Why our brains cherish humanity: *Mirror neurons and colamus humanitatem*

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Abstract

Commonsense says we are isolated. After all, our bodies are physically separate. But Seneca's *colamus humanitatem,* and John Donne's observation that "no man is an island" suggests we are neither entirely isolated nor separate. A recent discovery in neuroscience—that of mirror neurons—argues that the brain and the mind is neither built nor functions remote from what happens in other individuals. What are mirror neurons? They are brain cells that process both what happens to or is done by an individual, and, as it were, its perceived "reflection," when that same thing happens or is done by another individual. Thus, mirror neurons are both activated when an individual does a particular action, and when that individual perceives that same action done by another. The discovery of mirror neurons suggests we need to radically revise our notions of human nature since they offer a means by which we may not be so separated as we think. Humans unlike other apes are adapted to mirror interact nonverbally when together. Notably, our faces have been evolved to display agile and nimble movements. While this is usually explained as enabling nonverbal communication, a better description would be nonverbal commune based upon mirror neurons. I argue we cherish humanity, *colamus humanitatem,* because mirror neurons and our adapted mirror interpersonal interface blur the physical boundaries that separate us.

Resumen

El sentido común dice que estamos aislados. Después de todo, nuestros cuerpos están separados físicamente. Pero la obra *Colamus humanitatem* de Séneca y la observación de que "ningún hombre es una isla", que hizo John Donne, sugieren que no estamos ni completamente aislados ni separados. Un descubrimiento reciente de la neurociencia, el de las neuronas espejo, sostiene que el cerebro y la mente no son construidos ni funcionan alejados de lo que pasa en otros individuos. ¿Qué son las neuronas espejo? Son células cerebrales que procesan tanto lo que le pasa como lo que hace un individuo, y, por así decirlo, su "reflexión" percibida cuando esa misma cosa le pasa a, o es hecha por, otro individuo. Por lo tanto, las neuronas espejo se activan cuando una persona realiza una acción específica y cuando percibe la misma acción realizada por otro. El descubrimiento de las neuronas espejo indica que es preciso revisar radicalmente nuestras nociones sobre la naturaleza humana, ya que estas neuronas ofrecen un medio por el cual no concebimos estar tan separados como pensamos. A diferencia de otros simios, los humanos están adaptados a interactuar de forma similar no verbal, cuando están juntos. De manera particular, nuestras caras han evolucionado para mostrar movimientos ágiles y rápidos. Mientras esto usualmente explica cómo se logra la comunicación no verbal, una mejor descripción sería la comunicación no verbal

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basada en las neuronas espejo. El autor sostiene que valoramos la humanidad, *colamus humanitatem*, porque las neuronas espejo y nuestra interfaz interpersonal adaptada de espejo desdibujan las fronteras que nos separan.

Palabras clave: neuronas espejo, empatía, sí mismo, emociones sociales, comunicación interpersonal, sentido de comunidad.

Why cherish humanity—Seneca's *colamus humanitatem*? Why care about other people? Why should we go beyond the boundaries of our own personal lives and value the lives of other men and women? Is it, perhaps, because we are all members of the same species, *Homo sapiens sapiens*? Or, maybe, it is because when I see another person in pain, I know rationally that what they experience is much the same as when I suffer myself pain? But these answers are not by themselves convincing: for, why should the fact that other people are like me either in body or in their capacity for experiences such as pain, cause me to care or cherish them? We do this—and feel we ought to—but it is not a logical necessity. After all, the cells of my body under the microscope might be much like those of earthworms or some other lowly creature but that does not mean I should necessarily value the life of earthworms. Yet Seneca's observation about 2000 years ago touches a deep insight as to human nature and what it is to be a human. An unidentified aspect about being a human exists that causes us to cherish other people. As John Donne once noted in his *Devotions* that "no man is an island, entire to itself," and "Any man's *death* diminishes *me*, because I am involved in *Mankind*." Here poets catch a truth—but what kind of truth is it—for it is not one of logic. Can science illuminate this aspect of our unknown humanity?

Here, however, is not a problem that most psychologists and philosophers seek to fathom. Rather scholarly and scientific attempts to understand the nature of humanity mostly start from the premise that other people's experience does not fundamentally matter. Yes, people may say words about valuing others for courteous appearances but that underneath each of our minds really in fact lives as isolated as if were an island. As the social psychologist James Fiske has observed: "From Freud to sociobiologists, from Skinner to social cognitionists, from Goffman to game theorists, the assumption in Western psychology has been that humans are by nature asocial individualists ... social relationships are instrumental means to nonsocial ends, or constraints on the satisfaction of individual desires" (1992, p. 689). And again, as another psychologist, C. Daniel Batson has observed, "Perhaps the reason that psychologists have spent little time on the question of our social nature is because they already know the answer... our behavior may be highly social; our thoughts also may be highly social; but in our hearts, we live alone... We are *social egoists*" (1990, p. 336).

