The Hidden Power of SCENT

Far from being a weak and unimportant sense, our odor-detecting ability is surprisingly acute and shapes our social interactions in ways we do not consciously realize

By Josie Glausiusz

A tangle of tubes and polyurethane pouches binds a naked man and woman—he, paunchy and unperturbed, she, slim and similarly unself-conscious. This setup is not some esoteric sex game; it's "Smell Blind Date," an installation created by artist James Auger on display this past spring in New York City as part of the Museum of Modern Art's exhibition *Design and the Elastic Mind*. The PVC tubes—which run between the subjects' chests, with outlets extending to pouches attached to their noses, armpits and genitals—allow the man and woman to inhale each other's body odor through a wall that divides them. In theory, they are on a truly blind date, each undistracted by the other's looks, assessing the other's potential as a mating partner by his or her smell alone.

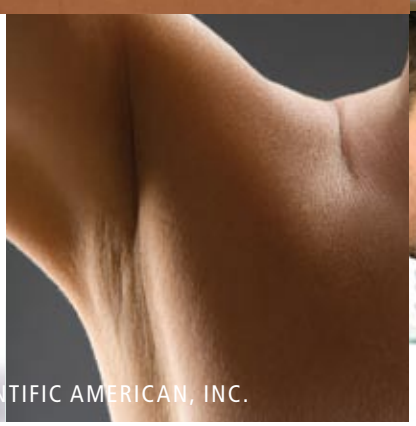
The human sense of smell is often seen as insignificant, dismissed as a distant also-ran to our keen eyesight or sensitive hearing. But this sense is keener and

ANTONIO M. ROSARIO *Getty Images (nose)*; GETTY IMAGES *(unsmiling couple)*; JUPITERIMAGES *(armpit and smiling couple)*; ISTOCKPHOTO; JOE McDANIEL *(dirty socks)*, JAKUB SEMENIUK *(lemons)*; CHRISTINE GLADE *(urine sample)*; OKTAY ORTAKCIOGLU *(rotten apple)*; JANIS LITAVNIEKS *(smoke)*








Dogs' long, large snouts are superior odor detectors, enabling canines to track the scents of lost or missing people and elusive items such as drugs and bombs.

more influential on our species than many people realize. In particular, as Auger's fanciful art project illustrates, smell facilitates a variety of human social interactions, both casual and intimate. Indeed, people who lose their sense of smell often gain a new appreciation for its importance [see "When the Nose Doesn't Know," by Eleonore von Bothmer; Scientific American Mind, October/November 2006].

Much of this influence goes unnoticed because it falls under the radar of consciousness. For instance, research demonstrates that we subconsciously use smell to assess a person's likability, sexual attractiveness and emotional state. Through scent, people can distinguish stranger from friend, male from female and gay from straight. Thus, olfaction may facilitate reproduction and prevent risky encounters. "If you look at nature, you see that every living organism has some form of chemosensory detection mechanism" that enables it to sense threats at a distance, explains neuroscientist Johan Lundström of the Monell Chemical Senses Center in Philadelphia. By the same token, deficiencies in olfaction may contribute to social withdrawal, such as that which accompanies schizophrenia [*see box on page 44*].

FAST FACTS

Social Sense

1» **The human sense of smell is often seen as insignificant, but this sense is keener and more influential on our species than many people realize.**

2» **Smell subconsciously facilitates a variety of human social interactions. People use smell to assess a person's likability, sexual attractiveness and emotional state. They can also use scent to distinguish a stranger from a friend, a male from a female and someone who is gay from someone who is straight.**

3» **Deficiencies in olfaction may contribute to social withdrawal, such as that which accompanies schizophrenia.**

Gifted Sniffers

Not only have scientists long snubbed human smell as feeble, but laypeople—at least in the past century or so—have often discounted the importance of odors in human life and society. The rise of sanitation standards in the 19th century was accompanied by repugnance for the putrid miasmas of ages past. Or, as Auger puts it: "Smell was devalued by scientists and philosophers in the 19th century, because they considered it to be a bestial, animalistic sense."

