The Consequences of Fully Understanding the Brain

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We start with questions:

- How does memory work?
- How does learning work?
- How does recognition work?
- What is knowledge?
- What is language?
- How does emotion work?
- What is thought?

In short: How does the brain work?

We have nothing better than vague, approximate answers to any of these questions at the present time, but we have good reason to believe that they all have detailed, specific, scientific answers, and that we are capable of discovering and understanding them.

We want the questions answered in full detail -- at the molecular level, at the protein level, at the cellular level, and at the whole-organism level. A complete answer must necessarily include an understanding of the developmental processes that build the brain and body. A complete answer amounts to a wiring diagram of the brain, with a detailed functional understanding of how the components work at every level, from whole brain down to ion channels in cell walls. These are questions of cognitive science, but to get detailed, satisfying, hard answers, we need the tools of information technology, biochemistry, and nanotechnology.

How important would it be if we did achieve full understanding of the brain? What could we do that we can't do now? How would it make our lives better? Unfortunately, scientific advances don't always improve the quality of life. Nevertheless, let's go ahead and look at some possibilities opened up by a full understanding of how the brain works.

New Capabilities Enabled by Full Understanding of the Brain

We understand the input systems to the brain -- the sensory systems -- better than the rest of the brain at this time. Therefore, we start with ways of fooling the senses via electronic media that can be done now, with our present understanding of the senses.

A. Virtual Presence. The telephone, a familiar tool for all of us, enables auditory-only virtual presence. In effect, your ears and mouth are projected to a distant location (where someone else's ears and mouth are), and you have a conversation *as if you were both in the same place*. Visual and haptic (touch) telepresence are harder to do, but nevertheless it will soon be possible to electronically project oneself to other physical locations, and have the perceptions you would have if you were actually there -- visually, haptically, and aurally -- with near-perfect fidelity. Some tasks that could be accomplished with virtual presence are:
1. Meeting with one or more other people. This will be an alternative to business travel, but will take the time of a telephone call, rather than the time of a cross-country plan flight.

2. Interacting with physical objects in the distant location. Perhaps it is a hazardous environment, such as a nuclear power plant interior or battlefield, where actual human presence is impossible or undesirable.
3. Interacting with objects in microscopic environments, such as the interior of a human body. (I have worked on a prototype system for doing this, the NanoManipulator. See http://www.WarrenRobinett.com/nano/)

B. Better Senses. Non-invasive, removable sensory enhancements (eyeglasses) are used now, and are a first step. Eyeglasses and contact lenses are very useful, but why not go the second step and surgically correct the eyeball? Even better, replace the eyeball. As with artificial hips and artificial hearts, people are happy to get a new, better component; artificial sensory organs will follow. We can look at binoculars , night-vision goggles, and Geiger counters (all currently external to the body) to get an idea of what is possible: better resolution, better sensitivity, and the ability to see phenomena (such as radioactivity) which are imperceptible to unaugmented humans. Electronic technology can be expected to provide artificial sensory organs which are small, lightweight, and self-powered. An understanding of the sensory systems and neural channels will enable, for example, hooking up the new high-resolution electronic eyeball to the optic nerve. By the time we have a full understanding of all human sensory systems, it is likely we will have a means of performing the necessary micro-surgery to link electronic signals to nerves.

C. Better Memory. What is the storage mechanism for human memory? What is its architecture? What is the data structure for human memory? Where are the bits? What is the capacity of the human memory system in gigabytes (or petabytes)? Once we have answers to questions such as these, we can design additional memory units which are compatible with the architecture of human memory. A detailed understanding of how human memory works, where the bits are stored, and how it is wired will enable the capacity to be increased, just as you now plug additional memory cards into your PC. For installation, a means of doing micro-surgery is required, as discussed above. If your brain comes with 20 petabytes factory-installed, wouldn't 200 petabytes be better?

Another way of thinking about technologically-enhanced memory is to imagine that, for your entire life, you have worn a pair of eyeglasses with built-in, lightweight, high-resolution video cameras which have continuously transmitted to a tape library somewhere, so that every hour of everything you have ever seen (or heard) is recorded on one of the tapes. The one-hour tapes (10,000 or so for every year of your life) are arranged chronologically on shelves. So your fuzzy, vague memory of past events is enhanced with the ability to replay the tape for any hour and date you choose. Your native memory is augmented by the ability to re-experiencing a recorded past. Assuming nanotechnologically-based memory densities in a few decades (1 bit per 300 nm^3), a lifetime (3×10^9 seconds) of video (10^9 bits/second) fits into 1 cubic centimeter. Thus, someday you may carry with you a lifetime of perfect, unfading memories.