Neuroscience, as I will show here, provides grounds for rejecting the idea that we are "asocial individualists" and "social egoists." By contrast, we now know that the neural fabric out of which each of our minds is woven is such that the lives and experiences of other people are as vital to us as our own. The neuroscience discovery which is responsible for this goes by the name of "mirror neurons." These neurons, I shall argue, support John Donne and Seneca's view of human nature. Neurologically, no brain is an island. Our neurons wire us to exist within, to use a Latin word for "common", as a nonverbal *communio,* or commune.

What are mirror neurons?

To understand mirror neurons, we need first to appreciate how the brain was traditionally—and mistakenly—thought to work. If one looks at a diagram of the brain, it is labeled with terms such as visual, auditory and motor. Thus, there is the visual cortex at the back of the brain that indicates that this area handles sight, and the motor cortex in the front that this area deals with the body's movements. These areas have divisions; hence the motor cortex gets divided up, for example, into the primary motor cortex and the premotor cortex. There are good reasons for the existence of these terms—injury to the visual cortex causes blindness and, likewise, injury to the motor cortex causes paralysis. This labeling has turned out however to cause false expectations about the workings of the brain. One of them is that the function of the motor cortex areas does not include also an important role in perception. After all, labels for perception such as vision and audition have been given to parts of the brain elsewhere. So it was unexpected when in 1992 that Giacomo Rizzolatti and colleagues of Parma University (1992) found that certain neurons in a part of the motor cortex, the F5 inferior premotor area, had a role in perception. The motor cortex here did not only control the body as might be inferred from the label but also perceived the movement of other individuals.

Rizzolatti's initial work involved macaque monkeys using electrodes implanted in their brains. What he found was that certain neurons in their motor cortex discharged when they did a particular hand action, say reaching to grasp a raison, while others were activated by other actions such as tearing something up. Nothing surprising here. What was unexpected was that the same neurons also discharged when they saw another monkey or the experimenter doing these same actions. Thus, a neuron would spike when a monkey grabbed a raison and also when it saw the experimenter grab one, and different neurons would be activated for different actions such as tearing and seeing another individual tearing. Neurologically, these neurons were like mirrors reflecting what others did in the external world onto the brain doing same actions.

Since 1992 several more things have been established about mirror neurons. They are not confined to monkeys: functional brain imaging and other techniques finds them also in humans. When people observe actions made by other individuals, much the same areas in their brains lighted up as when they perform them. Such mirroring only applies to actions done by bodies – those done by robots do not activate these neurons (Tai, Scherfler, Brooks, Sawamoto, & Castiello, 2004). Such brain areas respond, moreover, not only to the sight of other movements but also their perception through sound (Galati et al., 2008). (This might seem an obscure point but in fact our vocal ability to pronounce a word or name that we have just overheard depends upon such auditory-motor mirroring.) The activation of mirror neurons occurs even when the object of an action is hidden, provided the intention of the goal of the movement is clear (Umilta et al., 2001). Mirroring applies to emotional expression and experience also, for example, when we see the expression of disgust on the face of another person after smelling a revolting odor, we activate the same areas in our own brain (the anterior insular—a part of the emotional brain near the motor cortex) that gets activated when we ourselves smell that odor and express disgust (Wicker et al., 2003). If we see another individual with an electrode on their hand that gives painful shocks and then a cue when they are electrocuted, many of the same parts of our brains get activated as when we receive an electric shock (Singer et al., 2004).

Mirror neurons, or neurons related to them are found outside the motor cortex. Mirror neurons are found in the posterior parietal cortex, though these neurons are concerned with the kinesthetic and somatosensory aspects of actions rather than their execution. As already noted, mirror neurons related to affective reactions such as disgust are found in the insula cortex suggesting the existence of mirror neurons for the expression of emotions. Mirror neuron-like cells have also been found in the superior temporal sulcus area. These neurons are particularly interesting because though they are not activated by a person's own movement, they get activated by what is called "biological motion" (Johansson, 1973). To gain a sense of what biological motion entails, imagine a person masked and wearing black in a black room with light diodes attached to their limbs so they cannot be seen; only the dots of light they are wearing. Remarkably, when an individual walks, jumps and in other ways moves—the movement of the light dots lets us identify instantly what they are doing, even though we cannot see their actual bodies. People have been found to be able to identify immediately not only what someone is doing—walking, dancing, and so on—from the movements of such light dots, but also their gender and who the individual is—we each have our own movement signature. Interestingly, we can identify such movements as having been made by us rather than someone else which is remarkable since we never or only rarely see our own actions.