After all, dogs and rats, for example, would easily dominate humans in any kind of sniffing competition. Bloodhounds bred for tracking scents have about 300 times the number of odor-detecting cells in their noses as humans do. And rats possess three times as many functional genes for the protein receptors that pick up scents. The snouts of dogs and rats are also better adapted to detect odors than humans' noses are, because they are long, have a greater surface area, and are equipped with a filtering apparatus that cleans, warms and humidifies inspired air. Dogs also sniff much faster than humans do, which could contribute to their superior ability to track a scent.

Humans do, however, have a remarkably sophisticated olfactory apparatus. When people smell, air currents infused with chemicals swirl up the nose, passing over the moist olfactory epithelium on the roof of the nasal cavity and its roughly 12 million odor-detecting cells. Tiny cilia on each olfactory cell are covered with proteins that grasp odor molecules as they enter the nose. Each odor-detecting cell bears one of about 350 different olfactory receptor proteins and is specialized for sensing a limited number of odorant molecules. These receptor proteins work in

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Recent research shows that the human sense of smell is keen enough to enable some types of navigation.

different combinations to enable people to detect at least 10,000 scents. Sensory nerves carry signals from the odor-detecting cells to the brain's olfactory bulb, which in turn relays information about the inhaled odors to other areas of the brain [*see box on next page*].

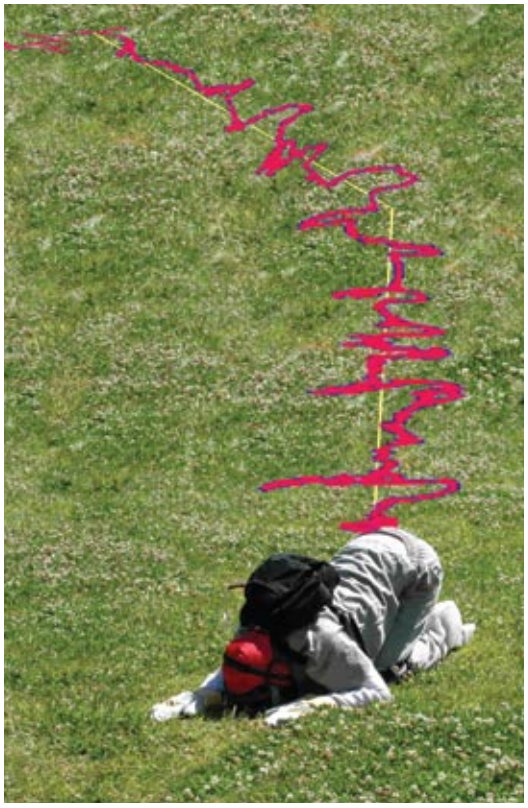
Scientists have recently revealed just how sensitive and versatile this odor-perception machinery is. An unusual experiment published in 2007 in *Nature Neuroscience* demonstrated that our sense of smell is keen enough to enable some types of navigation—and that this ability can improve with training. Neuroscientist Noam Sobel, along with his former graduate student, Jess Porter, both then at the University of California, Berkeley, and several colleagues, persuaded 32 undergraduates—16 men and 16 women—to don earmuffs and crawl blindfolded on hands and knees through a meadow, trying to track the scent from a rope coated in chocolate through the grass. Surprisingly, two thirds of the volunteers could follow the 33-foot twine line to the end, sniffing from side to side in a zigzag path, as a dog might. In a second experiment, two men and two women trained on the same trail three times a day for three days and cut their completion time from 10 to three and a half minutes by increasing their sniffing rate. The more they practiced, the faster they sniffed, and the faster they followed the trail.

This past March neurologist Jay Gottfried and his colleagues at Northwestern University published further evidence that humans can fine-tune their sense of smell. They asked people to sniff two very similar fragrant substances whose chemical structures were mirror images of each other. At first, nobody could tell the chemicals apart. But after the researchers paired the smell of one of the molecules with an electric shock, all the subjects learned to smell a difference between the two. The study shows that under certain conditions people can be acutely sensitive to minute differences in odors they might not otherwise be able to tell apart.

