Chapter 7

The machinery for the perception of mind

One approach in searching for the social circuitry in the brain is to start at the eye and work inward through the visual system. Much of what we perceive about other people, much of the raw data we use to reconstruct another person's mind, comes through vision. We see someone's face and read the facial expression. We see the eyes and deduce what that person is looking at and thinking about. We see the gestures and movement of limbs, the body language that reveals so much about the person's inner state. All of these computations depend on vision. Therefore we should expect the visual system to flow into the circuitry for social perception. We might also expect the circuitry for social perception to have a back and forth, an inflow and outflow with the circuitry for language, since the conscious mind is obviously capable of understanding language and expressing itself verbally. What structures in the brain lie between vision and language, and are also expert at computing mental states? Areas TE and STP (see Diagram 6-3) are prime candidates.

Social neuroscience began in the 1960s, when Gross and his colleagues studied neurons in area TE of monkeys. (Charlie Gross was my graduate advisor and is my longtime mentor and friend. I cut my teeth scientifically in the lab where social neuroscience began.) Area TE lies at the pinnacle, the highest hierarchical level, in the visual stream that processes object shape and color. Gross and colleagues discovered two especially interesting types of neurons: hand neurons and face neurons.

A hand neuron fires off signals when the monkey looks at a hand or a picture of a hand. If the monkey looks at a picture of a leg or of an alligator, or if he closes his eyes, that neuron withholds signals. When the monkey opens his eyes and looks at a hand, the neuron begins to deliver signals again. The signals are sent on to other parts of the brain, in a sense telling the rest of the brain, "There's a hand in view!"

If the monkey looks at an obvious picture of a hand, then the hand neuron fires off signals at a high rate, shouting, "It's a hand!" as often as fifty times a second. If the picture is ambiguous, the hand neuron fluctuates in its decision. It shouts out its signal less often. If the monkey is looking at a block of wood instead of a hand, the hand neuron shouts out its signal perhaps once every two or three seconds, hundreds of times less frequently than with an actual hand.

Face neurons are similarly choosey. They become active when the monkey looks at a face, whether a monkey face, a human face, a profile, a frontal view, an actual person in front of the monkey, a photograph, or a line drawing. A face neuron might become more active in some of those conditions than others—a real face usually drives a bigger response than a mere drawing—but the preference for faces is consistent. Other, non-face images will generally cause only a weak response in the cell.

Hands and faces appear to be special. There are no banana cells, or bird cells, or tree cells. No other category of object has its own dedicated class of neurons, at least that anyone has found thus far in monkeys. A generic machinery seems to be sufficient for processing and recognizing the vast majority of visual images, whereas hands and faces are evidently so important that they require their own, dedicated population of neurons. (The scientist Kanwisher and her colleagues found the corresponding region in the human brain that emphasizes faces.)

It is easy to understand why faces require a specialized machinery. Not only are faces extremely important for social communication, but they are also extremely similar to each other. One face is almost identical to the next. Suppose you had a hundred heads of lettuce in front of you, laid out on the ground. Would you be able to recognize them individually so that, at a glance, within a fraction of a second, you would know without doubt that you were looking at Lot 56, #3, the lettuce head, instead of any of the other ninety-nine? If you think heads of lettuce are much too similar for any chance of success, consider just how different they really are in size, shape, rottenness, the exact pattern of the outer leaves—there is more visual variety in a hundred heads of lettuce than in a hundred faces. But we can recognize faces, even thousands of them, with so little effort that we take the skill for granted. We almost certainly owe our astonishing ability to the presence of a dedicated population of face cells whose job it is to perform this task.

It is less obvious why monkeys and humans need hand cells. One possibility is that hand cells have a similar social importance. We certainly look at each other's hands in order to judge each other's gestures and intentions. It may also be that we primates spend so much time manipulating objects, looking at our own hands, that our visual systems have become hand experts simply through overexposure.