The existence of mirror neurons might on first impressions seem rather odd. But there is a subtle logic at work if we appreciate that the general workings of the motor cortex is not like that implied by most diagrams of its functioning. This is often of some piano-like mechanism in which motor neuron activation as it were hit keys that then act like hammers upon strings upon the body's muscles. The motor cortex is not like this, for a start it is not a motor-muscle cortex as much as a motor-goal one. While there is a homunculus general layout of the body on the motor cortex, it is very much more rough than, say the one for our sense of touch upon our body in the somatosensory cortex, or the retina in the visual cortex. This reflects the fact that the motor cortex does not control muscles, but a much higher level of movement creation—that concerned with programming motor goals. Such programming is unlike that done by any robot—if we make a reaching movement to grab, say, an apple, and our hand receives a sudden jolt that displaces it from its planned course, our motor system automatically compensates so that our hand still reaches its target—the apple. No robot can do this. The motor cortex is concerned with processing the motor goals, like reaching the apple, rather than processing the particular muscles used by our arm and hand.

This higher level of processing allows the motor cortex to process movements independently of the body, for example, when we imagine, as if, making an action in "our heads." When we mentally imagine in this way making a motor action, we light up much the same parts of the brain that get activated when we actually make that movement. Here, we are as it were mirroring not another's action but our own in our own thoughts. The curious thing is that such imagination has real effects on actual bodily actions—we improve our skills in them. One explanation is that what we are doing is rehearsing the motor goals which organize actual movements. Motor skill requires the ability to coordinate together such goals—learning to tie a knot is less a skill in movement than doing actions in the right order. More is involved in the link between imagination and actual processing than this though since it applies also to when we visualize in our imagination seeing an object. When we do this we activate many of the same visual areas involved when we actually recognize and see that object. A general rule of function in the brain seems to be that online and offline processing take place in many of the same brain areas.

Motor imagination concerns our own movements but it readily blends into mirroring the actual world. For example, when asked to judge whether a glove shape fits the left or right hand, we activate a part of the appropriate right or left side of the motor area in our brains that controls which of our hands would fit that glove. We, in a sense, identify whether a glove would fit our left or right hand by imagining the appropriate part of our body and seeing how it would fit into the glove (Parsons et al., 1995). It is a small jump from this for such neurons in their processing to imagine what it is like to be another.

Motor perception

The neuroscience discussed above gains its full importance from what psychologists have found about movement and perception. In what follows, I am slightly speculative because the phenomena I mention have not all so far been linked directly to the mirror neurons and the motor cortex. But that is due to lack of research, not lack of logical connection.

Ten years before Rizzolatti's discovery of mirror neurons, for example, Jennifer Freyd found that people after seeing a photograph of a human action had difficulties rejecting other pictures from a sequence of photos of the action taken later on (1982). This suggested that when people had looked at that static image, they had storied it in terms of its dynamic body movement—which would suggest that when we look at actions we do not recognize them as objects but in terms of their actions. It is reasonable to suggest that this happens in motor neurons responsible in us for controlling the same kind of movement. In another case of motor perception Jennifer Freyd and Maggie Shiffrar (1990) found that when we see "apparent motion" between two alternating static pictures of a person doing an action, what we see links not to the shortest possible path between the two images but to the anatomical plausible action that links them. Again, this suggests that our perception of bodily movements happens not in terms of objects but in terms of knowledge held in the motor cortex as to how our own movements could carry them out. In a sense, the brain sees the actions of others by parasitizing its own knowledge of the actions it can do with its body.

But perception must go much deeper than even this. Take the following example of motor perception found in the illusion created first by Paolo Viviani at the University of Geneva (1992). Here Paolo Viviani presented a light dot on a screen moving repetitively around an elliptical path. What is odd is that when people look at its movement, they see it as only uniform if it imitates the biomechanical constraints of a human hand moving the dot along that path—faster when curvature is less, slowing down at the sharper ends. Such perception is so powerfully shaped by our sense of action that Viviani found that a gradual shift of the path to a circle went unnoticed providing the elliptical velocity was retained. Here, our perception is of an abstract movement that we could make. Again, this suggests that mirror neurons enable us to see the world filled not so much in terms of objects as with actions which with we, as if as it were, "empathize."

Such motor empathy can be practical in various ways. Consider the problem of recognizing cursively joined handwritten letters. We do it automatically, but there are few clues as to which letter strokes matches which alphabetic letter—it is not like identifying an object where we are presented with many sources of information in the form of color, form and shape. Mary Babcock of Cornell University (1988) has found that people identify cursive letters at least in part from the dynamic information their drawing strokes contain about how they were written. If you look closely at the strokes of letters, they have slightly different angles and curves depending upon which letter preceded them. The elliptical beginning of the stroke starting the letter "l" after another "l" has a different shape to that after an "m." The brain when looking at the lines making up such letters picks up from such clues how they were written to identify what they are. And this applies not just to alphabetic handwriting: Jean-Pierre Orliaguet in France (1997) has found that Chinese logographs are perceived in terms of the flow of the movement strokes used to paint them. This would seem a factor in the perception of Chinese and Japanese logographs which are often learnt first by learning how to draw them. A group from Japan has even reported motor cortex activation accompanies the perception of oriental writing.

