A Magic Touch: Deaf Gain and the Benefits of Tactile Sensation

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In this article I argue that tactile senses are important in many ways. They play a role in communication, in physical development, and in the formation of a healthy psycho-social self. Tactile senses contribute to our overall cognitive awareness and intelligence, and they are now used in a variety of career paths, including teaching, medicine, creating virtual-reality telecommunication systems, to name a few. So strong tactile sensitivity is of great benefit to the individual.

This fact matters in a volume on Deaf gain. When a particular sense is absent, changes in the brain allow better use of those senses that are present. This plasticity of the brain is responsible for the advantages in visual acuity that deaf people have over hearing people--as Matthew Dye (in this volume) has documented. But this plasticity has also resulted in acute tactile sensitivity among deaf people. The role of touch in Deaf culture tends to promote that tactile sensitivity. And the use of a sign language nurtures that sensitivity while employing it to enrich one's cognition in a profound way.

In sum, a heightened tactile sense is an important Deaf gain, physically, psychosocially, cognitively, and professionally.

Please note that touch is a multi-modal sense in itself. It covers tactile information via the skin as well as temperature, proprioception (knowledge of one's own body position), kinesthesia (knowledge of one's own body movement and behavior), and nociception (pain). By *touch*, then, I mean the entire somatosensory system, a complex system that processes information via muscles, bones, organs, blood vessels, the skin, and the epithelia (epithelial tissues line internal body surfaces, form glands, and perform a range of functions beyond the detection of sensation, including secretion, absorption, protection, and transport of materials between cells). In this article I will primarily use the terms *touch* and *tactile* to refer to somatosensory activity and experience because those are the terms used in ordinary talk and in most of the literature cited here.

Touch Communication

Vision is the dominant sensory modality among all higher primates (humans, apes, monkeys); in this way higher primates strongly contrast to most other terrestrial mammals, in which smell is dominant.[1] While linguistic-based communication (whether oral-aural or manual-visual) dramatically enriches human social cohesion, body language--perceived visually--has been argued to be a principal vehicle of human communication and the one that displays the greatest range of texture and subtlety with respect to the overall message sent.[2]

Close behind vision, however, come our tactile senses, then our auditory senses.[3] Nevertheless, human communication has not used tactile senses anywhere near as extensively as vision, probably for a number of reasons, including how very dominant vision is.[4] Also, tactile communication has many limitations. Tactile communication is possible only when two beings are in close proximity and tactile information is distorted under very low temperature.[5] Additionally, tactile communication is reliable in that it is difficult to intentionally modify tactile information, but that very reliability means that one cannot conceal or deceive easily, which is a drawback in communication; further, tactile information consists mainly of "symptoms rather than signals" so it allows few degrees of freedom.[6]

Despite these limitations, however, tactile senses are of enormous importance to human communication and to the very experience of being human.[7] Very small children who have not yet uttered an intelligible word will communicate via touch that they know what an object is used for. For example, a 9-month old might pick up a toy phone and hold it to her ear briefly, or make a quick stirring motion with a spoon, or touch a hairbrush to her hair.[8] These actions happen in passing; they are not because the child wants to talk on the phone or cook or brush her hair, but just because she wants to acknowledge, through touch, the knowledge that she has. We use touch to confirm our reality our whole life long. Klein[9] argues that touch is one of the important ways we express and understand our gender, thus it is critical to identity. And it is special:

Haptics (that is, touch voluntarily initiated) within human society involves experience in a unique way in that it is at least partially symmetric. That is, if Raul touches Mateo, Raul has a tactile knowledge of Mateo, but Mateo also has a tactile knowledge of Raul, though the limited nature of the knowledge will be different in each case. Thus, Raul may learn the feel of Mateo's whole arm under his fingertips, while Mateo may learn the feel of Raul's fingertips along his whole arm. Vision and hearing are not like this. It is possible for one person to see a second person without being seen and without the second person having any sensation associated with seeing the other or being seen by the other. Likewise, it is possible for one person to hear another without any symmetric relationship occurring. This is equally true of the two remaining senses, smell and taste (at least insofar as a taste event is not accompanied by a haptic event). A haptic event between people, then, entails an exchange, an interaction in which each participant experiences something.