D. Better Imagination. The purpose of imagination is to be able to predict what will happen or what might happen in certain situations, in order to make decisions about what to do. But human imagination is very limited in the complexity it can handle. This inside-the-head ability to simulate the future has served us very well up to now, but we now have computer-based simulation tools that far outstrip the brain's ability to predict what can happen (at least in certain well-defined situations). Consider learning how to handle engine flame-outs in a flight simulator -- you can't do this with unaugmented human imagination. Consider predicting tomorrow's weather based on data from a continent-wide network of sensors and a weather simulation program -- this is far beyond the amount of data and detail that human imagination can handle. Yet it is still the same kind of thing: predicting what might happen in certain circumstances. Thus, our native imagination may be augmented by the ability to experience a simulated future. At present, you can dissociate yourself from the flight simulator -- you can get out. In future decades, with peta-FLOP computing power available in cubic micron-sized packages, we may find personal simulation capability built-in, along with memory enhancement and improved sensory organs.

Now The Really Crazy Ones

E. Download Yourself into New Hardware. Imagine that the brain is fully understood, and therefore the mechanisms and data structures for knowledge, personality, character traits, habits, and so on are known. Imagine further that, for an individual person, the data describing that person's knowledge, personality, etc. could be extracted from his brain. In that case, his mind could be "run" on different hardware, just as old video games are today run in emulation on faster processors. This of course raises lots of questions. What is it that makes you you? (Is it more than your knowledge and personality?) Is having the traditional body necessary to being human? Nevertheless, if you accept the above premises, *it could be done*. Having made the leap to new hardware for yourself, many staggering options open up:

1. No death. You back yourself up. You get new hardware as needed.
2. Turn up the clock speed. Goodbye, millisecond-speed neurons; hello, nanosecond-speed electronics.
3. Choose space-friendly hardware. Goodbye, Earth; hello, galaxy.

F. Instant Learning.

If the structure of knowledge was fully understood, and if we controlled the "hardware and software environment" of the mind, then presumably we understand how new knowledge gets integrated with old knowledge. The quaint old-fashioned techniques of "books" and "school" would be sometime reenacted for fun, but the efficient way would be to just get the knowledge file and run the integrate procedure. Get a PhD in Mathematics with "one click."

G. Hive Mind.

If we can easily exchange large chunks of knowledge, and are connected by high-bandwidth communication paths, the function and purpose served by individuals becomes unclear. Individuals served to keep the gene pool stirred up and healthy via sexual reproduction, but this data-handling process would no longer necessarily be linked to individuals. With knowledge no longer encapsulated in individuals, the distinction between individuals and the entirety of humanity would blur. Think Vulcan mind-meld. We would perhaps become more of a hive mind -- an enormous, single, intelligent entity.

H. Speed-of-light Travel.

If a mind is data that runs on a processor (and its sensors and actuators), then that data -- that mind -- can travel at the speed of light as bits in a communication path. Thus Mars is less than an hour away at light speed. (We needed a rocket to get the first receiver there.) You could go there, have experiences (in a body you reserved), and then bring the experience-data back with you on return.

I. Self-directed evolution.

If mind is program and data, and we control the hardware and the software, then we can make changes, as we see fit. What will human-like intelligence evolve into if it is freed from the limits of the human meat machine, and humans can change and improve their own hardware? It's hard to say. The changes would perhaps be goal-directed, but what goals would be chosen for self-directed evolution? What does a human become when freed from pain, hunger, lust, and pride? If we knew answer to this, we might be able to guess why we haven't detected any sign of other intelligences in the 100 billion stars of our galaxy.

Conclusions

What we know now about how the brain works is dwarfed by what we don't know. I believe we barely know some of the right questions to ask, at this point. The state of our knowledge about the brain is similar to that of life scientists about the mechanisms of life at the time (1944) when Erwin Schroedinger wrote "What Is Life?" It was imagined that the mechanisms of life could be understood in terms of chemistry, but details such as DNA and protein synthesis were completely unknown.

Understanding the brain will unleash staggering changes upon humanity. Perhaps we should think this through a bit before we go and do it.