The Ironies of Smell

by Jason Ross

The sense of smell is absolutely unique in its evolutionary primacy, its emotional power, and the heterogeneity of the impressions it provides. At its inception, what was to become the sense of smell, was simply the ability of life to respond to its surrounding environment. Bacteria moving towards higher concentrations of food sources are using what can be considered a sense of smell, just as a dog following a trail is smelling its path. The simple sense of smell of the bacteria still exists in complex life in a new form: the internal regulation of bodily processes by means of chemical messengers. Just as river-spawning ocean fish recognize their birth stream by smell, so may people be brought back to memories of childhood by the smell of a familiar house, town, or food. The rich variety of smells, not simply of different shades, but of wholly distinct types and characters, makes the field of smell one that is uniquely difficult to categorize, quantify, and describe, and one that is singularly rich.

Internal Communication

Bodily functions and processes are regulated in a number of ways. Voluntary activities and conscious sense perceptions involve the central and somatic nervous systems. However, most of the involuntary activities of the body are controlled by the separate autonomic nervous system, including: retinal dilation, urine production, heart rate, saliva production, digestive gland activity, the opening and closing of gastrointestinal valves (sphincters), and sweating. These behaviors are controlled by nerves, but not by the brain. In addition to control via nerve impulses, there is also a hormonal chemical regulatory system, known as the endocrine system.

Endocrine regulation does not involve direct nervous connections to the affected tissues. Rather, chemicals known as hormones are secreted into the bloodstream, where they come in contact with all organs, and can cause their activity to change. This form of internal communication is similar to the types of communication available to simpler creatures. Absolutely all organisms respond to their chemical surroundings. With the development of multi-cellular life, a distinction between *inside* and *surface* cells of the organism could be made. Thus, in addition to environmental chemical detection and communication between organisms, it was now possible for life to have an internal environment, both from a stable nutritive standpoint, and an internal regulatory environment. By changing the internal environment, cycles in the organism can be regulated.

The human endocrine system has major glands in the brain, and in the thyroid, kidneys, pancreas, and gonads. Familiar hormones released by these glands include growth hormone, melatonin (sleep regulation), thyroxine and triiodothyronine (overall metabolic rate), insulin (glucose uptake from the blood), adrenaline, androgen, and estrogen.

The Physiology of Smell

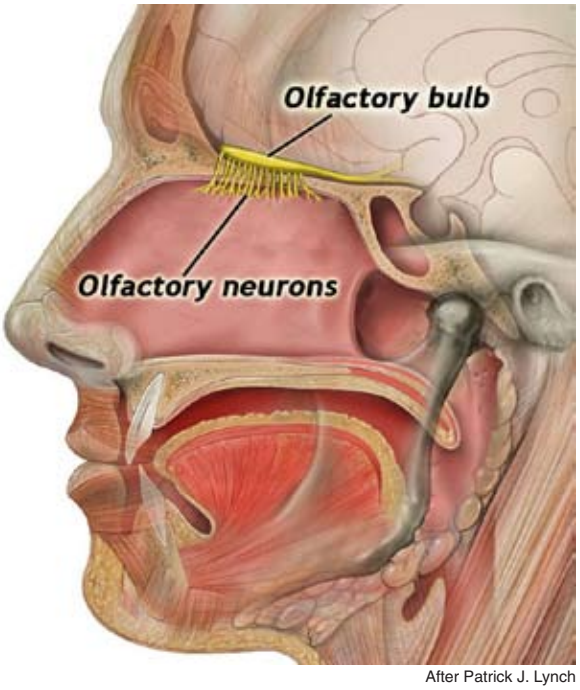
While it is said that we smell with our noses, the actual detection of scents occurs about three inches beyond our nostrils, deep in the nasal cavity. There, a small structure known as the *olfactory epithelium*, containing 10 to 40 million olfactory receptors, does the work of smelling.[1] Each olfactory receptor is a neuron with a dozen ciliate tips that extend into a patch of mucus lining the nasal cavity (**Figure 1**). These neurons do not live long: After one to two months, they die and are replaced by a new receptor grown from a stem cell.[2]