It's not surprising, then, that many (most?) cultures have rituals that involve haptic exchanges, particularly in greetings or partings. These exchanges range from kisses (which can be heartfelt or merely motions of the lips in the air, perhaps beside the cheek) and handshakes (which can be relatively limp or, instead, firm clasps, sometimes involving the forearms; and which can be true shakes or just fist bumps or high-fives) familiar in Western societies, to rituals that are more confined to a particular culture or just a few cultures. Nupe men who are well-acquainted, for example, stretch out their hands many times successively and touch each other's fingers lightly.[10] Some cultures engage in nose rubbing, or at least did at an earlier point in their history, including the Maori (who also touch foreheads and share breath as part of this ritual) and the Inuit.[11] Many cultures use hugs and shoulder taps or combinations of them, as in Ethiopia.[12] Such rituals are important: "Greeting rituals imply a positive acceptance of the person met, a willingness to establish a social relationship; parting rituals imply a recognition that the relationship has been established and some hint that it could continue",[13] and doing them incorrectly or in an inappropriate context can be severely offensive--as with the Maori nose rub.[14]

I suspect that one reason such deep offense can be taken from an inappropriate haptic event is the inalienable interactional nature of haptic events. That is, by touching me inappropriately you have given me no choice but to partake of an inappropriate event. Thus the active participant in the haptic event exercises more power than the passive participant by the very fact that the active participant initiates the event in the given circumstances, and, thus, the active participant's touch can arouse discomfort to the point of disgust, fear, and the feeling of being molested.[15] In general, the less well we know someone, the more their "touch rights" in regard to us are limited to task-oriented ones,[16] and if they go beyond that, they are in violation of social norms and of our sense of privacy.

Another reason for offense at inappropriate haptic events may be that haptic events elicit the greatest emotional responses when they are on areas of the body other than the hands.[17] In many (most?) cultures areas other than the hands and arms are more likely to be off-limits to strangers, and thus targets for inappropriate haptic events. Therefore the taboo touch results in a strong reaction.

And a third reason for offense at inappropriate haptic events may be that we are able to understand to a great extent the emotions of the person who touches us simply via their touch. In a study in which people were touched on the whole body by unacquainted partners, the passive participants were able to decode the emotions of anger, fear, disgust, love, gratitude, and sympathy--all emotions that had been shown to be communicated by touch in earlier studies--but also happiness and sadness, two emotions that had not been previously recorded to be detectable.[18] If someone touches us in an inappropriate way and we detect an emotion that is disagreeable to us, we might well take strong offense.

Conversely, done properly and with sincerity, haptic events can be enormously positive. They can seal a friendship, confirm a love, satisfy sexual needs. While many supervisors fear using touch in the workplace due to concerns about sexual harassment,[19] in fact a sincere handshake or pat on the back can be very effective in the workplace, particularly in delivering an apology.[20] Certain kinds of touches occurring in situations where the person being touched is in need of comfort or reassurance can be effectively supportive; they can “nurture, reassure or promise protection.”[21] “ . . . touch is one of the most basic human needs . . . Research shows that people need touch for physical and psychological health.”[22] As the poet Maya Angelou says, “I’ve learned that every day you should reach out and touch someone. People love a warm hug, or just a friendly pat on the back.”[23]

Touch and Infant Development

But touch delivers far more than these easily identifiable emotional and social benefits. The skin is our largest sensory organ and the one that conveys tactile senses, so touch is the first sense to develop in humans[24] and the primary one to deliver stimulation to the fetus.[25] Once an infant is born, touch is the most immediate and direct connection to the world, and the infant needs it in order to develop properly--physically and emotionally.[26] There have even been cases in which an infant declared dead at birth was held against the mother’s bare skin and cuddled, and, after hours of this, revived[27] (this was the case with my own maternal grandmother, who revived after a night of being left for dead against her mother’s breast).

