A Primer on Touch

By Elise Hancock

What does touch do for us?

What does it not do might be the easier question, for the sense of touch pervades every inch of the body, inside and out. That's why it is also called the somatosensory (body-sensing) system.

Without touch, we would be unable to coordinate even simple movements; to manipulate the environment (vide the famous opposable thumb); or to know what is happening at the surface of the body. Without touch, we couldn't walk or balance or heft a pot.

Conversely, it is thanks to touch that our hand jumps willy-nilly off a too-hot handle. That a surgeon can tease apart nerves so small they can only be seen at 30X through a microscope. That a pianist can render sounds ranging from thunder to mist droplets falling into stillness.

Neurologically, how does touch work?

In a variety of ways, each with its own type of nerve fiber and receptors.

To coordinate movement: Informed by the kinesthetic and proprioceptive nerve fibers (proprio- as in property), the somatosensory cortex can sense your every infinitesimal movement. It then clues the motor cortex to send orders accordingly. For instance, sight tells you where to reach for your coffee cup, but it takes constant feedback to let you slow your hand at just the right point in space, then close your fingers smoothly around the handle. At the same time, the body shifts subtly to maintain balance--again, guided by internal sensations.

No wonder it takes babies weeks to master the cup. Even the simplest-seeming acts would be impossible without our sensing the whereabouts of the body's muscles, tendons, joints, and internal organs.

To manipulate the environment: How is it that you don't hold a cup so tightly it breaks, or so loosely it drops from your hand? Here enter the "cutaneous mechanoreceptors," systems that respond to mechanical deformations of the skin. They help your brain gauge the right grip: just firm enough, as measured by pressure receptors. If the cup starts to slip, vibration receptors will report the movement and your grip will adjust, all with no conscious thought from you.

Kenneth Johnson, scientific director of Hopkins's Krieger Mind/Brain Institute and a researcher in the neurology of touch, explains that pressure receptors work much as the eye does. "You probably know," he says, "that when the cones and rods in your retina fire, they produce a recognizable picture of whatever you're looking at? Well, this is like that. The finger sends off to the brain a picture that is exactly like the object itself. We call it isomorphic." (Iso = same, morphic = form.)

For example, if you stroke a fingertip over a raised letter A (raised as in Braille), the skin is indented, ever so slightly. That causes several hundred neurons to fire, each sending its piece of A up its particular nerve fiber. Up the arm the signals go together, up the spine, up the brain stem, through the thalamus. As the journey ends, neuronal firing on the surface of the somatosensory cortex forms a recognizable A.

Receptors for vibration are deeper in the skin, and they work more like the auditory system. Indeed, Johnson says they fire "in such a way that it's very hard for auditory neurophysiologists to tell which it was." Tactile vibration is handled in a part of the brain not far from the auditory area.

Vibratory receptors "are extremely sensitive," says Johnson. Even at some distance, "your hand can feel vibration of 100�, not much more than the thickness of a cell membrane." Such precision is highly useful for handwriting, machining tools, weaving fish traps, or anything else requiring fine motor control. For humans, its importance is right up there with the opposable thumb.

To protect our bodies, we also have "nociceptors" (noci- as in noxious): two kinds for temperature (heat or cold), and two for pain (rapid pricking pain or slow burning pain). Cold receptors report only cold, and warmth receptors only heat. Both can register a sudden change as small as a hundredth of a degree, but quit at the point of tissue damage. Then pain receptors take over, as they do for other injuries. Presumably, we then take remedial action.

Also, a powerful somatic sensation "sensitizes" the body, strengthening other sensations. Besides its entertainment value, this fact is also protective. Pain can leave the body responsive to even a whisper of sensation, like breeze on a sunburn. Youch! Sensitized, we stay in the shade, get off that ankle, etc.

Does every part of the body have those same nerve types?

Yes, and more. For instance, hairy skin has special receptors dealing with movement of the hairs. But nerves for pressure, vibration, movement, pain, and temperature are the major ones. They're found all over the body in proportions you can see in the "homunculus" (little man) below, named after the medieval notion that we each contain a little man, a kind of puppet-master for the body.

If you think about touch signals like that A traveling intact through your nerves, you will see that there's only one surefire way to make that happen: the nerves for the entire fingertip must stay together, as well as those for the finger, neighboring fingers, the hand, and so on.

It's the same on the surface of your sensory cortex, where mapping the neurons from each body part reveals the sensory homunculus, which sprawls over an arc between the front of each ear and the crown of the head. (There's one for each side of the body.) It is here that somatosensory signals first report--tongue sensations to the tongue region, big toe sensations to the big toe, and so on.

As you can see by the space their neurons take up, the tongue, lips, and fingers are the most touch-sensitive parts of the body, the trunk the least. Each fingertip has more than 3,000 touch receptors (most for pressure), each reporting events in overlapping fields about one-tenth of an inch across. The trunk has about as many receptors as a fingertip, spread thin. The touch homunculus, by the way, was first mapped at Hopkins, some 60 years ago, by Clinton Woolsey.

What happens after touch signals reach the brain?

At that point signals are pre-sorted, by the nature of the receptors, for pain, cold, and the like, and for intensity by the speed at which the nerves fire. Now begins integration.

Underneath each cell group of the homunculus are a set of columnar brain structures like those discussed for hearing, but devoted to touch. Here, as a signal moves deeper in its column, it becomes more precise--the brain recognizes edges and motion, for example, as the visual system does--but also more abstract and difficult to study. (A neurological code for edge-ness wouldn't necessarily look like an edge, for instance.) Coded impulses fan out to other parts of the brain, becoming more and more enigmatic.

Let's go back to the A: At the second level in, the A is still perceptible, but blurred. By the fourth level, Johnson says neurologists have no idea what's happening. Deep neural readouts, when they can be obtained, look chaotic.

As we touch that A, "how do we know whether it's an A or a B?" asks Johnson. "The image of A must be stored in memory as a pattern, a template." The brain compares the A from the finger with its template and says "aha! it's an A!--that's pattern- recognition. People do it magnificently. Machines do not."

Johnson says the template must be in an abstract, all-purpose kind of form, because the brain does not care whether the A comes from sight or touch. It is not fooled by small print, Olde English lettering, or anything else. We recognize A-ness, says Johnson, and B-ness, and the -ness of our mother's handwriting, and of whatever else we happen to have learned, much of it non- verbal. We recognize things in an instant, even in forms we've never seen before.

How is touch affected by advancing age?

Touch in old age is just beginning to be studied, says Johnson. So far, it's known that people lose receptors. At age 10, most people have about 50 touch receptors per square millimeter of skin. At 50, we have about 10. Nevertheless, there is little midlife loss of sensitivity. Johnson points out that even at 50, "there are still more receptors than nerve fibers." But preliminary results show a 50 percent loss in touch acuity by age 70 or so.

Send EMail to *Johns Hopkins Magazine*

Return to table of contents.