Biological motion

After discovering hand and face cells, Gross and colleagues began to study an area of the cortex next to TE that they named STP. (The name stands for the Superior Temporal Polysensory area, referring to its location in the brain and its properties. It is shown on Diagram 6-3.) Here, they found a bewildering range of cells. Some were face cells, just as in TE. Some were sensitive to motion, especially to the motion of an object looming at the monkey, invading its personal space. Some cells were sensitive to touch on the monkey's fur, or to sounds nearby in the room. STP was definitely not exclusively visual.

Among the strange cells they found in STP, one type of neuron became active when the monkey looked at a person walking. The cells were sensitive to "biological motion." They were prowl cells. A person wheeled past on a cart was no good; nor was a person walking in a baggy gown. A specific biological motion of limbs triggered this type of neuron. Other biological motion cells seemed to be sensitive to other kinds of limb movements.

Our ability to recognize biological motion is another example of an overlooked skill. We are so good at it, and it comes so automatically, that we take it for granted. But we are good at it because, like monkeys, we have an elaborate brain mechanism dedicated to the task. The importance of biological motion was demonstrated particularly beautifully by Johansson. He fixed small lights on the limbs and bodies of dancers, put the dancers in a dark room, and filmed them walking, running, dancing, riding bicycles, and so on. He then showed the films to other people. The result was sensational. There is something about the biological prowl of human limbs that we instantly recognize. On the basis of a few points of light wiggling around a screen, any normal person can say, "That's easy, that's a person running," or, "That's a person riding a bicycle," or even, "That's two people dancing, swirling around each other." But if the film is played upside down, the response is likely to be, "That's a bunch of lights jiggling randomly." Our detectors for biological motion are evidently so expert that a few points of light, moving in the right way, evokes in our minds an instantaneous perception of a body. The gestures, the intent, the meaning of the movements all appear obvious.

One can guess that this machinery evolved early and is probably shared by a great range of species. For example, an antelope sees a lion. By the exact prowl of the lion's limb, by its body language, the antelope can sense whether the lion is hunting or just passing by. Even in this simple example, the antelope is computing something about the inner state of the lion in order to predict its behavior. Perceiving biological motion is fundamentally about constructing a perceptual model of another intentional agent.

Another socially relevant type of neuron in area STP, the gaze neuron, was discovered by Perrett and his colleagues. (Perrett is known to give scientific lectures while wearing neon hair and a superhero outfit.) Gaze cells are sensitive to the direction of someone else's gaze. If you show a picture of a pair of eyes to a monkey, the gaze neurons will become active depending on whether those eyes are looking to the right or left. Some gaze neurons signal one direction of gaze, some signal another direction. Monitoring someone else's gaze is at the heart of social perception. It allows us to guess at whether someone is listening to us, noticing us, attending to that other person or that passing car, aware of this or that object. If the eyes are the windows to the soul, then a neuronal machine for monitoring gaze direction goes a long way toward computing a model of someone else's soul.

Some of the other properties of STP, less thoroughly studied, may also play into the same story of social perception. For example, many neurons in STP respond to an object looming in toward the body, invading the monkey's personal space. Nothing works so well to activate these cells as a person looming toward the monkey's face.

Personal space plays a large role in the social behavior of monkeys and humans. In the 1950s, Hediger, a naturalist and zoo curator, studied personal space by observing the behavior of a range of animal species. In the 1960s, Hall extended the work to human interaction. Hall observed that humans are exquisitely sensitive to interpersonal spacing. We maintain a margin of safety around us (the size of a comfortable margin of safety varies from culture to culture) and we judge other people's mood and aggression partly by how they respect or violate that margin of safety. The looming-sensitive neurons discovered in STP could plausibly be part of the underlying mechanism for assessing personal space.

The brain's special sensitivity to objects looming into personal space may seem like an esoteric topic—I suppose it is—but I have a special interest in it, having published half a dozen technical reports on it. The brain contains several areas, cortical and subcortical, that seem to play a role in detecting looming stimuli and in controlling defensive behavior such as ducking and flinching. Some of these areas are probably part of basic, essential reflex loops meant to protect the body. I have always thought, however, that the looming-sensitive neurons in STP must play a special role in social interaction. They seem to be especially sensitive to the movement and location of people and animals rather than of inanimate objects.