Research conducted at the University of Miami’s Touch Research Institute has confirmed the benefit of touch for infants. Preterm neonates are the subject of many of their studies. Those who were massaged three times a day for 10 to 15 minutes averaged a 47% weight gain, showed better sleep-awake patterns, were more alert when awake, and showed better motor and range of state behavior than the control group, resulting in their hospital stay being 6 days shorter.[28] One reason for this may be that massage affects the vagus nerve, which then stimulates the gastric system to release food absorption hormones. Thus another study of preterm neonates showed that massage with moderate pressure was more beneficial than massage with light pressure with respect to greater weight gain and increase in vagal tone,[29] and another showed massage increased vagal activity and gastric motility, both associated with weight gain.[30] A second reason why massage may lead to overall health improvement for preterm infants is that massage increases their levels of those hormones that help the body respond to stress.[31] Repeatedly, preterm neonates who receive massage therapy show fewer stress behaviors than those who don't receive massage therapy[32] and connected to lower stress is better feeding behavior. A third reason why massage therapy is so beneficial may be that touch helps infants have better-organized sleep states; this is important because release of the human growth hormone is correlated with that portion of sleep cycles that shows slow, synchronized electroencephalographic activity, which doesn't occur until after about a half hour into sleep.[33] So a massaged infant sleeps better and therefore grows better. Further, massage therapy increases a premie's serum insulin and insulin-like growth factor 1,[34] allowing the child to gain more weight. A fifth reason may be that massage therapy raises a premie's internal temperature, even when the incubator portholes remain open during the therapy[35] and conserving body heat is a primary concern in the survival of premies.[36] Finally, moderate-pressure massage therapy aids preterm infants in their response to pain; their heart rate increases less and returns to baseline faster than that of premies who experience the same painful procedures but don't receive massage therapy.[37] Since pain can interfere with brain development in the premie,[38] massage therapy may benefit overall development.

Preterm infants who had experienced further health complications before massage therapy gained more benefits from the massage therapy than those without other complications.[39] Those exposed to cocaine who were given massage therapy averaged 28% greater daily weight gain, showed fewer postnatal complications and fewer stress behaviors, and show more mature motor behaviors than the control group of premies.[40]

The benefits of massage therapy for preterm infants may positively affect later growth and development.[41] Likewise massage has been shown to be substantially beneficial to full term infants; indeed, tactile stimulation from birth and through the first several years of life is crucial for healthy brain development.[42] Newborns for whom touch is paired with food develop an anticipatory appetitive response, which helps in forming good feeding habits and naturally enhances overall growth.[43]

Touch stimulation positively affects physiological, behavioral, and social development, and the touch-interaction between small child and care-giver is critical here, particularly in communication.[44] In orphanages, children who are not touched waste away and perish.[45] In a study of infants with eating disorders, the children received little touch from their mothers and showed touch aversion.[46] While sensitive and responsive caregiving (which includes a great deal of touch) affects the child positively at least throughout the preschool years, for the child who is maltreated in early life an enhancement in caregiving later may help to reverse the negative effects on behavior and neurobiology.[47]

Additionally, just as premies benefit in an extraordinary way from massage therapy, so do full term infants who suffer from a range of risk factors. For example, when massage therapy was given to infants with depressed mothers, they gained more weight, exhibited better temperaments (they could be soothed more easily and were more sociable), and had greater decreases in stress neurotransmitters/hormones than those who didn't receive massage therapy.[48] And autistic children showed better attentional behavior when given touch therapy; indeed, while many autistic children have an aversion to touch, these children accepted the touch therapy without trouble.[49]

Two other fascinating studies on infants and parents reveal important benefits of touch. In one, when depressed mothers received massage therapy, their infants fared better than those of depressed mothers who didn't receive massage therapy; the infants smiled more, babbled and talked more, and had better orientation and motor skills, as well as more mature emotional behavior.[50] Presumably the benefits the mothers received from the tactile experience allowed them to respond to their children in ways that resulted in benefits to them. That is, the benefits of touch are passed along. A different benefit of touch is revealed in a study in which fathers massaged their infants for 15 minutes prior to their daily bedtime for one month. At the end of the month, the fathers were more expressive and exhibited more pleasure in floor-play interactions with their infants than the fathers who had not given their infants massage therapy.[51] So massaging carries benefits to the active participant as well as to the passive participant.

Touch and Cognition

While many studies have been cited thus far, I don't expect the reader to be surprised at the physical, psycho-social, and emotional benefits of touch that are demonstrated in the cited studies. What is less well known as part of common wisdom, however, is that touch has important cognitive benefits.

In studies of premies, those who received massage therapy showed more mature orientation and habituation[52] (where habituation is the process of growing inured to an eliciting stimulus and thus showing a decline in the elicited behavior, similar to fatigue). Similar results with respect to cognitive activity were found in another study.[53] Touch is of importance to general cognitive development of full term infants, as well. 4-month old babies who received massage therapy prior to an audio-visual task showed response recovery from habituation, whereas babies without the therapy did not.[54] Experiments on infants from birth up to 5 months of age show that infants might "perceive and understand the physical world through their hands without visual control"[55]--that is, haptic abilities carry the infants from perception to cognition.

