Brain Morsels: Packet 7

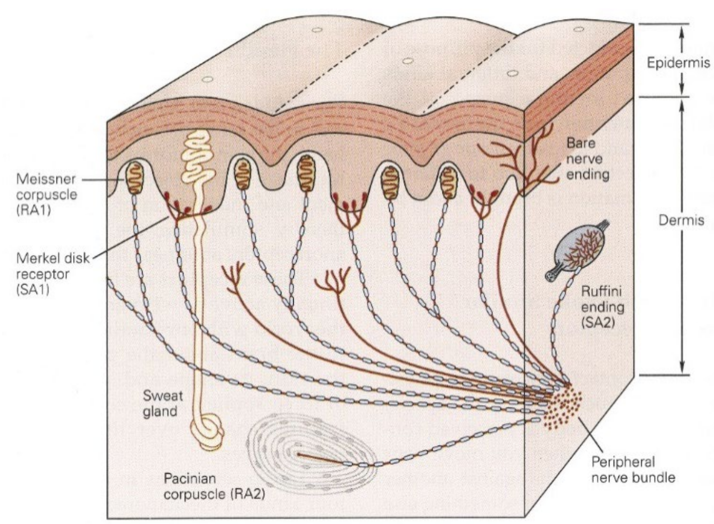
The Power of Touch

If you are thinking that this packet's topic is straying rather far from the pillars of brain health, you would be correct. It's included nevertheless because: 1) it's just plain interesting to discover how our brains receive, process, and distribute information from the touch system, but also 2) touch can be a highly social element in our interactions with other, in both positive and negative ways. In a later packet, the importance of the pillar of social interaction for maintaining brain health as we age will be the subject. You can remember then how touch affects us.

To begin....

Close your eyes and pay attention to your index finger. Run it along your shirt, across the buttons or across a seam. Now think of running it along a piece of velvet, or the leaf of a lamb's ear plant, or across a baby's bottom. Think of inadvertently touching one of the desert's spiny plants, or a hot stove burner. Think about holding a warm mug of coffee or tea in the winter. What a remarkable capability to be able to distinguish all these sensory inputs so finely!

Though this essay is mainly about touch specifically, understanding how the sensory apparatus in our skin works will set the foundation for understanding the amazing powers of touch in our lives. So here is a brief tutorial about the pathways to the brain.



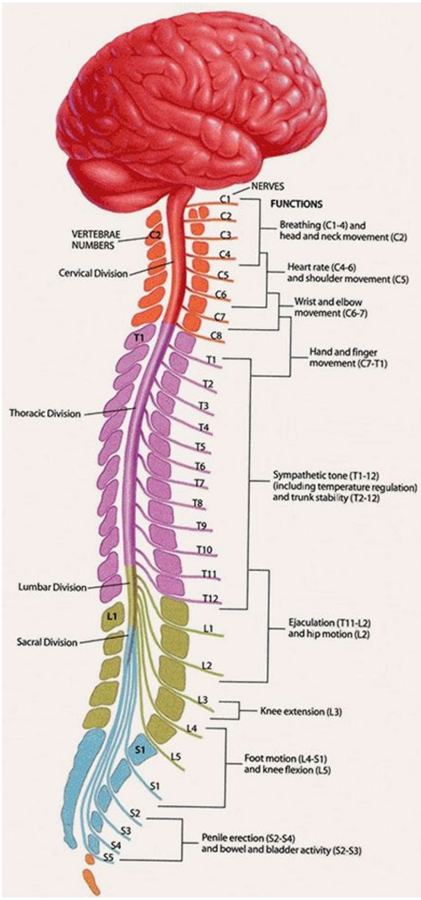
Skin has several layers. The topmost layer, the one that gets sunburnt easily, is the epidermis. This layer contains pigment cells, serves as a barrier to various infectious agents, and regulates water loss from the body. The next layer, the dermis, is where the action is. It contains sweat glands, oil glands, small blood vessels, and nerve endings.

