The Cognitive Side of Odor Perception

Pamela Dalton, PhD

Monell Chemical Senses Center, Philadelphia, PA 19104

June 10,2009

Although often underrated in importance, the human sense of smell has both evolutionary and contemporary significance: our ability to perceive odors provides information that guides our responses to our environments. For example, the rich aromas wafting from a bakery encourage us to linger and savor them, whereas the smell of rotting garbage impels us to move away. No account of the role of smell in our lives would be complete, however, without an acknowledgment that people vary in their perception of ambient odors in their environment. Some of this variability has been attributed to inter-individual variation in sensitivity: some people have a keener sense of smell than others. However, recent findings in olfactory research has revealed that an important source of differences in response to ambient, environmental odors may also stem from cognitive factors, such as an individual's beliefs and expectations about the consequences of exposure to an odor.

A belief that ambient odors can influence health for better or for worse has a long history: Prior to the discovery of germ theory, for example, unpleasant odors were deemed to be carriers of disease while good odors were viewed as potentially curative (Levine & McBurney, 1986; LeGuérer, 1994). In modern times, this belief is manifest in concerns about becoming sick from exposures to environmental odors (Dietert & Hedge, 1997; Cain & Cometto-Muñiz, 1993). Currently, aromatherapy is the most prominent example of the belief that certain fragrances can have beneficial effects on health, mood and mental well-being (e.g., Stoddard, 1990; van Toller & Dodd, 1988). At the same time, however, there exists a growing set of beliefs about health risks associated with exposure to airborne odors and pollutants (e.g., Bell et al, 1993).

Odors have important signal value. Unfamiliar or unpleasant odors can both arouse and alarm community-dwellers and building occupants. The mere presence of an odor can increase symptom reporting (Alexander & Fedoruk, 1986; Neutra et al., 1991; Roht et al., 1985; Smith, Colligan, & Hurrell, 1978; Stahl & Lebedun, 1996) and is often the most significant correlate of perceived health risk for individuals whose neighborhoods have been sprayed with pesticide (Ames, Howd, & Doherty, 1993; Neutra et al., 1991; McClelland, Schulze, & Hurd, 1990) or near factories thought to be the source of pollution (Cavalini, Koeter-Kemmerling, & Pulles, 1991; Taylor et al., 1997).

Researchers in the field of olfactory science have identified several plausible ways in which odors can produce adverse effects. First, almost all volatile chemicals produce not only an odor, but at higher concentrations, can elicit eye, nose and throat irritation, through stimulation of one or more sensory nerves in the upper airways. The resulting perception of pungency or sensory irritation is often a primary determinant in people's assessment of the quality and acceptability of indoor air (Cain, 1987; Boxer, 1990). Adverse reactions to odors are not always based on irritancy, however. An odorant (or even multiple odorants) can be present at concentrations below those known to elicit sensory irritation, yet nonetheless provoke adverse responses (Dalton et al., 1997; Wysocki et al., 1997). Moreover, perception of irritancy can depend on context: Some odorants (e.g., menthol, wintergreen, eucalyptus) elicit a pungent sensation, yet produce positive responses. (Dalton, 1997). Here, an individual's experience may play a key role. Studies from our laboratory have suggested that odors are reported as irritating or annoying when individuals do not recognize them and attribute erroneous effects or consequences to exposure (Dalton, 1996; Dalton et al., 1997). Recent studies have shown that in an implicit association task, individuals associate the concept odor with illness rather than health (Bulsing, Smeets & van den Hout, 2009).

In a series of studies, we have examined the influence of experience, familiarity and expectations on people's perception and response to ambient odors. The basic procedure used in this research involves measuring people's responses to an odorant before, during, and after a 20 minute whole-body exposure to the odorant under controlled conditions in an exposure chamber. Numerous measures of an individual's response to the odor are obtained, including ratings of perceived odor and irritation intensity during exposure, and reports of subjective health symptoms following exposure. The principal question concerns whether subjects' reactions to either of these odorants during a 20 minute exposure are altered by their previous experience or experimentally-induced beliefs about the odorant. In some conditions, volunteers have had previous occupational or community exposure to the odor in question, while others are naive. All volunteers receive either a positive, negative or neutral bias about the nature and consequences of exposure to the odorant. In some studies this information is provided prior to the exposure by the experimenter, while in other studies odorant information is conveyed by the behavior/symptoms/verbal reports of a 'sham' or 'confederate' subject (in reality, an actor whose positive or negative responses are scripted).

In all cases, the information provided to the subject greatly influences their experience during and following exposure to the chemical. The level of reported odor and irritation during exposure to acetone varied systematically with the information subjects were given about the source of the odor. We found similar results when the expectation about the chemical was conveyed by the "confederate" subject. In both types of studies, however, the frequency of spontaneous (Dalton, 1996) and surveyed (Dalton et al., 1997; Dalton et al., 1997) symptom reports varies significantly with perceived odor intensity, suggesting that symptom perception is correlated with or triggered by the awareness of an odor. Experience can modulate this response: we have observed in a number of studies that individuals who are occupationally-exposed to a volatile chemical perceive less odor and exhibit far fewer symptoms from exposure (Dalton et al., 1997).