While vision assumes a more important role after early infancy, a study of 10-year old children demonstrated a strong correlation between overall intelligence and the ability to discriminate sensory stimuli of all types,[56] just as Francis Galton[57] postulated over a century ago. Measures of tactile awareness in tests on roughness discrimination, part-whole matching, and pressure sensitivity show as high a correlation with intellectual ability as measures of auditory or visual acuity show, and some are better predictors of intelligence than measures of simple sensory acuity.[58] In a battery of twenty-seven cognitive ability and mental speed measures, tactile-kinesthetic abilities shared much with broad visualization and fluid intelligence.[59] And the relationship between haptics and cognition is a persistent one throughout life. Tactile awareness correlates to higher-level cognitive functions in adults, as measured by palm writing and object identification tasks,[60] and information moves bidirectionally between tactile sensation and cognition.[61] In a study of impaired and demented elderly, tactile stimulation appeared to improve cognitive functioning, reduce disturbances in behavior, and have beneficial influence on the patient-caretaker relationship.[62]

Haptic sensory stimuli can deliver complex physical information (as discussed below), but also complex abstract information. In a series of experiments involving people holding heavy or lightweight clipboards, touching hard or soft objects, and solving rough or smooth puzzles, subjects expressed impressions and made decisions about unrelated people and situations. For example, heavy clipboards made job candidates appear more important; rough surfaces made social interactions appear more difficult; touching hard objects led to increased rigidity in negotiations between people. So tactile sensations influenced higher social cognitive processing in dimension-specific and metaphor-specific ways, creating "an ontological scaffold for the development of intrapersonal and interpersonal conceptual and metaphorical knowledge, as well as a springboard for the application of this knowledge."[63] A very different kind of evidence for the claim that the conceptual system uses the perceptual system for the purposes of representation comes from a study based on a modality detection task. People were subjected very briefly to a modality-specific object property (such as warm, crimson, shrill, musky, bitter) and asked to judge whether the property corresponded to a particular target modality (ie., tactile, visual, auditory, olfactory, gustatory). Consistently people needed more time to detect haptic information than any other modality, confirming the link between sensation and cognition.[64] Others have argued that our various kinesthetic engagements with our world make possible a range of cognitive activities, from apprehension to recognition and creative imagination.[65]

How haptics convey physical information, however, is the more studied area. Primates' tactile senses are sensitive and fine-tuned. Apes and humans, for example, can use touch, particularly of the prehensile hand and fingertips, to locate objects, determine information about their substance, and even recognize their shapes "by stringing together a succession of independent chunks of information, and hence recognizing the relationship of individual parts to each other in time rather than space", as well as detect vibrations that allow information about what lies under the surface of the objects.[66] That is, haptic systems have distinct encoding pathways from visual systems, and in haptic systems substance is more easily discriminated than shape.[67] Haptic and visual systems also differ on encoding pathways for size discrimination, where using both senses together yield a better estimate of size than either alone does.[68] Still, in experiments of implicit and explicit memory within the modalities of vision and haptics as well as cross-modally between the two no effects of modality change were noted, one explanation being representational similarities between vision and haptics.[69]

The highly rich sensory pathways of haptics makes this sensorimotor continuum reliable[70]: our haptic sense is responsible for our knowledge of an object's geometry, allowing us to recognize and manipulate it.[71] Our haptic knowledge tells us when a fruit we squeeze lightly is ripe; it is essential in making and using tools.[72] In studies of the geometric information that people can glean through feeling objects with their eyes closed haptic perception compared well with that same kind of information gleaned through spatial vision in other studies.[73] Additionally, haptic feedback turns out to be an excellent way to learn about physics; students who were taught about gears using force-feedback-based computer simulation performed better on tests.[74] Further, while people used to believe that haptic information degraded immediately,[75] it has been shown, to the contrary, that haptic memory persists and is reliable.[76] In experiments that adapt classical paradigms in the study of human memory to haptics (such as touching a series of objects and indicating whether each object had been touched before), haptic working memory showed a high accuracy rate (for both common and uncommon objects),[77] and in another study haptic memory of location of objects was strong.[78] And tactile memory, like visual and auditory memory, can be subdivided into several functionally distinct neurocognitive subsystems, where some are short lasting and others are long lasting. Optimal performance on tactile memory tests occur when people are allowed to work at their own pace rather than presented with a brief stimulus.[79] Finally, there appear to be different pathways in the tactile cortex system, one for object recognition and one for object localization, which are intertwined.[80]