You see from the diagram that there are lots of different nerve endings - different in size, shape and position within the dermis. Each is specialized in terms of the stimulus to which it responds, the duration of the response to the stimulus, the density of receptors in a given area of the skin, the size of the area to which the receptor is sensitive, and even the direction of the stimulus. For example, certain receptors respond best and specifically to long slow strokes across the skin, like in a massage or a comforting or sensual back rub. Another group responds to pressure but only briefly so that even if the pressure continues you don't notice it after a while. When you first put your clothes on, certain receptors tell you that something is touching your skin, but again, after a while, you cease noticing. The Pacinian corpuscle, deep in the dermis, responds very well to vibration but doesn't tell you exactly where the vibration is.

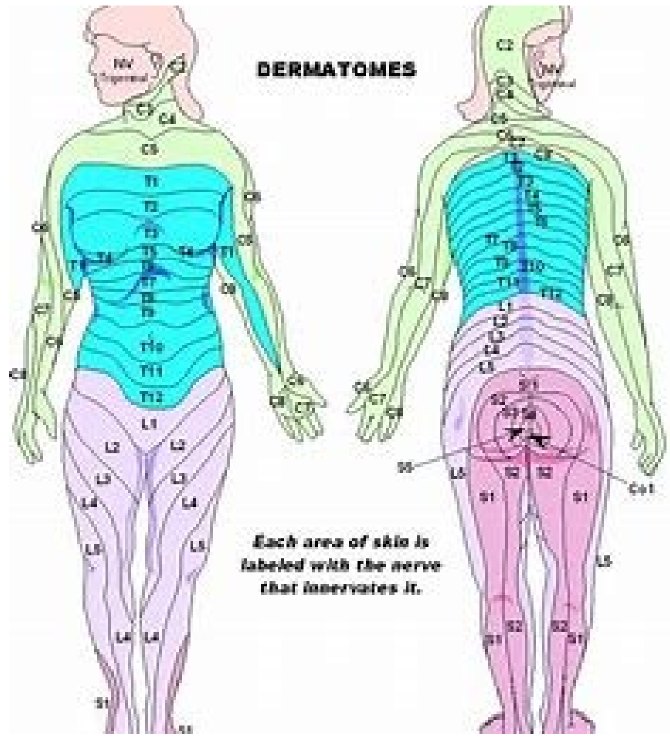
And these receptor neurons are just the ones related to touch and pressure and pain (the bare nerve endings). There are others in the dermis that sense temperature.

When a stimulus to the skin causes a receptor to be activated, an electrical signal is sent along the axon, the neuron's long transmitting process, to the spinal cord via the dorsal root. The figure below shows a cross-section of the spinal cord with its associated roots. The ventral root at each level of the spinal cord carries motor axons leading to muscles while the dorsal root carries sensory information from the surface of the body to the spinal cord. That information eventually reaches a relay station deep in the brain called the thalamus. From there the information goes to a specific region of the brain's cortex called the somatosensory (body sensation) cortex and then on to a higher-order part that assembles the information coming from all the senses into a perception of what is happening in the world around us. And *in* us, for that matter.

But, you say, I know when my finger is touched and exactly where on my finger it is touched, or when my belly or some other place on the skin is touched. How, you ask, does the brain know where that sensory information is coming from?

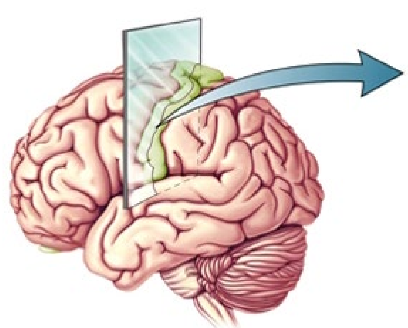


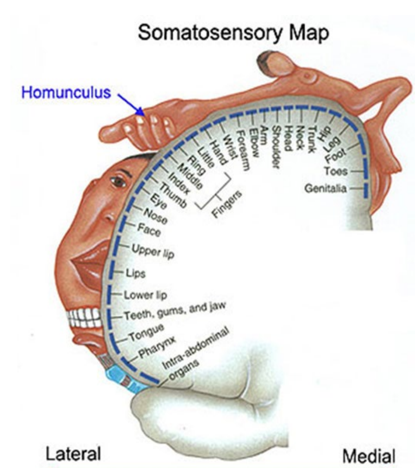
An elegant solution is at hand! You know that you have a bony vertebral column that houses the spinal cord. Each level has a spinal nerve and that spinal nerve comes from a specific region of the body called a dermatome.