Recognizing the interaction between the sensory and the psychological responses to odors is of significant value when trying to remediate indoor air-quality problems. The perception of health risks from short- or long-term exposures to chemical odors is of escalating concern to the general public (Lees-Haley & Brown, 1992) and research indicates that such concerns will likely amplify the vigilance and attention paid to even low-level, neutral, background odors. Our research also suggests that interventions that reduce ambient pollutants, but which do not eliminate all odors may not remediate the concerns and anxieties of occupants. Educational materials and effective communication regarding the relationship between odors, irritation, perceived toxicity and actual risk may be of greater value when occupants are trying to determine whether an ambiguous or unfamiliar odor in their environment poses a short or long-term hazard to their health. Moreover, continued efforts in the scientific community to conduct research that explores the relationship between odors, perceived health-risk and air-quality complaints can be of significant benefit to scientists and practitioners alike.

Reference List

Alexander, R.W., & Fedoruk, M.J. (1986). Epidemic psychogenic illness in a telephone operator's building. Journal of Occupational Medicine, 28, 42-45.

Ames, R.G., Howd, R.A., & Doherty, L. (1993). Community exposure to a paraquat drift. Archives of Environmental Health, 48, 47-52.

Bell, I.R., Schwartz, G.E., Baldwin, C.M., Hardin, E.E., Klimas, N.G., Kline, J.P., Patarca, R., & Song, Z.Y. (1997). Individual differences in neural sensitization and the role of context in illness from low-level environmental chemical exposures. Environmental Health Perspectives, 105, 457-466.

Boxer, P.A. (1990). Indoor air quality: A psychosocial perspective. Journal of Occupational Medicine, 32, 425-428.

Bulsing, P.J., Smeets, M.A.M. & van den Hout, M.A. (2009) The impliciat association between odors and illness. Chemical Senses, 34, 111-119.

Cain, W.S. (1987). Indoor air as a source of annoyance. In H.S.Koelega (Ed.), Environmental Annoyance: Characterization, Measurement and Control. Amsterdam: Elsevier.

Cain, W.S.,& Cometto-Muñiz, J.E. Irritation and odor: Symptoms of indoor air pollution. In Anonymous. Volume 1. Health Effects: Vol. 1. Indoor Air '93: Proceedings of the 6th International Conference on Indoor Air Quality and Climate.

Cavalini, P.M., Koeter-Kemmerling, L.G., & Pulles, M.P.J. (1991). Coping with odour annoyance and odour concentrations: Three field studies. Journal of Environmental Psychology, 11, 123-142.

Dalton, P. (1996). Odor perception and beliefs about risk. Chemical Senses, 21, 447-458.

Dalton, P. (1997). Cognitive influences on odor perception. Aroma-chology Review, 6, 2-9.

Dalton, P., Wysocki, C.J., Brody, M.J., & Lawley, H.J. (1997). Perceived odor, irritation and health symptoms following short-term exposure to acetone. American Journal of Industrial Medicine, 31 , 558-569.

Dalton, P., Wysocki, C.J., Brody, M.J., & Lawley, H.J. (1997). The influence of cognitive bias on the perceived odor, irritation and health symptoms from chemical exposure. International Archives of Occupational & Environmental Health, 69, 407-417.

Dietert, R.R., & Hedge, A. (1997). Toxicological considerations in evaluating indoor air quality and human health: Impact of new carpet emissions. Critical Reviews in Toxicology, 6, 633-707.

Lees-Haley, P.R., & Brown, R.S. (1992). Biases in perception and reporting following a perceived toxic exposure. Perceptual and Motor Skills, 75, 531-544.

LeGuérer, A. (1994). Scent. New York: Kodansha America.

Levine, J.M., & McBurney, D.H. (1986). The role of olfaction in social perception and behavior. In C. P. Herman, M. P. Zanna, & E. T. Higgins (Eds.), Physical Appearance, Stigma, and Social Behavior: The Ontario Symposium, Volume 3. (pp. 179-217). Hillsdale, NJ: Lawrence Erlbaum.

McClelland, G.H., Schulze, W.D., & Hurd, B. (1990). The effect of risk beliefs on property values: A case study of a hazardous waste site. Risk Analysis, 10, 485-497.

Neutra, R., Lipscomb, J., Satin, K., & Shusterman, D. (1991). Hypotheses to explain the higher symptom rates observed around hazardous waste sites. Environmental Health Perspectives, 94, 31-35.

Roht, L.H., Vernon, S.W., Pier, F.W., Sullivan, P., & Ree, L.J. (1985). Community exposure to hazardous waste disposal sites: Assessing reporting bias. American Journal of Epidemiology, 122, 418-433.

Smith, M.J., Colligan, M.J., & Hurrell, J.J. (1978). Three incidents of industrial mass psychogenic illness. Journal of Occupational Medicine, 20, 399-400.

Stahl, S.M., & Lebedun, M. (1996). Mystery gas: An analysis of mass hysteria. Journal of Health and Social Behavior, 15(44), 44-50.

Stoddard, M. (1990) The scented ape: the biology and culture of human odour. Cambridge: Cambridge University.

Van Toller, S. & Dodd, G. (1988) Perfumery: The psychology and biology. London: Chapman.

Taylor, S.M., Sider, D., Hampson, C., Taylor, S.J., Wilson, K., Walter, S.D., & Eyles, J.D. (1997). Community health effects of a petroleum refinery. Ecosystem Health, 3, 27-43.

Wysocki, C.J., Dalton, P., Brody, M.J., & Lawley, H.J. (1997). Acetone odor and irritation thresholds obtained from acetone-exposed factory workers and from control (occupationally non-exposed) subjects. American Industrial Hygiene Association Journal, 58, 704-712.