Applications of Touch

A developed haptic sense is becoming ever more important in our highly technological world. Somatosensory intelligence is pertinent to everything "from the design of materials and virtual environments to the dynamics of cellular microenvironments."[81] Haptic interfaces are used in teaching academic subjects, such as physics (mentioned earlier), but also chemistry (in structural molecular biology[82]) and many other areas.[83] Haptics are studied in enriching immersive telecommunication environments, so that participants can really "feel" like they are present in the remote experience,[84] particularly in the design of computer video games.[85] Information about haptic communication is gleaned from shared virtual experiences in order to help develop new human-computer interfaces and network protocols that integrate touch and force feedback technology; potential applications are in collaborative teleoperation in removing hazardous material or in space station tasks or others.[86]

In all these and in so many other areas, people with a greater haptic sensitivity and knowledge will be able to contribute to new developments. Indeed, our fine-tuned and reliable haptic sense is now used to guide and train motor systems in complex tasks. Early research showed haptic guidance to be ineffective, but more recent work (on tracking a dot moving in a two-dimensional plane with a haptic interface) suggests high potential for haptics playing a role in the motor learning process.[87] A study comparing haptic and visual aiding in virtual-reality-based training found that when people receive only haptic assistance, they develop personal strategies, whereas when they receive only visual assistance, they rely on the aiding instead of a strategy, so assistance needs to be properly designed to help users "with different perceptual styles,"[88] nevertheless, a tactile-oriented person does very well in such training.

In medicine, haptics are used in clinical skill acquisition, as in medical examinations and interventions that call for touch (palpations and the like); in simulation training and evaluating clinical skills that call for touch such as anesthesiology, dentistry, veterinary medicine, and many others; and in newer areas of medicine that call for direct contact between patient and clinician, as with bilateral teleoperators and "smart" instruments that use devices to display tactile sensation or that use sensory substitution systems, or that use other methods that enhance haptic feedback to a clinician.[89] Haptics are particularly useful in training for minimally invasive surgery, where building up haptic sensitivity while probing a virtual object allows surgeons to develop a feeling for tool-tissue interaction that leads to more accuracy in the procedures.[90] Virtual-reality based programs of rehabilitation are built on a haptics foundation.[91]

Haptics and Plasticity

Given all we have seen above, one can conclude that the person with more developed haptics has psycho-social, emotional, and cognitive benefits, as well as additional professional opportunities. The question now is how this impinges on the deaf person. The answer is that deaf people have increased tactile sensitivity and focus simply because of their deafness, and that Deaf culture continues to promote haptic abilities throughout life.

Different areas of the brain are responsible for our different senses, but those various senses interact in neuronal convergences in networks of cortical regions of the brain called the multisensory regions.[92] Some of these regions show properties of integration of specific senses. The caudate nucleus, for example, is for audio-visual integration and the fusiform gyrus is for visuo-haptic integration, where the two show little overlap; so neural mechanisms of sensory integration are unique to particular sensory pairings.[93] Sometimes synesthesia occurs, where a tactile stimulus, for example, might elicit a response from another sense (such as taste) or might evoke an emotion.[94] Clearly, the senses interact in the brain.

What happens to the areas of the brain that would ordinarily process information from a particular sense when that sense is not operative? Does it change? And how?

The capacity of the nervous system to modify its organization is called neuroplasticity. Neuroplasticity is variable over the course of a life, with the greatest flexibility in early childhood but quite a lot throughout life,[95] although this plasticity varies as a function of timing (and critical periods--some abilities must be acquired before a certain age or they can never be (fully) acquired) and the nature of changes in experience.[96]

There is considerable evidence "that sensory deprivation is associated with crossmodal neuroplastic changes in the brain."[97] That is, the unused part of the brain is recruited for use by the other senses, leading to heightening of those other senses. A competing explanation for the heightening of those other senses is "unmasking"; that is, the absence of one sense (either because it was never there or because it was damaged) allows neuronal connections elsewhere to strengthen.[98] For our purposes, this debate is irrelevant. What matters is that the absence of one sense correlates with the strengthening of another. Thus in what follows I will talk of plasticity rather than unmasking, but nothing in the argument hinges on this distinction.

