1.94
Coumarin	1.08	0.72	5.80	
Eucalyptol	0.35	0.22		
Eugenol	0.99	0.67	6.27	2.10
Guaiacol	−0.49	−0.07	4.64	5.10
1-Heptanol	0.41		4.93	4.62
1-Hexanol	0.33			4.66
Isovaleric acid	−1.57	−1.21	2.00	
Limonene	1.49	0.22	5.80	
Linalool	1.12	0.47	6.20	
l-Menthol	0.57	0.19	5.93	4.50
Methylsalicylate	1.18		7.93	1.83
Phenylethanol	1.23			2.83
Pyridine	−1.60		2.00	8.91
Safrole	0.91			2.00
γ-Undecalactone	0.41	0.22		
Vanillin	1.25	1.18	6.73	0.71

Coefficients of determination for comparison of data from different sources (number of pairs in parentheses)

Coefficients:	Data sets compared:			
Vs. profile-derived				
0.66 (16)	X	X		
0.77 (16)	X		X	
0.92 (14)	X			X
Between literature data sets				
0.71 (12)		X	X	
0.90 (8)		X		X
0.84 (12)			X	X
Notes on methodology used:				
Odor presentation	Impregnated chips	Dynamically in air	From bottles	From bottles
Number of subjects	120–150	9–15	15	20
Hedonic scale	Calculated per this work	Length of tape	Numerical, 9–1	Numerical, 1–9
Most pleasant	+4	+2	9	1

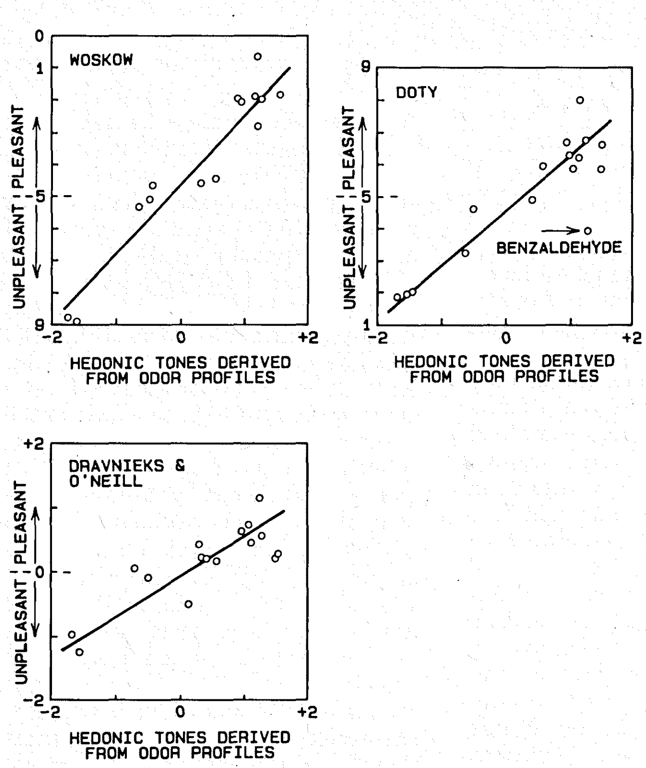

Figure 1. Correlations between hedonic tones of odors obtained by direct rating in three studies, and the hedonic tones (indexes) derived from odor profiles in this work.

hedonic impressions. Thus, an odor's hedonic tone derived from its profile should be independent from such impressions.

Conclusion

The hedonic tone of an odor can be estimated from the odor character profile, using a table of hedonic tones of the odor descriptors. Such estimates agree with the hedonic tones of odors evaluated directly in separate studies.

The connection between the annoyance that may be caused by an air pollution odor and this odor's hedonic tone needs further study. The entire hedonic spectrum should be considered, from the most unpleasant, through neutral, to the most pleasant odors.

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Dr. Dravnieks is Director, Institute of Olfactory Sciences, 211 Tampa Street, Park Forest, IL 60466. Mr. Masurat is Senior Scientist, Chemical Research, and Mr. Lamm is Director, Statistics and Information Services, Warner-Lambert Company, 170 Tabor Road, Morris Plains, NJ 07950. Based on material originally presented as paper number 82-28.3 at the 75th APCA Annual Meeting and Exhibition in New Orleans, June 1982. This note manuscript was peer reviewed.

CALENDAR

July 23-25, 1984
Western State College of Colorado will hold the Ninth Annual Water Workshop, cosponsored by APCA, at the Aspinwall-Wilson Conference Center, Gunnison, Colorado. Theme is "Acid Rain and the West: Direct and Indirect Effects." For details, contact Theo Colborn, Water Workshop Director, Western State College, Gunnison, CO 81203; (303) 943-2082 or 641-2747.

August 27-30, 1984
EPA's Industrial Environmental Research Laboratory, RTP, and EPRI's Coal Combustion Systems Division are cosponsoring the fifth symposium on "The Transfer and Utilization of Particulate Control Technology" at the Hyatt Regency Hotel, Kansas City, Missouri. For information contact Franklin A. Ayer, Symposium Coordinator, Research Triangle Institute, P.O. Box 12194, Research Triangle Park, NC 27709; (919) 51-6260.

October 14-18, 1984
APCA's TP-8 Data Analysis Committee and the American Society of Quality Control are sponsoring a Specialty Conference on "Quality Assurance in Air Pollution Measurements." The conference, hosted by the Rocky Mountain States Section, will be held in the Hilton Harvest House Hotel, Boulder, Colorado. For details, contact APCA Headquarters, P.O. Box 2861, Pittsburgh, PA 15230; (412) 621-1090.

October 16-19, 1984
The Fourth Joint Conference on Applications of Air Pollution Meteorology will be held in Portland, Oregon. It is being cosponsored by APCA's TT-3 Meteorology Committee and the American Meteorological Society. Technical program information can be obtained from Norman Bowne, TRC Environmental Consultants, Inc., 800 Connecticut Blvd., East Hartford, CT 06108; (203) 289-8631.

October 17, 1984
The Conference on Hazardous Waste Source Reduction, sponsored by the Massachusetts Department of Environmental Management, Bureau of Solid Waste Disposal, will be held at the Sheraton Inn, Boxboro, Massachusetts. For details, contact Teresa Habib, Bureau of Solid Waste Disposal, 100 Cambridge Street, Boston, MA 02202; (617) 727-3260.

October 28-31, 1984
Indoor Air and Human Health will be the topic of the 7th Oak Ridge National Laboratory Life Sciences Symposium at the Hilton Hotel, Knoxville, Tennessee. The symposium will focus on the possible adverse health effects of increased levels of five principal classes of indoor air pollutants: cigarette smoke, passive cigarette smoke, radon, organic combustion products, and microorganisms. For details, contact Dr. S. V. Kay, Oak Ridge National Laboratory, P.O. Box X, Oak Ridge, TN 36830; (615) 574-5845.