Mirror neurons and human nature

Why do mirror neurons exist? One idea is that they might have arisen to aid motor imitation. Individual monkeys spend months learning skills such as how to best crack open a nut – it would advantage another monkey to get a head start on learning that skill by observation. However, learning by imitation is unlikely why mirror neurons arose. First, as noted, they exist due to how the motor cortex organizes actions in terms of goals. This suggests that when a mirror neuron is activated by an observed action, it is a case of what Stephen Gould called an exaptation (Gould & Vrba, 1982). An exaptation contrasts to an adaptation -- in an adaptation, the origin of a thing arises from its utility, but with an exaptation, its origins come from it being a fortuitous and incidental side effect of something else—in the case of mirror neurons, to the already existing processes of motor neurons. A second reason is that nonhuman primates do not readily imitate. This may be surprising—after all, "to ape" means "to copy." But in spite of intense research, the search for evidence that monkeys and chimpanzees imitate, has not been very fruitful—the conclusion is that in general "apes do not ape." This applies not just to the copying of body movements but also vocalizations.

Evolution could, however, have developed mirror neurons, once they had arisen as part of the motor cortex. Exaptations—incidental side effects—can be the raw stuff upon which natural selection works. Further, and this is an idea that I will now expand upon—mirror neurons could have shaped the evolution of the body. The nature of this will become clearer in the next sections. In these I shall argue that human evolution changed us so it could exploit mirror neurons. This story, I suggest, underlies our ability to create tools, language, sociability, cognitively put ourselves in other people's "shoes," and even the very reason why we seek to understand "human nature."

Human evolution and mirror neurons: Hands and tools

Many animals use and make tools including chimpanzees and the New Caledonian crows. But nothing compares to the abilities of our species—from early infancy, we are described by child psychologists as "copying machines." It is in part, a result of our large brains being able to organize the complex actions needed to fashion tools and then use them. Another factor is that hands are "designed" to be dexterous. But I will argue a further factor was the prior existence of mirror neurons.

First, I will focus upon our hands—they differ from those of other apes but not in the way most people imagine (Napier, 1993). Other apes, like us have an opposable thumb. And finger control of even monkeys can, like ours, be precise, for example, when using their hands to feed delicately upon seeds. Anatomically, slight variations in ligaments and muscles also exist. But the key difference is that humans do not use their arms and hands for getting about. Bipedality freed our upper bodies. The muscles, ligaments, joints and bones of our upper limbs as a result do not have to carry body weight when climbing or knuckle walking. That might seem a rather small point but the impact upon our arms and particularly our hands was enormous. It enabled them to specialize without compromise in excellence in hand control. The fingers of chimpanzees, for example are long and their thumbs short—adaptations which aid tree climbing and knuckle walking. But your fingers and thumb are just the right lengths to work easily with each other—just play around with your hands and you will feel how well your fingers and your thumbs fit. To carrying body weight, chimpanzee wrists and fingers ligaments are thick and strong, but those in our hands are only stiffened sufficiently to enable dexterous finger movements.

There is another factor: feel the tips of your thumb and fingers; they have broad nails and soft flesh pads. Prick them and they bleed as they are rich in blood vessels—these are need to support a skin dense with sensory nerve endings. Such sensitive finger tips are unique to us—in other apes they are narrow and hard and backed by very tough nails—good for climbing and grabbing on surfaces but not for touch manipulation.

Those finger pads revolutionized the hand by giving the brain a vast range of complex and hierarchical motor goals linked to their touch awareness. Here is where mirror neurons became important. When you observe another person making delicate finger movements, say when they tie a knot, you see their fingers moving sequentially in terms of their "touch space." You see not so much finger movements as a sequence of finger goals. As a result, there is much more to motor mirror. Finger and thumb touch pads arose to make highly dexterous finger actions, in particular, for manufacturing and using tools and artifacts. The usefulness of such skills, however, first depended upon the ability to acquire them. When the organization of actions are simple, an individual can learn them on their own, but with the complex ones needed to make artifacts, an individual must pick them up—at least in part—from others. Thus, the brain's ability to imitate was critical in the evolution of finger pads since without the ability to copy finger skills, there would be no advantage in them. Mirror neurons, of course, played a key part in enabling such imitation and so the rise of our specialized fingers.