Faces, gestures, limb movements, the direction of someone else's gaze, the looming of nearby bodies—all of these form the raw material for social perception. At some point in the evolution of the brain, the streams for analyzing object motion, object shape, and object location must have fused at the highest level and formed area STP, a specialist in social signals. The particular neuron types that have been discovered so far are presumably only the most obvious, the most easily demonstrated in a monkey. The presumption is that STP must be chock-full of neurons that process the subtleties of social perception.

Social perception and social cognition

Monkeys and humans are both experts at social perception, and both have the brain area STP that seems to perform some of the necessary computations. (In humans, the cortical area is sometimes called STS. I will call it STP for consistency.) Humans, however, are much better than monkeys at social cognition. Does STP perform social cognition in humans?

I described social cognition in Chapter 2. A particularly clear example of social cognition is the theory-of-mind task. In that task, you are told a story and asked a question. Sally puts a sandwich in the refrigerator; when she's not looking, Anne hides it in the freezer; where will Sally look for her sandwich? To answer the question, you must use some basic social cognition. You must analyze the events from Sally's point of view. As far as she knows, the sandwich is still in the refrigerator, and therefore that is where she will look. Solving this task requires some theorizing about the inside of Sally's mind.

When a person is placed in a brain scanner and asked to solve the theory-of-mind task, area STP and some surrounding cortical areas show an elevated activity. In humans, therefore, STP is not solely involved in basic social perception, but is also involved in more complex tasks of social cognition. A possible network of areas involved in social perception and cognition is currently being explored. This network includes STP, a nearby cortical area called TPJ, an area in the front of the brain called the medial prefrontal cortex, and several subcortical structures. Whether these areas are exclusively dedicated to social cognition, or serve a range of other functions, is not yet clear.

Are these areas, that are involved in social intelligence, also important in creating our own conscious awareness? The following sections describe several hints that this efficiency of function may be the case. The social circuitry—the mechanism that constructs models of other people's minds, of other people's awareness and intentions—may indeed double as the circuitry that constructs our own personal perceptions of awareness and intent. This circuitry may lie at the heart of human consciousness.

Conscious and non-conscious vision

Of all the visual signals that flow through the enormously complex cortical visual system, we are consciously aware of some signals and not others. We are generally conscious of object shape, object motion, and object location. But we are peculiarly unaware of the processing in the action stream. If someone throws a rock at you, for example, you duck reflexively long before you are aware of the rock.

The view that the action stream is nonconscious, whereas the other visual streams feed into consciousness, was first suggested by Goodale in the 1990s. He studied people who had damage to the visual cortex caused by strokes, carbon monoxide poisoning, or other accidents. (Part of the study of the brain, unfortunately, is a somewhat grim search for people with disabilities.) One patient had no conscious awareness of the shape of objects. She could not report whether an object was a square, a circle, or an oblong, even when it was directly in front of her and she was looking at it. But when asked to reach out and pick up the object, her hand correctly shaped to grasp the object. Her action stream "knew" about the object's shape, and used that knowledge to put her fingers in the right positions as her hand approached the object, but that information was not available for conscious report.

The pattern of results found by Goodale suggests that the action stream can function independently of consciousness. Any consciousness circuitry, if such a thing exists, receives signals flowing out of the lower streams but evidently not as much out of the action stream. This finding could be said to be the first clue, the initial hint that the social regions of the brain may be important in conscious awareness. Area STP is unique in the lower streams in that it receives and combines signals from all of them.

The mirroring, the use of my motor system to mentally imitate, is a tool that is used to help enrich and refine my understanding of John's action.

Like a spider at the center of a web, the core circuitry for social perception (perhaps mainly STP, perhaps including other brain areas) generates hypotheses and sends pings to the rest of the brain—to the motor brain, to the memory brain, to the emotional brain, to the vocal brain—receives feedback, asks whether this or that computed property makes sense, receives confirmation, asks for further details, probes for consistency, tests for resonance, and in this way builds a rich model of the other person's mental state. We use the idiosyncrasies of our own brains to construct a model of another mind.