Not all humans smell equally well. According to cognitive neuroscientist Rachel Herz of Brown University, women are, on average, marginally more sensitive than men to trace odors and are most sensitive to odors when they are ovulating. A female's heightened sense of smell while fertile could aid in mate selection. In addition, a woman's acute sense of smell may improve her infants' chances of survival. Women can distinguish their babies' unique odors within an hour of birth, and two-day-old babies can identify their own mothers by smell—strategies that may help keep babies safely in their mothers' arms.

Identity by Scent

Although humans probably do not ordinarily use smell to navigate toward the nearest source of chocolate, we do seem to use odors—in most cases, subconsciously—to evaluate potential mates. Each of us has a unique scent: milky exudates of various glands, including the apocrine glands, which are located around the nipples, genitals and armpits, contain roughly 200 chemicals. The ratio of chemicals, which are metabolized into an aromatic brew by skin-dwelling bacteria, varies from person to person. Men and women, for example, have distinct odors governed by different ratios of sex hormones.



In one experiment, blindfolded people could follow a 33-foot chocolate-soaked piece of twine through a meadow (*red path*). With practice, they tracked the scent faster by increasing their sniffing rate.

SOURCE: "MECHANISMS OF SCENT-TRACKING IN HUMANS," BY J. PORTER ET AL., IN *NATURE NEUROSCIENCE*, VOL. 10, NO. 1; JANUARY 2007

Fragrances trigger subconscious responses in the brain before eliciting a conscious perception of an odor.

Neurons that convey odors from the nose to the brain's olfactory bulb have close connections with the oldest areas of the human brain: the limbic system, the region that includes the amygdala, which governs emotions such as aggression and fear, and the hippocampus, which controls memory acquisition. Thus, odors trigger subconscious emotional responses before arriving at the brain's outermost section, the cerebral cortex, for conscious assessment. What this means, Lundström explains, is that "a great deal of processing odor is done on a nonconscious basis."

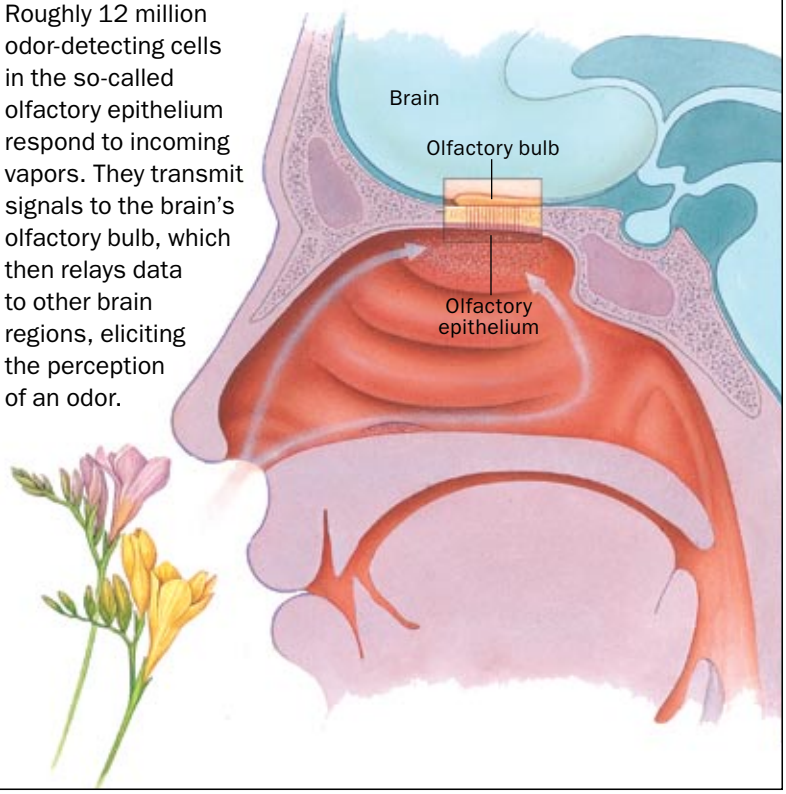
One trait that people may be subconsciously evaluating through scent is immune system status. Some studies suggest that variations in the major histocompatibility complex (MHC)—a gene region coding for cell-surface proteins that help our immune system distinguish our own cells from those of invaders—can influence body odor. In a now classic 1995 experiment biologist Claus Wedekind of the University of Lausanne in Switzerland and his colleagues demonstrated that women can determine the status of a man's immune system by sniffing his body odor. When women rated the odors of T-shirts men had slept in for two nights, they consistently preferred the scents of the men whose MHC genes differed significantly from their own, the researchers found. (Men could also differentiate MHC genes by smell.) This tendency may be adaptive: a mixing of divergent MHC genes through mating may lead to a more robust immune system in the resulting children than would occur from the mixing of similar MHC genes.