Vocalization

When we consider imitation, we think of hand movements or perhaps, the vocal copying of birds such as parrots. We may be aware that we can imitate other individual's speech but do not give it prominence as a skill, nor as a key innovation in the origin of language. That honor we give to syntax and semantics. But our abilities to mimic speech are remarkable and central to the existence of language (Skoyles, 1998). Other animals may communicate but humans are unique in doing so by means of a vocabulary of many tens of thousands of words and names. The existence of vocabulary thus depends upon an ability to acquire all these thousands of pronunciations. Not just any means, but one that can do so in very young children in spite of the fact that their vocal organs have a different shape and size to adults and older children whose pronunciations they copy. And, of course, such imitation must convert information contained in sound into vocalizations. Thankfully, we are all rather good at doing this, as can be seen when we shadow speech containing unfamiliar words. After strokes, people may lose their ability to initiate speech but can still echo what they hear other say. The size of a child's vocabulary, as might be expected, depends upon their earlier ability to repeat unfamiliar words. Part of the trick has been to make the sounds of speech those that are easiest to replicate. Though it tends to get overlooked as an insignificant detail about speech but its most elementary units, phones, are scientifically characterized not in terms of auditory sound but the manner and place in the vocal track in which they are made. Indeed, one theory of hearing speech called—the "motor theory of speech perception"—argues that we hear words in terms of how they are articulated (Liberman & Mattingly, 1985).

Here we can see a fundamental importance for mirror neurons—in fact two. First, vocabulary based language got off the ground due to the ability provided by mirror neurons to copy vocal articulations. Second, such mirror neurons shaped the *very* vocalizations that make up speech. If you reflect on it, learning vocabulary is a bottle neck upon the development of speech. As such, it will powerfully shape speech sounds by causing the preferential propagation of those sounds which are most easy to copy. Sounds which are not so easy to imitate will not be picked up by new speakers leaving only those speech sounds that are easy to copy (Skoyles, 1998). Mirror neurons, in other words, in the past caused a mini natural selection upon speech sounds with the criteria of survival being imitiability.

Mirror neurons and our face

Mirroring is closely linked to sociability in certain animals, though not nonhuman primates such as chimpanzees. Dolphins in particular show spontaneous social imitation not only of each other but even of humans. A human trainer making a head movement visible through a port hole in a tank to a dolphin will see the dolphin trying to interact by copying their movements—shaking their heads if the trainer shakes their own head (Delfour & Marten, 2001). The sounds of dolphins also involve much imitation. Recent research shows that dolphins have as complex social lives as chimpanzees. Why then do dolphins but not chimpanzees use mirroring in their sociability? The reason lies in the different opportunities for interaction offered by life in water compared to that on land. A chimpanzee can smell another, they can mutually groom, and they live in a shared territory. Dolphins cannot do these things. Fortunately, life in water makes imitation of movement and sound easy, which lets movement (together with sounds) take their place. There is no problem of gravity. If a chimp copies another's movement its motor neurons must work out the different effects of gravity upon its own and the other individual's movements. While this is not impossible—we can do them all the time, they are a problem that dolphins in water can ignore (for the same reasons that astronauts to train for gravity-free existence, do so in water tanks).

Human evolution made mirroring much easier for us than for a chimp. As noted, bipedality freed our hands to become highly dexterous because of imitation. And bipedality even itself aided mirroring as it causes us to keep a constant posture—even when sitting we tend to keep our upper bodies in the vertical. Chimps, in contrast, live much of their lives in the horizontal plane as they climb and knuckle walk. As a result, we present ourselves to each other in a much more constant position—we rarely interact with people who are upside down. Moreover, because it is erect we are in the position which is most easy to see. That makes it easier to mirror each other.

But these merely aid mirroring—in contrast, mirror neurons seem to have actively shaped our faces. To appreciate this, look at your own face in a mirror. Human faces—and your facial movements upon it—are unique among primates in having been selected to be easily seen.

First, alone amongst mammals, the sclera of the human eye—the area surrounding our iris and pupils—is exposed, wide and white. In other animals, the surrounding area is either minimally exposed, or dark to mask the visibility of the pupil. This makes sense: eyes are easily spotted by predators and so it advantages an animal to make them difficult to see. And for animals that are predators, they need to hide their eyes least their potential prey detect them. But the human species has eyes that are visible to onlookers—our sclera is exposed and white so that others can see it contrasted with our dark pupils. This does not advantage their function as organs of sight but makes their movements highly noticeable (Kobayashi & Kohshima, 2001).

A further difference is that compared with other apes, our faces are not framed by hair. Chimp faces are surrounded by fur—this makes them less easy to see. But human faces particularly those of the young and women limit the presence of hair except to the top of the head and above the eyes. Having a "good head of hair" cuts the chance of heat stroke that we risk when standing upright from the overhead sun. Eye brows are also functional: they are in effect sweat bands that stop brow sweat running down and stinging our eyes. (One needs here a brief distraction to mention that such sweating and nakedness links to three unique features of our species. First, we can run energetically for many hours—most animals move fast only in brief spurts. The reason for this is that we have a second uniqueness: The adaptation to get rid of the heat caused by the muscular exertion of constant exhausting activity by sweat evaporation. A runner, for example, can during a marathon lose five quarts of sweat. This leads in turn to a third uniqueness: If we were covered with fur, that sweat could not cool our bodies by evaporation—it would either drip off or form a sticky mess. Thus, unlike all other primates, we are nearly entirely naked. See Skoyles & Sagan, 2002.)

