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Primal, Acute and Easily Duped: Our Sense of Touch

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Imagine you're in a dark room, running your fingers over a smooth surface in search of a single dot the size of this period. How high do you think the dot must be for your finger pads to feel it? A hundredth of an inch above background? A thousandth?

Well, take a tip from the economy and keep downsizing. Scientists have determined that the human finger is so sensitive it can detect a surface bump just one micron high. All our punctuation point need do, then, is poke above its glassy backdrop by 1/25,000th of an inch — the diameter of a bacterial cell — and our fastidious fingers can find it. The human eye, by contrast, can't resolve anything much smaller than 100 microns. No wonder we rely on touch rather than vision when confronted by a new roll of toilet paper and its Abominable Invisible Seam.

Biologically, chronologically, allegorically and delusionally, touch is the mother of all sensory systems. It is an ancient sense in evolution: even the simplest single-celled organisms can feel when something brushes up against them and will respond by nudging closer or pulling away. It is the first sense aroused during a baby's gestation and the last sense to fade at life's culmination. Patients in a deep vegetative coma who seem otherwise lost to the world will show skin responsiveness when touched by a nurse.

Like a mother, touch is always hovering somewhere in the perceptual background, often ignored, but indispensable to our sense of safety and sanity. "Touch is so central to what we are, to the feeling of being ourselves, that we almost cannot imagine ourselves without it," said Chris Dijkerman, a neuropsychologist at the Helmholtz Institute of Utrecht University in the Netherlands. "It's not like vision, where you close your eyes and you don't see anything. You can't do that with touch. It's always there."

Long neglected in favor of the sensory heavyweights of vision and hearing, the study of touch lately has been gaining new cachet among neuroscientists, who sometimes refer to it by the amiably jargony term of haptics, Greek for touch. They're exploring the implications of recently reported tactile illusions, of people being made to feel as though they had three arms, for example, or were levitating out of their bodies, with the hope of gaining insight into how the mind works.

Others are turning to haptics for more practical purposes, to build better touch screen devices and robot hands, a more well-rounded virtual life. "There's a fair amount of research into new ways of offloading information onto our tactile sense," said Lynette Jones of the Massachusetts Institute of Technology. "To have your cellphone buzzing as opposed to ringing turned out to have a lot of advantages in some situations, and the question is, where else can vibrotactile cues be applied?"

For all its antiquity and constancy, touch is not passive or primitive or stuck in its ways. It is our most active sense, our means of seizing the world and experiencing it, quite literally, first hand. Susan J. Lederman, a professor of

psychology at Queen's University in Canada, pointed out that while we can perceive something visually or acoustically from a distance and without really trying, if we want to learn about something tactilely, we must make a move. We must rub the fabric, pet the cat, squeeze the Charmin. And with every touchy foray, Heisenberg's Uncertainty Principle looms large. "Contact is a two-way street, and that's not true for vision or audition," Dr. Lederman said. "If you have a soft object and you squeeze it, you change its shape. The physical world reacts back."

Another trait that distinguishes touch is its widespread distribution. Whereas the sensory receptors for sight, vision, smell and taste are clustered together in the head, conveniently close to the brain that interprets the fruits of their vigils, touch receptors are scattered throughout the skin and muscle tissue and must convey their signals by way of the spinal cord. There are also many distinct classes of touch-related receptors: mechanoreceptors that respond to pressure and vibrations, thermal receptors primed to sense warmth or cold, kinesthetic receptors that keep track of where our limbs are, and the dread nociceptors, or pain receptors — nerve bundles with bare endings that fire when surrounding tissue is damaged.

The signals from the various touch receptors converge on the brain and sketch out a so-called somatosensory homunculus, a highly plastic internal representation of the body. Like any map, the homunculus exaggerates some features and downplays others. Looming largest are cortical sketches of those body parts that are especially blessed with touch receptors, which means our hidden homunculus has a clownishly large face and mouth and a pair of Paul Bunyan hands. "Our hands and fingers are the tactile equivalent of the fovea in vision," said Dr. Dijkerman, referring to the part of the retina where cone cell density is greatest and visual acuity highest. "If you want to explore the tactile world, your hands are the tool to use."

Our hands are brilliant and can do many tasks automatically — button a shirt, fit a key in a lock, touch type for some of us, play piano for others. Dr. Lederman and her colleagues have shown that blindfolded subjects can easily recognize a wide range of common objects placed in their hands. But on some tactile tasks, touch is all thumbs. When people are given a raised line drawing of a common object, a bas-relief outline of, say, a screwdriver, they're stumped. "If all we've got is contour information," Dr. Lederman said, "no weight, no texture, no thermal information, well, we're very, very bad with that."

Touch also turns out to be easy to fool. Among the sensory tricks now being investigated is something called the Pinocchio illusion. Researchers have found that if they vibrate the tendon of the biceps, many people report feeling that their forearm is getting longer, their hand drifting ever further from their elbow. And if they are told to touch the forefinger of the vibrated arm to the tip of their nose, they feel as though their nose was lengthening, too.

Some tactile illusions require the collusion of other senses. People who watch a rubber hand being stroked while the same treatment is applied to one of their own hands kept out of view quickly come to believe that the rubber prosthesis is the real thing, and will wince with pain at the sight of a hammer slamming into it. Other researchers have reported what they call the parchment-skin illusion. Subjects who rubbed their hands together while listening to high-frequency sounds described their palms as feeling exceptionally dry and papery, as though their hands must be responsible for the rasping noise they heard. Look up, little Pinocchio! Somebody's pulling your strings.

This article has been revised to reflect the following correction:

Correction: December 10, 2008

The Basics column on Tuesday, about the sense of touch, misstated the thickness of a micron. It is one-25,000th of an inch, not one-400,000th.