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Swappable minds

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Consider the following oddities: a chicken with a piece of quail brain moves like a quail but sounds like a chicken; a 70-year old man with Parkinson's, confined to his wheel chair, receives a piece of brain from a pig, and in no time at all is out golfing, without a hint of his porcine accessory. This is not science fiction, á la Douglas Adams. This is scientific fact. Today, we can swap brain tissue among individuals of the same species, as well as between species. And such exquisite neurobiology is revolutionizing our understanding of the brain, including how it changes during evolution and is wired up in development. As we learn more and more about the brain, we ultimately learn more about what it's like to be another animal. But the consequences and directions of this revolution are only just being contemplated. This essay grapples with the scientific excitement and ethical concerns.

To understand how minds work, we need to understand what they have been designed for. To understand what they have been designed for, we need to understand the historical patterns of selection. To understand the historical patterns of selection, we need to understand the kinds of problems individuals confront in their attempt to survive and reproduce. And to understand the kinds of problems confronted, we need to study individual minds under natural conditions, and preferably, the habitat in which they evolved. Consider two mammals who are relatively unique in being largely hairless and exceptionally good cooperators: naked mole rats and humans. For a naked mole rat, the natural habitat is an underground metro, a series of interconnected thoroughfares with a palatial room for the enormous queen and her minions. For humans, the natural habitat is the savannah, a broad swath of earth, dotted with acacia trees, lions, gazelles, and of course, other humans. Unlike the naked mole rat, whose cooperative society is founded almost entirely on high degrees of genetic relatedness, cooperation among humans is based on both genetic kinship as well as a set of norms, emotions, beliefs, and expectations. Like the naked mole rat, humans cooperate because it generally pays greater dividends in the economy of survival and reproduction than does selfish behavior. By studying naked mole rats and humans, as well as a variety of other cooperative species, we shed light on the kinds of minds that are capable of cooperation.

So, what is it like then to be another organism? This question, formally articulated by the philosopher Thomas Nagel in his famous paper "What is it like to be a bat?", is generally about the mental lives of animals, and specifically about their subjective experiences ¾ their feelings. For some, this is an impenetrable problem, at least with respect to current scientific tools. For others, it is a difficult problem, but one within reach of science. Since it is easier to talk about such issues if there is an example on the table, let me serve one.

In the mid-1960s, two groups began experiments on rhesus monkeys designed to explore how individuals respond to seeing another receive shock. At about the same time, the social psychologist Stanley Milgram began experiments designed to explore how people respond to authority, and in particular whether they will obey an authority figure who instructs them to shock another human being. In one of the rhesus experiments, an individual was trained to pull levers to obtain its daily bread, a ration of food. Having learned this task, a second rhesus monkey was introduced into the adjacent cage. Now, when the monkey in control of the levers pulled, he delivered a severe shock to the other monkey. Surprisingly, not only did the first monkey stop pulling, but he did so for several days. By not operating the levers, he forfeited his daily ration of food. He was starving, but the guy next door benefited by avoiding shock. Monkeys in control of the levers were more likely to abstain from pulling if the other monkey was a familiar cagemate, than if he or she was an unfamiliar individual or a member of another species, such as a rabbit. Lastly, individuals withheld longer if they themselves had been in the hot seat, experiencing shock delivered by another actor, than if they lacked such experience.

The rhesus monkey experiments are particularly striking in light of Milgram's diametrically opposite results with humans. When an authority figure such as an experimenter in a white lab coat tells a subject to pull a lever to shock another human, the subject readily does so, even though the actor reacts dramatically to the "shock". If a Martian descended to earth to watch these two experiments, he would be forced to conclude that rhesus monkeys empathize while humans do not. Rhesus appear to know what it is like to be another in pain, while humans either do not or simply do not care. Of course we know that humans *CAN* care and *CAN* empathize with others, consciously thinking about what it's like for someone else to have an emotional experience. When we read George Eliot's poignant novel "Adam Bede", we can readily feel what Adam feels when he sees Hetty. The following passage should do the trick:

> *That blush made [Adam's] heart beat with a new happiness. Hetty had never blushed at seeing him before. 'I frightened you,' he said, with a delicious sense that it didn't signify what he said, since Hetty seemed to feel as much as he did…'*

It is tempting to conclude that rhesus monkeys empathize and care about the well being of others. The experiments described seem to support this point. But there are alternative interpretations. Perhaps the lever-pulling actors simply find the recipient's response to shock aversive; when things are aversive, individuals stop what they are doing. Perhaps the lever-pulling actors were concerned about retribution, that one day they might be in the hot seat with a less than benevolent actor. If so, then abstaining from pulling is not mediated by empathy, but by selfishness. Regardless of which account is correct, these experiments point to a particularly keen sensitivity to social context, that animals have emotions and goals, and can act on them. We can use such information to motivate the connection between studies of animal minds and animal welfare.