In a 2006 study experimental psychologist Bettina Pause of Heinrich Heine University in Düsseldorf, Germany, and her colleagues showed that the brain does indeed differentiate among the aromas of divergent immune systems. Pause collected armpit hair from 61 donors whom she had instructed to wash their armpits only with water and to avoid eating smelly foods such as onions and garlic for two days beforehand. She then had 40 volunteers sniff the hair while electrodes monitored the electrical peaks and valleys of their brain activity. The researchers found that the odors of donors whose MHC genes were similar to those of the sniffers provoked both faster and stronger electrical responses in the sniffers' brains than did the odors of those with dissimilar MHC DNA. "The smell helps us avoid those people who are [immunologically] similar to us; thereby, inbreeding is prevented," Pause explains. "Thus, the smell does not lead us to the right person but helps us avoid the wrong person."

Sniffing may enable us to pick out partners of a certain sexual orientation. In a 2005 study psychologist Yolanda Martins and sensory neuroscientist Charles Wysocki of the Monell Chemical Senses Center asked six heterosexual men, six gay men, six heterosexual women and six lesbians to wear cotton gauze pads under their armpits for three days. After collecting the pads, Martins and Wysocki had 80 volunteers—of both sexes, gay and straight—to take a big sniff of the gauze (whose wearers were not identified) and to report which pads smelled best. They found that heterosexual men and women and lesbians preferred the odor of the heterosexual men

Sensing Scents

Roughly 12 million odor-detecting cells in the so-called olfactory epithelium respond to incoming vapors. They transmit signals to the brain's olfactory bulb, which then relays data to other brain regions, eliciting the perception of an odor.



ROBERTO OSTI

and women to that of gay men, whereas gay men favored the odor of other gay men. Heterosexuals of both sexes and lesbians also liked the scents of lesbians better than those of gay males. (Gay men apparently have a distinctive odor for reasons that are, at present, largely speculative.)

But do particular human odors provoke sexual responses? Other animals secrete chemicals called pheromones that evoke a physiological or behavioral response in another member of the same species. For example, a compound called androstenone can drive female pigs into a frenzy of lust. Such an obvious behavioral effect of an odor has never been documented in humans. At least two nongaseous compounds, however, one exuded by men and one by women, do seem to elicit distinctive brain patterns of activity in men and women, indicating a possible divergence in their meaning to each sex, according to recent findings by neuroscientist Ivanka Savic of Karolinska University Hospital in Stockholm and her colleagues.

One of these chemicals—androstadienone, which is found in male sweat and semen—may help put women in the mood. In 2007 neuroscientists Claire Wyart of the University of California, Berkeley, and Noam Sobel, now at the Weizmann Institute of Science in Israel, reported that the smell of androstadienone was more likely than whiffs of baker's yeast were to improve mood and increase sexual arousal in 21 heterosexual women. Androstadienone also boosted levels of cortisol, a stress hormone, in the women's saliva. "It's the first report to my knowledge showing that smelling a specific component of male sweat was inducing significant changes in the hormonal balance of women," Wyart says.

Smelling Fear

Not everyone believes that androstadienone or any other substance qualifies as a human pheromone. For one thing, the perceptible amount of androstadienone in human sweat is extremely low—much lower than the concentrations used in scientific experiments. Many people cannot smell androstadienone at all; others find the smell sickening, which also argues against its utility as a sexual attractant. Nevertheless, some evidence suggests that humans may detect pheromones through nerves distinct from those that govern smell [see "Sex and the Secret Nerve," by R. Douglas Fields; Scientific American Mind, February/March 2007].