The way that the ciliate tips respond to odorants is not totally clear, although the most pursued hypothesis is that chemical receptors respond directly to particular odorant molecules. Hundreds of different receptor proteins have been identified in mice; and each neuron may have several, thus determining its sensitivity. The olfactory neurons pass through the skull and congregate in the olfactory bulb, part of the brain. They then pass directly to the olfactory cortex, without passing through the thalamus, as the other senses do. This makes smell anatomically unique among the senses, in its connection to the cortex.[3]

In trying to determine how these individual receptors make the tens of thousands of distinct smells we

1. Sources vary in the number of receptors.
2. Although this is presented as an anomaly for nerve cells, which are said not to reproduce, this phenomenon is increasingly found to be more common in the body than once thought.
3. Additionally, the olfactory bulb itself has connections with the hippocampus, amygdala, and hypothalamus.

FIGURE 1



After Patrick J. Lynch

Unlike what we preceive with our vision, smells are notoriously difficult to describe, despite the fact that the sense of smell has been central to the development of life. Shown: the human olfactory equipment.

can recognize, HHMI (Howard Hughes Medical Institute) investigators discovered a structure not in the distribution of receptors in the olfactory epithelium itself, but rather in the olfactory bulb. It appears that similar receptor neurons converge to the same portion of the olfactory bulb.[4]

In addition to the main olfactory epithelium, many animals have separate organs in the nasal cavity that perform a second function like smell. Known as the vomeronasal organs (VNOs), these structures have a different connection to the brain, connecting to auxiliary olfactory bulbs rather than the cortex, and may indeed cause changes unconsciously. Some animals must make an effort to cause air to enter the VNOs, such as the behavior known as *flehmen*, performed by deer: This involves raising the head and curling the upper lip.

Experiments with animals have revealed molecules known as *pheromones*, picked up by the VNOs, often involved in mating behavior and social identification. For example, one study with hamsters revealed that the VNOs are required for the animals to first become sexually active.[5] It seems that VNOs may function analogously to an inter-organismic endocrine system, regulating the social cycles of populations of animals.

The question of human VNOs, although interesting, is not yet settled. Small pits, with what appear to be VNOs, can be found in most humans, but a nervous connection to the brain has not yet been clearly identified. Unfortunately, much of the research done is funded by companies that market human pheromones in perfumes and colognes, making it difficult to gauge the reliability of the studies. The reported synchronization and entrainment of human menstrual cycles may involve VNO sensitivity.

Describing the Power of Smell

Smells are notoriously difficult to describe, and almost impossible to convey to someone who has not experienced the same smell in the past. This is very much unlike vision, where, although different objects may appear totally different and distinguishable, the domain of their possible appearances can be ordered. The different shades and tints of colors can all be described, and understood as a continuum, allowing them to be used as a verbal palette for painting an image. Sounds, although more difficult, can also be described, at least in terms of intensity, duration, and pitch. Similarly, although touch is itself a multifaceted sense, there is a continuum in each of its identifiable aspects.[6]

But, when it comes to smells, we find that besides indicating intensity, we simply lack a language to describe the domain of our perceptions; we have to describe either the effect of the smell upon us (stinky, pleasant, refreshing), or refer it to our experientially developed smell-vocabulary (citrus, rose, fetid, sweet). Although continuous variations may appear for certain similar smells and tastes, as Helen Keller noted, no conceptual space for *all* smells has been developed, at least not in popular understanding or discourse. Indeed, since different odors are so unique, smell has been an important part of chemistry, as a tool capable of distinguishing different substances, particularly organic ones. Enantiomorphic pairs of molecules may be difficult to

4. See the excellent HHMI report at: http://www.hhmi.org/senses/

5. Triggers of Innate Behavior. http://www.hhmi.org/senses/d220.html

6. That is, although temperature and texture are independent components of what is called touch, each of its components has its own reasonably complete lexicon.