How might we find out about an animal's needs, desires, and goals, important dimensions if we are to provide proper care for them? If only Dr. Dolittle were non-fiction and we could talk to the animals. There is, however, a fairly good substitute. It starts with careful observations of species-typical behavior, and then borrows the tools of economics to ask what an individual will pay to obtain what it wants. Consider a recent study of farm-raised mink.

Farmers think that mink live in satisfactory conditions. What satisfactory means is something like: *has all of the essential commodities for living a healthy life*. Those who disagree with this view of mink life question the idea that "healthy" *means sufficient food and water, and no noticeable signs of ill-health.* Arm-chair theorizing won't help this debate, but a crisp experiment will. Georgia Mason and her colleagues set up mink in individual cages, mimicking the conditions of mink farms: one nest box, drinking water, and food. Based on the assumption that all animals are pleasure-seekers, designed to obtain good things and avoid bad, each mink was offered a choice between seven alternative compartments, each associated with some unique property: a water-filled pool, a raised platform, novel objects, a second nest site, a tunnel, toys, and extra space. To access these compartments, the mink pushed open a door; on consecutive days, weights were attached to the door, making it increasingly difficult to open. The experiment therefore simulated a closed economy whereby individuals were required to pay for what they wanted. The key intuition underlying these experiments is that animals might pay more for things that they not only want, but crucially, things that they need.

When the mink were released from their home cage, they consistently chose the compartment with the water pool, spent the most time in this compartment, and paid the greatest costs to do so. Moreover, when a stress hormone known as cortisol was measured, levels were highest when mink were deprived of food and equally high when deprived of the water pool. What do mink want? Water pools. Why? Because in their natural habitat, they spend a considerable amount of time in the water, swimming and hunting for aquatic prey. Bottom line: mink farmers should spend the pittance it costs to buy small water pools to provide mink with a "healthy life." Mink without water pools are stressed as much as food deprived mink. And since no humane farmer would ever think of food depriving them, why deprive them of a water pool? It simply makes no economic or ethical sense.

The rhesus monkey and mink experiments demonstrate how science can uncover what animals feel and want, and how such knowledge can be put to good practical use. But the techniques described are quite crude, especially given recent developments in genetics and the brain sciences. With the capacity to insert or delete genes into an animal's genome, as well as to remove or replace pieces of brain, the range of possible questions is vast. So is the range of potentially charged ethical dilemmas. To illustrate, consider the recent creation of smart or "Doogie" mice, after the precocious young sitcom star Doogie Howser. These mice were genetically engineered by inserting extra copies of a gene called NR2B which plays an important role in memory formation. Mice with the extra genes were purported to be smarter than controls because they more rapidly learned to discriminate objects, acquire a fear response to an aversive stimulus, and to find a concealed ramp. Whether these abilities constitute the stuff of intelligence is certainly debatable. The results nonetheless show a difference in performance that appears to be mediated by the gene manipulation. For those interested in the genetics of higher cognitive functioning, such results are quite stunning. They not only reveal the power of this technological advance, but showcase the kinds of genetic engineering that might be used for applied purposes, especially the treatment of human medical disorders. For example, by changing the number of memory-related receptors, one could theoretically reverse the devastating memory losses of Alzheimer's patients. But the excitement associated with the findings on Doogie mice must be tempered by the results of another experiment that reveal the potential dangers of both gene and brain manipulations.

Two years after the scientific community was introduced to Doogie mice, they were presented with an unanticipated byproduct of, well, being smart. This byproduct is best captured by the mantra of athletes and dieters alike: "No gain without pain." Unlike their normal counterparts, Doogie mice have an increased awareness of acute pain for longer periods of time. This result has significant ramifications. Practically, and as the geneticist Richard Lewontin has pointed out in his critique of the Human Genome Project, we must avoid drawing naïve conclusions about the causal relationship between genes and behavior (ditto for the relationship between specific parts of the brain and specific mental functions), failing to appreciate the complex genomic and environmental contexts in which genes live. It's a genetic jungle out there, and when one gene is removed, another replaced or duplicated, we can only make educated (statistical) guesses about the kinds of consequences it will have. The implication of this criticism is not that genetic or brain manipulations are worthless. On the contrary, such technologies are likely to open up a landscape of novel discoveries and insights. Along with such findings, however, we must be prepared to uncover unpredicted complications and difficulties, some of which will certainly carry significant moral weight. It is thus important to recognize that for science to profit from the creative energy of its contributors, the intellectual climate must support radical and even risky explorations. But scientists must also realize the potential ethical consequences of their actions, and this includes studies of nonhuman animals. As George Bernard Shaw mused in *Major Barbara*, the secret of right and wrong "has puzzled all the philosophers, baffled all the lawyers, muddled all the men of business, and ruined most of the artists." He could have added scientists, who must continue to struggle with the distinction between the *is* of their results, and the *ought* of their conclusions.