So, if you touch your index finger, the receptors in that finger are activated and send an electrical signal along their axons in the nerve that enters the spinal cord at cervical (neck) segment 7. This kind of mapping is maintained all the way up the spinal cord to the thalamus and even to the cortex.

The body surface is mapped onto the somatosensory cortex. Areas that have lots of receptors, like your fingertips and your lips and face, take up lots of brain territory. Parts like your back and arms and legs – not so much. If you were to record the electrical signals coming to the somatosensory cortex (the green bit in the left-hand figure) from different parts of the body surface, you would get a weird looking map, but one that reflects well the parts of the body that we rely on for detailed touch information.



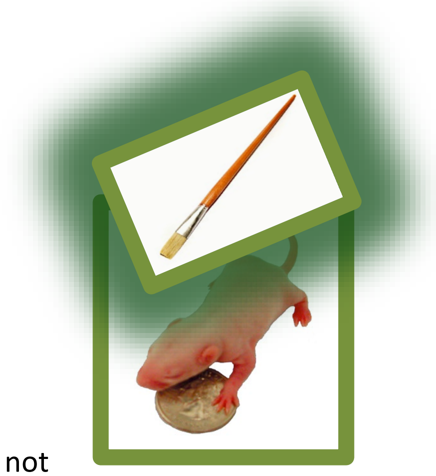


But you and I know that touching or being touched only rarely comes without a context, especially social and emotional contexts. Of course, the goodness or badness of touch is partly learned. For example, in one culture, touch is forbidden between certain individuals; in another there is no such restriction. Age and gender matter, too.

Think about exploring an object with your hands. You now know the pathways for that information to the brain, but how does your brain identify the object, often being able to do so even if your eyes are closed? How does the information coming from the sensory receptors in the skin get turned into a perception? Remember that the brain has many circuits, each with a specific function but interacting with other circuits to interpret, place in context or learn, or myriad other tasks. Central pathways from higher-order centers modify incoming information provided by sensory touch receptors in accord with previous experience, meaning, emotional context, attention and task goals. And, both necessarily *and* amazingly, all this processing is done dynamically, with new information constantly updating the brain.

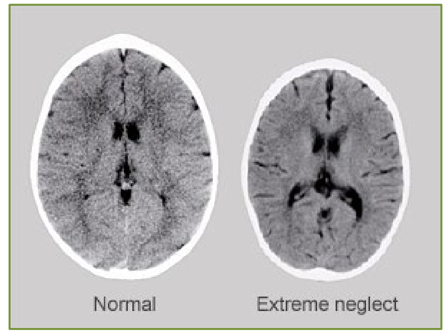
Look at these images of the hands. Sensory information is coming from the hands in each situation, but the context determines what the brain interprets and how it is used to direct ongoing muscle activity.

Touch is extraordinarily important, not only for the information from it that the brain uses in myriad tasks, but even for our development. Think of all the cultures in which humans swaddle infants or lace them into carry boards or front packs – keeping them close of course but also calming them. A newborn is placed on its mother's chest, skin to skin, which is common practice and calming for both the newborn and its mother; it also is known to strengthen especially fragile preemies (World Health Org.). The neonatal isolation units that are used for preemies are important, but it is now understood that those tiny babies have a greater chance of survival when they are held for many hours skin-to-skin by their mothers (or in a pinch, another adult). Mothers in many parts of the world routinely massage their babies, with long soothing strokes over the skin of the arms and back. In all these situations, stimulated skin receptors are sending complex sensory information to the brain where it is given emotional context in its mother's voice and heartbeat. From the lab we have learned that even when newborn rat pups separated from their mothers are fed nourishing liquid, they still are deprived of their mothers' licking and they usually die; they can be rescued by the simple expedient of stroking them with a paint brush several times a day. While young mammals are more sensitive to ongoing touch for survival than are human infants (we know, they are mammals, too), it is clear that early touch stimulation is associated with better growth (weight gain) in premature infants (both rats and human infants). Furthermore, touch reduces stress levels, allowing the brain to develop robust neuronal structures and connections.