If this is the correct general description of how the brain constructs a model of another mind, then perhaps it explains why we tend to perceive other people through the filter of our own selves. We judge other people to have the same motivations and foibles. A trustworthy person tends to trust others because, in building models of other people's minds, he relies on the quirks of his own mind. An untrustworthy person tends to suspect that everyone is cheating him. A happy person assumes that other people are happy. A person with a grotesque sense of humor assumes, annoyingly, that everyone else shares the same sense of humor. The same mechanism might explain why angry people, in their religious moments, when their perceptual machinery constructs a model of God's mind, tend to perceive God to be a force of furious punishment, and generous people perceive God to be a source of generosity and love. Certainly the Hellenic Greeks saw their gods as mirrors of their own human foibles, appetites, and decencies. In the mirror hypothesis, the minds that we perceive around us are constructed out of the raw materials of our own brains.

Advertisers bow to the amygdala, although they may not know it by name. The image of an attractive, scantily clad woman prods the sex nucleus in the hypothalamus. Photograph her holding a beer, and show the picture to a man a few times, and soon his amygdala learns a new link. When he thinks about beer, or sees a beer, he feels just a little bit sexy. The connection from his cortex (which processes the image and the thought of beer) to his hypothalamus sex nucleus is burned straight through his amygdala. That slight sexy tinge of feeling he has in reaction to beer has nothing to do with rational thought. He may not even remember seeing the ad. No matter; it still has its effect.

We tend to think that our convictions are absolute. We look inside of ourselves, examine the tendrils in the amygdala that have grown up organically as a result of our particular training history, and we think that we have found access to universal truth.

For example, a fundamentalist might hold in his cortex for a moment the thought of homosexuality. A link in his amygdala activates the anger and disgust and dread centers in his hypothalamus. These centers send output widely around the brain and body, the heart, the gut, the skin, and his cortical mechanisms for perception receive that emotional signal. He says, “Homosexuality is wrong. I know it, I am convinced of it, because I feel it in my heart, in my gut. I sense it to be true.” But what he feels is not a universal truth. His brain has no access to a repository of celestial truths. He is experiencing the consequence of a learned connection in his amygdala. Although he may invent rationalizations after the fact, intellectual reasons to support his moral conviction, the reasons are peripheral. At the center of his belief is a *perception* that homosexuality is wrong and disgusting. He perceives the emotional consequence of his amygdala tapping his hypothalamus.

Someone else, with a different training history and therefore a different set of connections through the amygdala, arrives at quite the opposite moral conviction and is convinced of the principle of equal rights.

My point here is not whether one or the other conviction is more constructive (my sympathies are decidedly with the egalitarian point of view), but that neither side represents a fundamental moral truth of the universe. There are no fundamental moral truths of the universe. Morality is not defined outside of us; it is a physiological construct of the brain.

The brain basis of morality is an emerging area of study. Scientists such as Green and Cohen have begun to pioneer the topic. At its core is the realization that when we plumb inwardly for moral truth, we follow a specific process of firing up thought X and assessing its emotional tinge. We may say to ourselves, “On deep reflection, I realize that X is wrong,” or, “X is right.” But the inner reflection does not reveal anything about a moral framework of the universe. Instead, the inner reflection is a way of assessing our own quirky, culturally and personally learned emotional associations.

The trainability of the amygdala was originally studied in rats. For example, as Ledoux showed, it is possible to train a rat to fear a red light by shocking the rat’s foot every time the light turns on. If the rat’s amygdala is then damaged, the link disappears and the rat no longer fears the light. Therefore the link between perceiving a red light and experiencing fear runs through the amygdala. If your foot were shocked every time a light turned on, your amygdala would learn the same connection. To some extent you train up your amygdala in this way, through life’s various metaphorical foot shocks and reward pellets.