I frequently ask my students to imagine the following thought experiment: If you had the opportunity to undergo a reversible brain transplant (reversible because you can get the original parts back with no deficit), accepting some specific part of a willing animal donor, which part would you pick and from which species? Over the years, my students have placed the following three at the top of their lists: the olfactory bulb of a dog, the auditory cortex of a bat, and the visual circuits of an eagle. This thought experiment is, however, equipped with a subtle trap. Although technology would enable the insertion of these cortical regions, something else would be needed to truly smell like a dog, hear like a bat, and see like an eagle. That something else is an interpretive system along with the peripheral organs, the wonderful snout of a dog, the radar-dish ears of a bat, and the double fovea of an eagle's eyes. With a newly outfitted canine olfactory system, a human would detect the millimoles of urine on the hydrant at 100 meters, but would interpret the odour as a human does. It would probably smell horrid because of its intensity, a pungency that no human had ever experienced before.

I want to emphasize (belabour) the importance of this interpretive problem because it is so often confused. A philosophical paradox and a horror film should help clarify the point. In logic, there is a theory of identity which states that for any two objects X and Y with multiple parts, X = Y if every part of X is a part of Y, and every part of Y is a part of X. The classic challenge to this notion of identity is the case of Theseus and his ship of Athenian sailors. When the ship sets sail, it is new. With time and wear and tear, the sailors replace the damaged planks with new ones. By the end of the voyage, all of the original planks have been replaced. The paradox: Is the ship that ends the voyage the same as the one that started the voyage? Is it still the Ship of Theseus? Before answering, consider Roman Polanski's movie "The Tenant", starring Polanski as Trelkovsky, a meek file clerk living in a Paris apartment. The previous tenant had attempted suicide and this launches Trelkovsky into a state of delusional paranoia that leads to a rhetorical monologue involving the elements of the self: "If I cut off my arm, I say 'me and my arm', but if I cut off my head do I say 'me and my head' or 'me and my body?" These two cases make the interpretive problem transparent. If we remove someone's olfactory system, and replace it with a dog's or even another human's, we haven't changed this person's identity. We have presumably changed how they smell, especially when the swap involves a dog. But the human receiving this new circuit still places his or her own interpretive spin on the smell. When it comes to other brain parts, we must ask about the identity question on a case by case level. As Damasio has articulated in his recent work on consciousness, different parts of the brain have different effects on the feeling of what happens to the self. Thus, some swappable parts are likely to have dramatic changes on identity, as the case of Phineas Gage makes clear ¾ damage to frontal lobe circuitry transformed Gage into an unrecognisable individual, someone lacking in all moral judgment.

To take the swappable minds problem further, imagine another thought experiment, one that builds on some spectacular new results from the world of neuroscience. Miguel Nicolelis and his colleagues have managed to record the electrical discharges of hundreds of neurons from an owl monkey's brain and use the signal to drive a robot's arm. This may sound like pure gadgetry, but it is not. It shows that at some level we can make sense of the neural code and use it to predict behavior. Now imagine that we could download the signals from any animal, creating a kind of hard drive library of their thoughts while they were interacting with the world. We would be able to *read* the mind of an animal as it eats, sleeps, grooms, has sex, and communicates. At some level we would have a deeper sense of what it's like to be them. We would be a Peeping-*Homo sapiens*. We might even be able to match our own brain waves with theirs, and experience a kind of inter-species harmony that had never been achieved before. This is clearly the ultimate in virtual reality games.

These are wonderful *Gedanken* experiments. One day, the necessary technology will be available, though no one may choose to use it in such a fanciful way. The excitement lies in thinking about how much we will learn about the brain, both our own and those of other thinking creatures. The concern is that our technology is launching us into unchartered worlds, with unexpected findings and fuzzy moral consequences.

Suggested Readings

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