There are other features linked to our visibility such as the reddening of our lips that make them and their movements more easily seen, and that our facial skin can blush. All together, this suggests that our faces have been subject to a natural selection to make them, and what happens on them, visible and distinct. Why? It is a story that, I suggest, involves mirror neurons.

Our faces are not only uniquely easy to see but also make movements that are worth looking at. One might invent a phrase and call our faces a "motor exposure board." It is packed with muscles but it is the looseness of flesh that makes their movements so delicately and agilely expressive—anatomically, we have much the same facial muscles as chimpanzees (though our ones are more differentiated). Feel your face—what your fingers prod and massage is remarkably loose and soft—there is nothing "leathery" about your face. This subtle flesh is exclusive to us. As a result we can much more agile use of our faces to make expressions. And not just the ones we see, but also micro expressions that flash across it for a 15th of a second. If you look at real people talking at say a station or airport, you will see that people's faces are in constant movement.

But this is only the beginning of an explanation—since why do we so persistently make these agile facial movements when with others? The obvious answer—and it is not entirely wrong—is that our faces enable us to communicate by making facial gestures, the familiar expressions of smiles, raised fearful eye brows, grimaces of disgust and down turned sad mouths. There is a universal communication system here—a smile says happiness whatever our language. But this expression of emotion is only part of the story of our faces. For a start, people are not that good at reading them as they confuse the expressions for fear and surprise, as well as the ones for anger and disgust. Further, chimps also use most of these expressions. In addition to emotional expressions—which are easy to study—we also engage when with others in what might be called facial animation in activity that is less easy to investigate. As noted, researchers that slow down videos of faces in communication find that we make micro expressions that do not get consciously noticed. But while they do not enter awareness, they are important as they let our faces say, "I heard you," "it is now my turn," "I am following what you say," and "I am with you." Our faces are not flashing out signs merely for "I am happy" or "I am sad"—they go far beyond this—they echo our social presence with each other.

William Condon of the University of Pittsburgh (1966) showed that people synchronize their voices with their body, arm and facial movements during conversation. He did this by looking at film taken at 48 frames per second. As two people talked, he was able to track a harmonious organization of movements between their bodies and speech—"the body," as he put it, "of the listener dances in rhythm with that of the speaker." Thus, the animation of our hands and our motor exposure board—our faces—is a subtle mirror upon which we bounce off expressions. The agility of the movement intercourse can be a shock when we have nothing to do but look at strangers in a public place. When engaged with others, the activity of faces does not register; but being outside a conversation we can see how subtly, agilely and exactly mouths contort, eyes raise and head and hands jog about in rhythm with each other. People might feel they are only talking but they are also sharing social presence through an intricate facial and bodily tango.

Ulf Dimberg (1982) has researched how the electromyclographic (EMG) responses of people's face muscles such as the *zygomaticus major* and *corrugator supercilii* of observers react when they see facial expressions made with these muscles. What Dimberg found is that we ever so slightly mirror in our own faces the expressions that we see in others. Thus we are not only synchronizing our movements, but also at the same time—at least ever so slightly—mirroring them. People not only mimic the movements but mimicry strongly affects others. Tanya Chartrand (1999) has found that people feel a strong rapport and personal liking for an individual that copies their own movements. But more than copying is going on, as this hidden mirroring does not usually become the basis of an exact copy. What is reciprocated is contingency since provides the cue for another related and linked expression. Mirror neurons responsible for expressions using the *zygomaticus major* and *corrugator supercilii* get activated by the sight of facial expressions using them, and such activation overflows to trigger the movements of these or other muscles.