The most useful property of the amygdala, however, is not that it can be trained by reward and punishment, but that it can learn through socialization. We believe what the people around us believe. We believe what we are taught. Above all, *we believe what we see others believing* . This tendency for beliefs to spread by social imitation is the topic of the final chapter.

subdivide cultural beliefs into units? To some extent the same difficulty exists with genes—the dividing line between genes can be poorly defined—but the confusion is less, and genes at least come in definite atomistic units, the base pairs of the DNA molecule. For these reasons, genetic evolution is easier to understand and to describe mathematically. Furthermore, gene mutations are thought to be essentially random, accumulating through generations at a steady rate, whereas the process by which memes mutate is not well defined. Indeed intelligent design is actually present in the case of meme evolution. A person can sit down, think hard, intelligently design a meme, and then send it out into the culture. The mixture of accident, random variation, intelligent design, and perhaps sometimes not-so-intelligent design, gives the process of meme evolution a confusing complexity. Yet even though the ground rules are modified and greatly diversified in the case of memes, the fundamental principles of Darwinian evolution are still present. Memes that are better at replicating, at spreading from person to person, outcompete the weaker memes. The hypothesis of cultural evolution by meme is almost certainly valid in principle.

The ideas discussed in this book provide a psychological and neuroscientific basis for the idea of meme evolution. The root cause is social perception. The method is imitation. The consequence is the spread of memes from person to person.

Religion

In previous chapters I discussed the spirit world including God, soul, ghosts, and angels, and suggested that these things are perceptions of mind. Yet for all the discussion of gods and ghosts I have not talked much about religion. Religion is a cultural phenomenon that is much larger than a belief in a soul or a deity. In this final section I would like to add a few brief speculations about religion as a cultural phenomenon.

I grew up as an atheist believing in the brain rather than the immortal soul. Like almost all people taken by a particular belief system, I harbored contempt and fear toward competing belief systems. I was hostile to religion just as the religious are often hostile toward each other and toward scientific atheism. We are all humans alike, I guess. It has taken me many years to grow away from that harsh position, and I think my opinions are still in the process of changing.

What I find most surprising is that I lost my negativity toward religion by insisting that I take an intellectually rigorous and scientific perspective. Religion is something complex and marvelous that people do. As a naturalist, I should be delighted to think about it and study it. I don't mean studying it for the purpose of reducing it and dismissing it. I mean studying it with a certain degree of respect, as one might study the incredible complexity of whale society, or the richness of the chemistry inside a cell. To gain some scientific understanding of religion does not explain it away or trivialize it. The analytical perspective hopefully can open a sliver of a window on who we are and how we got to be so, well, human.

I know that atheism is not palatable to many people. Some share my point of view and some do not. The ideas described below, however, stand whether or not one believes in a god. Through these ideas I attempt to come to an understanding of human religion from the point of view of social imitation and memes. It seems to me that both believers and atheistic scientists should find the speculations sensible. Whether you inhabit religion from the inside, or view it from a cultural distance, surely it is clear in either case that religion is something that changes through time, that the parts of religion that work well tend to spread, and that the parts that work poorly tend to die out.

Why do the religious believe so strongly in the importance of preaching to the masses and proselytizing people? Because this belief is intrinsically good at propagating itself. Religions that don't include this conviction don't spread. They are out-competed. This belief is, biologically speaking, the replication drive.

Why do so many people believe that religious doctrine is sacred and must never be changed? Because this belief is intrinsically good at protecting itself from change. Religions that include this belief are good at maintaining themselves. This is why all religions are protective of their doctrines. They are conservative. If they weren't, they'd die out.

Why do religions promote community? Because religions that help the community offer benefits to people, and benefits help to gain recruits and keep followers.

Belief after belief, each component of a religion is ultimately present for one historical reason; the religion was better able to spread and survive because of it. Darwinian evolution selected for those traits.

Each new person who enters into a religion, whether from the outside or born into it, contains a unique understanding of the religion. These variations among people are inevitable. Of these millions of variant beliefs, across millions of people, some are better able to spread to new recruits than others, and the more successful variants become dominant. As a result, over years, over millennia, a religion becomes honed, shifting, changing, until it is well adapted to survive. A religion is good at spreading, at protecting itself, and at fending off other religions, at cozying up to the quirks of human psychology, at tapping human emotion, because any variant of the religion that is weak in those respects is soon out-competed and dies off. New religious flavors, new interpretations, new splinter groups are constantly being formed, remain for a while, and fade away or take over, as they are worse or better at their own spread and survival.