Body odor also has nonsexual effects on human interactions, including the ability to signal mood. Psychologist Denise Chen of Rice University and her colleagues asks subjects to watch funny or scary movies while wearing gauze pads inserted into their armpits. She then collects the pads, stuffs them into bottles and asks other people to sniff them. In a 2000 study, for example, Chen and Jeannette Haviland-Jones of Rutgers University found that volunteers could reliably identify "the odor of people when they are afraid" versus "the odor of people when they are happy." That is, humans can differentiate "happy" from

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Men and women have distinct odors, governed by different ratios of sex hormones. Each one of us also possesses a unique scent. The sexes subconsciously size each other up using smell.

(The Author)

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"fear" scents at a rate better than chance when asked to do so, even though they are not consciously aware of the emotional content of each of these smells when experienced in isolation.

The emotion elicited by the odor can even alter behavior. In a 2006 experiment the researchers found that subjects smelling "fear sweat" improved their performance on a word association test as compared with those who either smelled sweat from people who were not scared or sniffed a clean pad. In other words, Chen says, human chemical signals of fear may serve as a warning sign, provoking vigilance and sharpening wits. "It's been widely shown that chemical signals of fear and alarm are really powerful messages in the lives of many animals; they increase cautious behavior in recipient animals of the same species," she says. "I suspect that in humans there might be some effect similar to that. It's possible that they are more vigilant on these tasks and thus are performing more accurately."

After all, smell enables us to avoid various types of danger: to detect rotting food or toxic gases or even—as Lundström and his colleagues showed in a 2007 study—the odor of a stranger. In this study, which was the first to use imaging to examine how the brain responds to body odor, the researchers used positron-emission tomography, which measures glucose metabolism in different areas of the brain, to peer into the brains of 15 healthy nonsmoking women while they sniffed each of three aromas: their own body odor; the body odor of a longtime friend; and the odor of a stranger. Each scent had accumulated in cotton pads sewn into the armpits of tight T-shirts, which participants wore for seven con-

Anosmic and Aloof

If smell is integral to relationships and social cues, could its impairment lead to social withdrawal? Psychiatrist and smell researcher Dolores Malaspina of New York University and her colleagues at the New York State Psychiatric Institute have tried to answer that question by measuring the olfactory competence—in particular, the ability to identify odors—of people with schizophrenia, many of whom withdraw socially, interacting very little if at all with others.

Schizophrenia patients who withdraw socially have marked difficulty identifying common odors, such as those from pizza, smoke and chocolate.

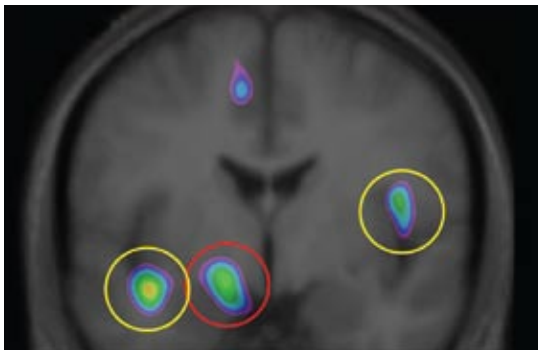
In a 2003 study Malaspina and her colleagues found that 70 schizophrenia patients scored significantly lower than 68 healthy subjects on a test requiring them to identify 40 common odors, such as the scents of chocolate, pizza, smoke and lilac. In addition, a subset of schizophrenia patients with diminished social drive—characterized by social withdrawal, self-neglect, poor speech and loss of motivation—scored worse than those who exhibited fewer social deficits. The worse the social deficit, the lower the scores on the smell identification test.