Such mirroring, of course, helps smooth interpersonal interaction, not only by making our faces more communicative. We need to be able to pick up information such as when people are losing interest in what we are saying, or seek a turn in the conversation. But even this hardly begins to express the function of our faces which has to do with making and sharing social togetherness. Here we are discussing, not a skill but one of the things that is most intimate to us as real, living humans. Consider what it would be like to have a face no one wants to interact with such as the "hideously" malformed one of Joseph Carey Merrick, the "Elephant man" (1862-1890). Facial deformity is a tragedy that really should not rationally exist—after all, whatever the appearance of our faces it can still be functional in allowing us to normally talk, breathe and eat, while the movements of other parts of our bodies can take the place of turn taking in a conversation. They are in a way "redundant." But if we imagine what it would be like being Joseph Merrick, we know that they are critical to our existence—a display board upon which we show and share our humanity. That is why the situation of Joseph Merrick touches us so profoundly: he was human—but due to the gross abnormality of his face, he was excluded, or nearly so, from sharing that humanity with others. Without the efforts of Sir Frederick Treves, the actress Mrs. Kendall and other good hearted people, the human that was Joseph Merrick would have been a very isolated island at a freak show. The quotes around "hideous" above need to be there, he was not hideous—it is in us, not him that in which the horror lies. Researchers that describe the function of our faces as non-verbal communication therefore seem to profoundly miss the point of having—or rather living as—a face. The facially deformed can make such communication or at least communicate their equivalents. The tone of our voice, for example, can convey whether we are happy or not. What a person with a deformed face cannot do is the dance of interpersonal togetherness as few want to look at a deformed face.

Our faces are therefore I suggest not so much communication devices but communion ones. The word "communion" comes from the Latin *communio* which simply means "common." Holy Communion in a service of common union—individuals which are separate are no longer so. But the word can be used more widely: a dance between two people can be cognitively—at least in motor terms—a communion. We do not communicate anything by doing a waltz or rumba, we use it to share a mutual social presence. What we do is cease to be separate islands—for a moment the movements of two people interact and live as one. Behaviorally, two people organize themselves as if one body. Social communion not communication is the basis of our existence as social entities.

After all, little of what we say either by words or nonverbal language concerns the pure transfer of information. Gossip, chit chat, the casual "how are you" patter of ordinary conversation may use words that communicate information but what is being transacted is togetherness. We do not like being alone. We seek relationships—we are an immensely social primate—and our relationships need to be kept in repair. Our faces evolved as exquisite display boards not to provide information but to enable people to be with each other through social mirroring. Two computers, after all, might communicate information between each other not to transfer information but to check that they are still connected.

We not only dance with each other nonverbally, but how we do so happens with a behavioral accent or dialect. Culture takes many forms but one of them is how we bounce our expressions off each other. The global variation in hand and facial gestures is well known. To greet, Indians put their hands together on their chests in a praying position while making a slight bow, Arabs sweep their right hand upward touching their hearts and foreheads, the Japanese bow, the Maoris of New Zealand rub noses while Tibetan tribesmen stick their tongues out. Under this, as it were tip of an iceberg, there is a vast subtlety in how people nonverbally dance with each other as they engage in social communion. When we visit people in foreign places—we feel a certain strangeness in their manners. People interact with a different flow and rhythm to that with which we are familiar. There is nothing surprising here since the fact that people have different vocal accents is well recognized. People pick up the subtle ways of their social group in which we string together speech sounds. We do likewise in how we articulate our faces and bodies when together. Or rather it is that our mirror neurons pick up these subtle differences.

Mirror neurons thus tune us as belonging to a particular group. Humans have a need for this behavioral identification of our home group since unlike other primates our sense of smell is much reduced (not least because standing upright our nose is in the wrong place). But that reduction could only have happened because we could substitute a behavioral alternative in its place. We, therefore, know a person belongs to our group not by how they smell but how they interact. We sniff, as it were, the "accent" of their behavior, and sense a reassuring familiarity. But equally we can detect a sense of strangeness. Mirror neurons, therefore, which have given us a powerful capacity to make social communion and so remove the boundaries which separate us as humans also as a result have a powerful downside—in that they can also lead us to experience other humans as lacking our humanity. If people are of a different social group, we fail to sense what binds us together. Our feelings do not resonant and as a result, it is easy to cease to care if we hurt them, or treat them in ways we would not our own kin or kind.

The role of mirror neurons in sociability makes human experience very different to that of chimpanzees. Chimpanzees lack this ability to engage with each other. They have little ability, for example, to share a mutual rhythm. In spite of the efforts of Sue Savage Rumbaugh to get Kanzi to dance and bang away with her in tempo, he finds it hard to pace along with her. Mirror neurons by synchronizing our interactions make us radically different to chimps. Few children, after all, have difficulty in making a dance, beating a drum, or singing a song. To be human is to love to mirror what you do with what I do. This is not to say that chimpanzees are not social and have as much need as we do to be accepted. But that they do this instead through olfaction and mutual grooming. Only humans create their sense of social existence through conversing or sharing music in the synchronized activation of mirror neurons.

The mutual reflecting of mirroring has the consequence of forcing us to be equals. But this is not always wanted, particularly if some individuals are more powerful and wanted to be treated with a high social status. Such individuals seek to stop the equality that comes with social mirroring. That is not hard: if you can stop others seeing you, then you can prevent them striking up a relationship with you as an equal. People can be stopped from, for example, in some cultures it is an offense to look at royalty. And this can be achieved not only by social taboos and rules about looking at each other. There are several reasons for the existence of facial hair on mature men. For example, it marks out dominant individuals in a group, like the lion's main. But another a linked reason is that it makes it harder for young men and women to mirror older men and so level their relationship with them.