distinguish chemically, but the nose has no trouble distinguishing many such pairs.[7]

Perhaps it is the uniqueness of smells, in addition to their direct connection to the cortex, that allows them to evoke memories with such power. A long-forgotten scent, once experienced anew, can bring back a flood of memories of people, places, and events in the past, in a way that no other sense can: or, at least, not in so unexpected and surprising a manner. An oft-cited example of this is by author Marcel Proust, who wrote in *The Remembrance of Things Past*:

> No sooner had the warm liquid mixed with the crumbs touched my palate than a shudder ran through my whole body, and I stopped, intent upon the extraordinary thing that was happening to me. An exquisite pleasure had invaded my senses, something isolated, detached, with no suggestion of its origin. . . .
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> Suddenly the memory revealed itself. The taste was of a little piece of madeleine which on Sunday mornings . . . my Aunt Léonie used to give me, dipping it first in her own cup of tea. . . . Immediately the old gray house on the street, where her room was, rose up like a stage set . . . and the entire town, with its people and houses, gardens, church, and surroundings, taking shape and solidity, sprang into being from my cup of tea.[8]

Human Experimentation

Interesting aspects of human smell have been explored in a small variety of experiments, covering subjects such as the smell of infants, emotional smells, and the courtship aspects of smell. Studies show a familial identification ability: Adults given the scent of a recently born nephew, niece, or grandchild, along with the scents of other infants born at the same time, are able to identify their relatives, despite not having met them before.[9] Some studies of the kinds of scents that people find to be attractive, reveal that there is a correlation between the nature of an individual's immune system and the attractiveness of his or her scent.[10]

The major histocompatibility complex (MHC) is involved in marking body cells as belonging to the body, making it easier to detect intruder cells. The scents of people with different MHCs are found to be more attractive, while those with similar MHCs reminded women of their brothers or other male relatives. These are not just preferences in choosing a spouse: MHC-similar couples are more likely to suffer miscarriages.[11] Apocrine glands produce both scents and a substrate that bacteria consume, creating smells. Those of men are larger than those of women, and are particularly active when emotional, such as at times of nervousness. Smell really can be a guide to emotional states.

Because of the intense power of smell, it is also studied for crowd-control applications. Rather than studying gases that actually cause pain in the nose (experienced via the trigeminal nerve), the Monell Institute has been developing a ill-smelling brew they call "stench soup," which is so foul that absolutely no one would want to be anywhere near it.[12]

Conclusion

The great variety of distinct smells, and the olfactory epithelium's direct connection to the cortex, make this sense powerful emotionally, in ways that are both conscious and unconscious. Compositions of smells and tastes (cooking skills) have their own harmonic aesthetics, that can be recognized even in food cultures unfamiliar with them, but these harmonic compositions have not been successfully used to communicate concepts or a quality of mind in anything more than a symbolic way. If this were possible, and developed, then cooking could truly be said to have become an art. Until then, smell serves us in many hidden ways, strengthening our memories, communicating our states of mind to others, and, possibly, altering our social dispositions.

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7. For examples, see "Chirality and Odour Perception" at http://www.leffingwell.com/chirality/cyclic_terpenoid.htm

8. Marcel Proust, *À la recherche du temps perdu*, 1913; English translation by C.K. Scott Moncrieff, 1922.

9. Peter K. Brennan and Keith M. Kendrick, "Mammalian Social Odors: Attraction and Individual Recognition," *Philosophical Transactions: Biological Sciences,* Vol. 361, 2009, pp. 2061-2078. http://jstor.org/stable/20209801

10. The performance of these experiments also reveals a social preoccupation with sex.

11. See Brennan and Kendrick, note 7; and F. Bryant Furlow, "The Smell of Love." First published March 1, 1996; last updated Aug. 13, 2010. Accessed at: http://www.psychologytoday.com/articles/200910/the-smell-love

12. This differs from currently used gases, which actually cause pain to the nasal cavities.