Absence of a sense can be congenital, due to injury, or due to aging, and in all types there is evidence for compensatory behavior among areas of the brain. For example, after a stroke a given function ordinarily controlled by a damaged part of the brain can re-emerge through rehabilitation because another part of the brain has taken it over,[99] just as can happen after other injuries.[100] Thus not only does absence of a sense lead to strengthening of the existent senses, it can also lead to compensatory behavior on other parts of the brain so that work ordinarily done by one sense can be handled (at least to some extent) by another. Repeatedly, we find that sensory deprivation coupled with long- and short-term learning (ie., rehabilitation or simple practice) can "dynamically modify the brain organization for the multisensory integration."[101]

A great deal of research has shown that blind people, for example, make better use of auditory input than sighted people. In an auditory discrimination task of detecting a rare target tone among frequent standard tones, congenitally blind participants performed better than sighted ones, suggesting compensatory adaptations within the auditory modality.[102] In tests of memory of auditory verbal material, the congenitally blind participants' performance was superior to that of the sighted participants,[103] implying that the blind people encoded auditory verbal material more efficiently, due to help from the visual (occipital) cortex (which is available to be co-opted). The versatility of the visual cortex with respect to processing auditory language information is confirmed in many other studies.[104]

Likewise, blind people exhibit superior use of tactile skills to those of sighted people,[105] which has been attributed to greater activity in the visual cortex evoked by tactile stimulation.[106] In the process of learning to read braille, for example, the sensorimotor cortical area devoted to the representation of the reading finger enlarges – and this is associated with recruitment of parts of the visual cortex (V1 and V2, in particular) in processing tactile information.[107] Other tactile tasks performed by the blind also show greater activity in the visual cortex.[108]

Perhaps unexpected is the fact that when sighted people undergo training specifically aimed at enhancing their tactile sense, there is evidence that their visual cortex is also involved in this enhancement, thus cross-modal plasticity occurs even when all the senses are intact.[109] Further, depending on the temporal frequency of tactile sensation, the auditory and/or visual cortices may be activated as well as the tactile cortex.[110]

When it comes to looking at crossmodal plasticity in deaf people, quite a lot of work has established the activation of the auditory cortex in processing visual information,[111] even among deaf individuals who have cochlear implants.[112] Additionally, studies show that, when deafness is considered to the exclusion of other possible confounding factors, deaf individuals exhibit selected enhanced visual cognition in comparison to hearing individuals.[113] So the auditory cortex has been reassigned certain visual tasks, leading to better visual acuity. Additionally, the auditory cortex is engaged in processing sign languages, where information is received visually, so some have argued that the auditory cortex is actually a complex of "polymodal neural tissue that has evolved unique sensitivity to aspects of the patterning of natural language"[114] rather than auditory information exclusively, in which case the term <u>auditory cortex</u> is a misnomer. I will continue to use the term, however, but with that caveat in mind.

In contrast, very little study has been done of deaf people's tactile abilities and of the activation of the auditory cortex as they engage in haptic events. Part of the reason for that is that research on haptics lags far behind research on vision. As Tobias Kalisch and his colleagues say, "Vision and haptics are the key modalities by which humans perceive objects and interact with their environment in a target-oriented manner" yet "compared to vision, the understanding of haptic information processing is still rudimentary." [115] Studies on hearing individuals, however, confirm that there is interaction between the auditory and the tactile cortices. When pianists engage in key-touch reading, the auditory cortex is activated,[116] where experience (through long practice) has led to this result. That means the auditory cortex has taken over some tactile functions, allowing greater tactile sensitivity simply because of practice. So perceptual learning leads to "long lasting changes to an organism's perceptual system that improve its ability to respond to that environment and are caused by that environment."[117] Given this, there is every reason to believe that the deaf individual's auditory cortex should be recruited for other sensory experience, including tactile experience.

In fact, in a study in which people were asked to discriminate the temporal duration of touches and their spatial length, the auditory cortex was activated much more in this tactile task in deaf individuals than in hearing individuals.[118] So it is clear that the auditory cortex is recruited into tactile tasks in a more robust way among deaf people than among hearing people. However, in this particular set of tasks, that recruitment did not result in better tactile sensitivity. In particular, it appears that temporal processing (but not spatial processing) relies heavily on hearing, and plasticity is not able to compensate for this.