Mirror neurons and minds

Mirror neurons underlie, it has been argued, our capacity to "put ourselves in other people's shoes." Scientists call this "the theory of mind." To illustrate what this involves, consider the following test that uses a puppet story. First, the child sees a puppet called Sally who hides a marble in a basket and then goes away. While she is gone, they see another puppet enter and take the marble and put it into a covered box. The Sally puppet returns. The child then is asked, "Where will Sally look for her marble?" Answering this correctly requires an ability to put ourselves in Sally's position and see what she might know. We have to put ourselves, as we say, in her shoes and so enter her inner world and see what she might infer within. In a word, we need to mirror what is in her mind.

This ability to put oneself in another's shoes has been attributed to mirror neurons. After all, these enable us to put, as it were, our own bodies—or at least our control of them—into those of others when viewing their situation and actions. Here neurons with which we organize behavior perceive what it would be to organize another's behavior given what they know and their goals.

Interestingly, it is not a skill that all individuals possess. While those with Downs Syndrome have no problems with the Sally puppet task, those with autism find it hard. Or if they manage to answer the task correctly, they do it oddly. Normally, we know spontaneously what Sally knows without any thought. But when those with autism manage to answer correctly, they do so by working it out as it were an intellectual problem.

Controversy exists how far nonhuman primates are able to read "minds." Many of the cases which we might feel show the evidence that chimps and other animals can do this turn out to be explainable in terms of acquired associations. Even if they do, it seems they have such abilities only to a very limited extent compared to that of humans. This is not to say other animals cannot empathize with suffering. Monkeys, for example, trained to pull a cord for a food reward stop when they see that this electrocutes a monkey in the next cage. But this does not originate in a theory of mind skill—very young infants also, for example, get upset with the suffering of others even though they are too young for this skill. It seems that mirror neurons while present in other primates fail to get used in cognition, while humans have exploited them to create many diverse ways. Perhaps they had an even more profound effect upon us.

Beyond mirror neurons to human nature

You are reading this because you are interested in human nature. Every religion provides an answer of some kind to this question. Why is this question so important, however? I suggest it is more than curiosity, and has to do with the central problem mirror neurons pose for our lives. If we create a sense of social togetherness through mirroring then it matters how similar we are—and with whom? How easily will it be for me to mirror another? Is there some core nature in me and all other humans in which we can find a common reflection?

During a talk upon whether animals suffer, a speaker switched in her slides without anyone noticing from asking whether animals had feelings to asking how they were like us. Questions about what is similar in our nature are not distant from those about who has feelings. When we ask, say, whether stones, snails, fish, cats, dogs, monkeys or apes have feelings—the question comes down to how similar they are to us. But why should this be so? One answer is our mirror neurons. After all, if we cannot mirror what is going on with another entity, we cannot attribute to it our own experiences such as feelings. But what is similar? It does not have to be that of looks—we do not look like dogs—but we feel they have feelings. But we can empathize with them since dogs mirror our social interactions with them—it may be a tail wag rather than a smile—but the contingency to our own movements lets us "mirror." Mirroring, similarity, feelings, and our sense of the essence of ourselves—our human nature—are thus all intertwined.

Conclusions

Natural selection created in us a brain that could care in a way which no other animal brain can. It did this because it created a brain that mirrored other individuals. At the most basic level this concerns the animation which happens when we converse. But from this foundation, it readily develops other cognitions built upon mirroring from which our humanity is built. It enables us to experience others as having minds. It enables us to ask the question, How far are others like us? While we may be physically separate, that due to mirror neurons our minds are not. They provide a cognitive communion, they prevent us experiencing individuals merely as objects but as having minds.

There is another side to Seneca's *colamus humanitatem,* cherish humanity. Terence, an African slave that became one of Rome's greatest dramatists and poets once observed: *homo sum: humani nil a me alienum puto*—I am a human being, so nothing human is strange to me. We can now see why. We care about each other not because we rationally know that our bodies and experiences are similar but because our awareness is built upon the neurological equivalent of a mirror. Rationality has nothing to do with it. Empathy is rooted in the very process by which we form our sense of self. Part of our brains is, as it were, blind folded as to whether that pain is happening in our own body or that of another. This gives us an automatic sense that another's suffering is my business and unease—at least to prevent and heal. Mirror neurons suggest we can never properly understand our nature in terms of being asocial individualists or social egoists. Such limited social psychology does not fit in with the evolution of our brains and so our minds. But mirror neurons offer us an opportunity to reappreciate such thinkers as John Donne. Mirror neurons argue it is not merely theology that "no man is an island, entire to itself," or "Any man's *death* diminishes *me*, because I am involved in *Mankind*." These are also truths of the human brain.

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