A religion can be thought of as an organized bundle of convictions, replicating from person to person in competition with other religions. It is a life form that grows in the Petri dish of human culture. This idea that religions are meme structures, and that the evolutionary pressure on them pushes them toward their own benefit and not ours, was proposed by Dawkins (*The Selfish Gene*) and elaborated by other philosophers of memes including Blackmore (*The Meme Machine*) and Lynch (*Thought Contagion*).

This situation with religion is arguably an example of a Nash equilibrium, an equilibrium between two interacting entities that have goals that are not quite identical. In this case the two entities are the religion itself and the people who comprise it. Religion can never be truly 100% in the service of the people, because the evolutionary pressure on religion is ultimately to promote itself.

One could even plausibly argue that conservative and liberal religions, or conservative and liberal groups within a religion, represent two distinct but stable mathematical solutions to the Nash equilibrium problem. A conservative religion is more stick than carrot. It has settled on a relatively draconian punishment attitude toward deviance from the core beliefs, thereby protecting itself from dilution. As a down-side, the draconian attitude risks making the religion alienating and unwelcoming, thereby impeding its spread to new recruits. In compromising among the various factors, it has found an equilibrium that places relatively more emphasis on protecting the ideology and relatively less emphasis on the needs of the constituents. It emphasizes both, but one more than the other.

A liberal religion is more carrot than stick. It has settled on a relatively lenient attitude toward variants of the core beliefs, thereby allowing itself to be welcoming to a greater diversity of people. It is better at pulling in recruits. As a down-side, the liberal religion risks dilution of its core beliefs and therefore its own extinction. It has found an equilibrium that places relatively more emphasis on furthering the needs of the constituents and relatively less emphasis on protecting the ideology.

These two strategies, or efficacious compromises, could be understood as distinct, stable solutions to the Nash equilibrium. Just as a guitar string can vibrate at different stable frequencies, so the religious culture might vibrate in different equilibrium states—conservative and liberal. (Conservative and liberal politics, at least in the United States, seem to be mainly carried over from conservative and liberal religious beliefs.)

As an atheist, I guess I am supposed to be anti-religious. Some commentators favor the complete eradication of religion, any religion, all of them, whatever the particular story of creation, or the particular name given to a deity or deities, or the particular set of rituals involved. The most common argument for exterminating religion is that it promotes brutality and intolerance. In startling contradiction, one of the most common arguments for spreading religion is that it promotes moral behavior. I find this question extremely interesting. Should we, as a rational scientific society in the information age, work to eliminate superstition and religion, or work to spread it further? Let the culture wars rage.

To be honest, I am not sure that religiosity is statistically correlated with brutality or decency. I tend to think that people are brutal and decent, selfish and incredibly generous, whatever level of religiosity they may practice. Yes, wars have been fought in the name of religion, but the Soviet Union also did a good job of violent mayhem with an atheistic premise. I remain utterly unconvinced by either argument. I am a scientist and to me the controlled experiments have never been done and the data do not support either contention. As far as I can tell, religion neither causes nor prevents violence, though it tends to come along for the ride either way, and may tend to intensify the emotions. There certainly are examples of religious splinter groups that advocate violence and those that advocate peace.

My main problem with the view that a rational society should eliminate religion, however, has nothing to do with the dangers or merits of religions. I simply think that eradicating religion is not possible. It is a fallacy that ignores the specs of the human machine. We are not rational entities. Religion, like all culture, grows on the social machinery in our brains. To function socially, we must understand each other's minds; therefore we are built to mirror each other's mind states; therefore beliefs and customs spread by imitation from person to person; therefore a cultural competition among beliefs emerges; therefore belief systems evolve to be especially good at promoting themselves. Therefore religion. For that matter, therefore politics. Therefore entertainment. Therefore business. Therefore all of human culture. If religion is profoundly irrational, so is the rest of human culture. Culture is by nature a complicated, bizarre, irrational, fantastic, addictive pleasure, sometimes brutal, sometimes incredibly generous. People being who we are, masters of inconsistency, we are able to be irrational and at the same time intellectually aware of it. We can study the human mind from a scientific point of view and come to a logical understanding of its intrinsically bizarre illogic. To me, that contradiction is one of the most marvelous properties that we humans possess.