So recruitment of the auditory cortex does occur in tactile events for deaf individuals, but it does not help in their perception of temporal duration. However, another study has shown that deaf people do have an extremely acute somatosensory sensitivity. Sazzad Nasir and David Ostry have found that profoundly deaf adults who have cochlear implants, when tested with their implants turned off, have precise somatosensory expectations (on the order of millimeters with respect to movement deviations).[119] These senses allowed them to use somatosensory feedback from displacing the jaw during speech to improve their speech motor control. No hearing control group was tested, of course. Nevertheless, the somatosensory acuity of these deaf adults was considered remarkable by the researchers, which suggests that it is enhanced compared with that of hearing individuals.

While the above study did not include scans of the cortices, so we cannot know if the auditory cortex played a part, a study of a deaf-blind individual, however, does show that the auditory cortex is recruited in interpreting tactile information, including reading braille, detecting palm writing, and understanding a haptic form of American Sign Language (hASL), much more so than in a hearing-sighted interpreter.[120] Since tactile enhancement in blind individuals who are not deaf involves the visual cortex (as discussed earlier), the involvement of the auditory cortex in this individual must be due to deafness, not blindness.

That the auditory cortex is activated in processing tactile information in deaf individuals is confirmed in two other studies. In one, 100 millisecond tones with a bass-reflex loudspeaker were delivered to a plastic blind-ended tube once every second, where this tube was applied to the left palm and fingers of a congenitally deaf adult and six control hearing subjects; only in the deaf individual was bilateral activation of the supratemporal auditory cortices involved.[121] A more recent study looked at the processing of bimodal information – visual and tactile. Karns, Dow, and Neville[122] designed a headset that had tubes clamped to it which flashed light and delivered air puffs to the face of the wearer. Brain activity was measured in an MRI scanner as the subjects responded to the lights and puffs. Tactile and visual information both activated the auditory cortex of deaf individuals more than that of hearing ones, but tactile information elicited stronger responses in the auditory cortex than visual information.

Touch and Deaf Gain

All this leads to the conclusion that the tactile senses of deaf people are enhanced simply by virtue of being deaf, so that concentrated attention is given to somatosensory information. That enhancement is further developed by the more frequent and more extensive haptic events common to Deaf culture. Ben Bahan (in this volume) describes how Deaf children learn to feel sound vibrations at an early age and how rock concerts are "tactile parties". His description makes me think of Paddy Ladd, a Deaf scholar of Deaf studies and Deaf education at the University of Bristol in the UK, who calls himself a "Deafhead" because he is a fan of the band The Grateful Dead (hearing fans call themselves Deadheads); he holds a balloon against his chest at concerts and enjoys the vibrations. Bahan also talks about how Deaf people use touch to get another's attention, sometimes with the result being misunderstanding on the part of hearing individuals, leading to lawsuits for assault. That Deaf people touch one another to express emotion and to get a person's attention is not just a matter of habit; it has beneficial results. Deaf mothers, for example, use touch frequently and effectively to maintain their deaf children's attention, much more so than do hearing mothers with their deaf children.[123] Basically, while there are different rules for what is considered acceptable touch in Deaf culture,[124] there is generally increased touching behavior during interactions between Deaf people as opposed to hearing people[125] even in such formal situations as that of colleagues doing research together.[126] Bahan suggests that touch helps in creating a sense of belonging within Deaf culture.

Touch interaction excites the emotions, as we have discussed. So the frequent touch interaction in Deaf culture may be one of the reasons why so many Deaf people focus on making every situation accessible to all deaf people who want to participate and to value their participation.[127] While there are many psycho-social and political reasons for this,[128] perhaps touch eases the way into this effective group behavior.

The role of touch is ever more extensive and binding among deaf-blind people. Terra Edwards discusses Deaf people who gradually lose their sight, passing from vision into blindness, and she explains how the temporality in visual worlds can be transferred to tactile worlds. Just as our "feet hit the pavement at regular intervals" so tactile language is "ordered according to particular patterns of motion and rest."[129] She considers at length how her deaf-blind subjects use the range of classifiers in ASL--those for size-shape, entity, handling--and discusses the role these classifiers play in a tactile world.