Broadening the conversation a bit to the results of "experiments" not just with touch deprivation but more global, severe sensory deprivation in animal and human infants and youngsters, we find that deprivation has a relentlessly negative impact on brain development. An early set of experiments was conducted by a 13th century German emperor who wanted to learn what the "first" language was. Was it Greek, or Latin, or Arabic, or perhaps the tongue of the parents to whom a child had been born? He simply gathered a bunch of peasant babies – he was the emperor after all, and it was his prerogative to do as he wished with his people - and divided them into two groups. One group received normal care by the castle nannies while the other group of babies were left totally alone save for suckling them, diaper changes, and occasional cleaning. Most importantly, the nannies for this group were forbidden to speak or sing to their charges. Did the king learn which language was the first language? No, because the children simply died.

Another ruler, the Romanian dictator Nicolae Ceaușescu (in power 1968-1989), put in place government policies that effectively required large families. However, there was no monetary backing for these policies, forcing parents who could not support the children to put them in orphanages. Over time, 170,000 children endured orphanages in which there was far from sufficient staff to care for the children. They were socially, emotionally, sensorily, and physically deprived, left in cribs for months and sometimes years with care that amounted to little more than what had been provided the infants in the 13th century situation. Many of those children subsequently were followed by researchers who wanted to understand the effect of such generalized deprivation. They found that even as adults, many could not do cross-body tasks. They had poor coordination. Language had been affected. Their brains had less gray and white matter and the region of the brain associated with empathy simply was not active. Furthermore, they had developed a view of the world as scary and threatening. They often were depressed and they suffered from conduct disorders, which are characterized by disregard for others, difficulty following rules - especially social rules, and often hostile behavior.



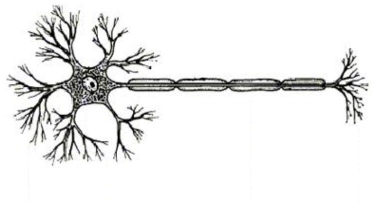
Here's an image of the brain of a normal 3-yr-old child compared to one who had suffered severe neglect. The difference in size is obvious, with both white and gray matter diminished.

But back to touch specifically….

As the infant progresses to toddlerhood and beyond, touch is critical for its exploration of the world about it, even to helping the very young child distinguish self from non-self. We teach our children about good touch vs bad touch. We also observe that some of us love to be touched; some of us prefer less, all rooted in our experience, our culture, and our individual physiology. Think of all the techniques that employ touch therapeutically, massage being the most obvious. Loss of touch can be punishing. Touch is fundamental to our social connections – hands held, kisses, embraces in love and in sorrow and comfort, handshakes, and of course, good sex. The kind of touch we use or receive can deeply communicate messages. Touch is one of our earliest sensory capabilities; it also is one of the last. Even as we reach the last moments of our lives, even when it seems to those of us waiting with the one we love that there is hardly any response, we need human touch. We simply want to touch and be touched by those we love, to reassure, to calm, to comfort, and to not be alone.

Activity

This is a simple one. Put on a glove – no, not the latex or nitrile kind, but say a cotton or light leather glove. Worse comes to worst, use a sock. Now, try identifying small objects someone else has put in a bag for you, first with the gloved hand and then with the ungloved one. Repeat with surfaces of different textures. You might try telling the differences among different sandpaper grits (eyes closed or at least turn the sandpaper pieces over so you can't see the sand grains.) It's obvious that there will be a difference in your touch capability, but are you surprised at the magnitude of the difference dulling the input of those finger touch receptors has made? The exquisite sensitivity of the fingertips, due to the high concentration of touch receptors, enriches our world and makes possible all sorts of activities.



Puzzle

This is a memory game. Look at the image for 1 min, then, without looking, list as many of the objects as you can.