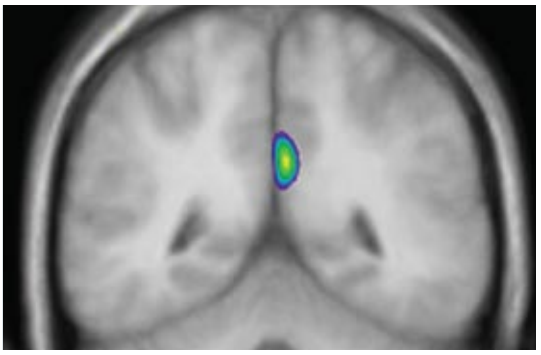
And in a 2005 investigation Malaspina and her colleagues found a similar association between an inability to identify odors and social isolation among 26 adolescents with early-onset psychosis, in which a person loses contact with reality, suffering delusions and hallucinations. The young patients who displayed typical schizophrenia symptoms, including social withdrawal, were more likely to have a marked difficulty identifying odors than those who suffered from psychotic symptoms of bipolar disorder, none of whom had an impaired sense of smell. Such findings suggest—but do not prove—that the smell impairment impedes social function. Schizophrenia might, after all, destroy areas of the brain that control both social motivation and smell. (Neurodegenerative diseases such as Alzheimer's and Parkinson's often destroy the ability to smell.)

Malaspina and New York State Psychiatric Institute research associate Deborah Goetz and their colleagues are now trying to pinpoint the neural origins of the putative deficits in smell and sociability. Ongoing studies are hinting that people with schizophrenia have impairments in the brain's inferior prefrontal cortex, which governs social behavior and motivation.

Malaspina hopes that her research will lead to new schizophrenia treatments, some of which might enhance social skills by sharpening the sense of smell. "It's really through the sense of smell that most mammals build social relationships," she argues. "The olfactory brain is really the social brain." —*J.G.*

VASKO MIOKOVIC *iStockphoto (pizza)*; NEWPHOTOSERVICE (*cigarette*); CHRISTINE BALDERAS *iStockphoto (chocolate)*





A stranger's odor activates the amygdala (*circled in red at left*) and insula (*yellow circles*), which process emotions such as fear. A friend's scent perks up the retrosplenial cortex (*right image*).

Our sense of smell enables us to detect various types of danger, including the potential threat of a stranger.

secutive nights as they slept. The pads were then encased in glass bottles for sniffing purposes.

The subjects could indeed identify their friend's scent: after sniffing each of the three odor-containing bottles, they correctly chose the one containing the friend's odor. (They picked the one emitting their own aroma with similar accuracy.) The participants also rated the smell of a stranger as more intense and less pleasant than that of their friend. What is more, their brains registered the difference between friends and strangers. The odor of a stranger activated the amygdala and the insula—which processes fear and disgust, among other emotions—whereas the smell of a friend triggered a response in the retrosplenial cortex, an area located at the brain's surface near the center of the head that encodes familiarity. "They are smelling a body odor they cannot identify," Lundström says, "and that in itself is a warning to the system: here comes an unknown individual."

Evidence also indicates that we use smell to help us decide whether we like a person. Few people are willing to stand close to someone who stinks, but research suggests that even at subliminal, undetectable levels, odors can influence our social preferences. In a 2007 study Gottfried and his colleagues exposed undergraduate students—18 women and 13 men—to three odors: one pleasant (lemon), one neutral (anisole) and one unpleasant (valeric acid, which smells like sweaty socks). The researchers then diluted each scent enough to make it undetectable and asked the participants to sniff the watered-down odors. After a whiff of each odor, the subjects judged a series of 20 faces on a 10-point scale from "extremely unlikable" to "extremely likable."

Even though the faces wore neutral expressions, the subjects rated a given set of faces as less likable if they had first sniffed the sweaty-smelling valeric acid (even though its odor was imperceptible) and more likable if they had inhaled the dilute lemony scent. "Human social judgments and social interactions are at least partly under the control of smells we can't perceive," Gottfried concludes.

Yet society continues to disdain the role that smell plays in everyday life. "It's a puritanical hangover from a Victorian attitude about civilization, how people who are civilized and have any valuable contribution should be scent-free for the most part," Herz says. Gottfried adds: "The human sense of smell is so often dismissed as being not only weaker than that of dogs or rats but really, truly inconsequential. That always gets my goat. If you take a harder look at the literature, all sorts of evidence suggests that the human nose is pretty damn good, actually." M

(Further Reading)

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- **The Scent of Desire: Discovering Our Enigmatic Sense of Smell.** Rachel Herz. William Morrow, 2007.
- Monell Chemical Senses Center: **www.monell.org**
- Artist James Auger's Web site: **www.smellplus.co.uk**

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