The classifiers are telling with respect to our interest here. While many signs in ASL have an articulatory form that is arbitrarily related to their meaning, this is not true of the classifiers. Instead, classifiers are identified crucially by their handshape, and that handshape is meaningful. This is easy to see in size-shape classifiers, of course, but is it also obvious in handling classifiers, which show how the hands move or position themselves in manipulating the relevant object. Sarah Taub says, "The use of body and instrument classifiers is strongly motivated by the distinctiveness of body actions: sometimes it is easier to produce and recognize body movements associated with an object than an analogue of the object itself."[130] Dan Slobin and his colleagues add, "Often such handshapes are literal gestures of an activity, and it is only the factor of conventionalization in the speech community that distinguishes sign from gesture."[131] But even the entity classifiers have articulatory parts that are meaningful. As Sutton-Spence and Napoli point out, although the referent of the handshape is typically unlike a hand (such as a car or book or cat), signers readily select relevant points of comparison between handshape and meaning and feel free to manipulate them in ways appropriate to that implicit analogy.[132] Dan Slobin' group further says that the handshape indexes "a particular referent according to properties that are appropriate for the current discourse. That is, the 'classifier' handshape designates, or specifies, or indicates a referent with a particular property (e.g., two-legged, horizontal plane, etc.)."[133] Signers can talk about a car crash, for example, and if the front end of the car gets crushed, they can flex the interphalangeal joints of the index finger and middle finger of the 3-handshape (the vehicle classifier) to show that. Indeed, if the crushing happened slowly – or if the signer wants to convey that sense of slow-motion that can sometimes occur in the middle of a terrifying experience--the fingers can curl slowly. So the very (form of the) hand becomes the car; internal parts of the hand distort to show the distortion of the crushed car.

Sign language poets often go much farther with this physical appropriation of language, both with the classifiers[134] and with embodiment. Debbie Rennie, in her ASL poem "Black Hole: Color ASL,"[135] is perched on the top of a ladder. When people shake the ladder from below, she flaps her arms to try to regain balance and those flapping arms transform into wings that carry her away. She flies. When Paul Scott, in his BSL poem "Too Busy to Hug, Too Blind to See",[136] becomes a mountain and trees grow out his sides, he twists away from the painful pokes. He writhes. And we, the audience, feel what the poet feels. We soar with Debbie Rennie; we suffer with Paul Scott.

So much of sign languages is open to a tactile interpretation. When a deaf-blind person remembers the sight of a sloped roof, her hands can make it in ASL, and her whole body can understand it in a somatosensory way. Edwards says, "In this way, American Sign Language, whether instantiated in a visual world or a tactile world, has a tactile dimension for sighted and blind people alike."[137] How true. The very medium of a sign language is somatosensory. While spoken language is articulated by the speech tract and thus calls for physical involvement of parts of the speaker's body, that involvement is, to a huge extent, arbitrarily related to meaning. Because a sign language is articulated by a much larger part of the body--the manuals as well as the extensive nonmanuals--and because the signer's body movements, shapes, and positions are, to a much greater extent, strongly related to meaning, the signer experiences language differently at a cognitive level; the somatosensory system and the language mechanism in the brain feed each other in a synergistic way. Language becomes the signer; the signer becomes language. The understanding of how deep a river is, how cold a wind is, even how searing a heartbreak is – these things can be conveyed in spoken language, of course, but we appreciate their semantic resonance so much more if the speaker's physical self beyond the speech tract is involved in the message, which is why we watch in awe as an internal conflict plays across the face of an actress like Laura Linney in the 2003 British film "Love Actually". But in a sign language, even ordinary conversation engages so much of the speaker's physical self. In this way, ordinary conversation in a sign language involves a deeper understanding of the message--bone deep--literally. That's one of the gifts that the somatosensory involvement of a sign language gives the signer. Sign languages are the jewels of Deaf gain.

Researchers have found that using gesture facilitates people's reasoning abilities,[138] perhaps by offering a way to express and explore concepts that may be difficult to negotiate through in a verbal way.[139] For example, the use of gestures helps children solve spatial transformation tasks, raising the possibility that gesture training may help in improving mental rotation skills.[140] What we need now is an investigation of whether using touch facilitates reasoning abilities. So let this paper be a call to arms (so to speak).

In the meantime, we can conclude that being audiologically deaf confers on a person increased tactile attention and acuity, and all the many benefits that ensue. Being part of Deaf culture nurtures that sense. And using a sign language, in particular, enriches one's cognitive understanding of human communication and, thus, of what it means to be human. So the next time you are offered a full-body hug, hug back. It may make both of you smarter, and it will surely make you happier.

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