Cognitive Processes

Psychology 309a

Readings and Notes
Winter 2011

Part 1:
Cognitive Representation

Lecture 1
Introduction

The article assigned for Lecture 1, *Forget What You Know About Study Habits*, concerns some important new ideas cognitive science has revealed about learning in the academic environment. In this regard, it makes three general and important points that set the tone for the course.

First, as you'll see, it presupposes a clear link between what happens in the mind and what happens in the brain. Part 1 of the course will emphasize this idea time and again, as to help us understand cognitive processes, we'll be looking at how changes in different parts of one's brain (due to things like surgery, disease, injury, and strokes) selectively alters different aspects of one's cognition.

Second, the article highlights how much of what we do in the cognitive (or mental) realm occurs automatically and outside of our conscious awareness. In the article, for example, we learn about how the brain will make "subtle associations" between material you are learning and the environment in which you are studying. In all three parts of the course, we'll be examining a number of these kinds of "automatic" or "implicit" cognitive processes.

Finally, there is useful, practical information in the article, in this case, how one might improve one's study/learning habits. What's the point here? If nothing else, my goal in teaching Psychology 309a is to help you as students understand how your own mental (or cognitive) processes work. What we'll talk about in the course speaks to how you function in your everyday lives, from simple things like knowing where to place your feet when walking to complex skills like reading other peoples' thoughts and emotions. If UBC bills itself as "A Place of Mind", then this is the course at UBC where one can learn the practical ins and outs of how that mind actually works.

September 6, 2010

Forget What You Know About Good Study Habits

By BENEDICT CAREY

Every September, millions of parents try a kind of psychological witchcraft, to transform their summer-glazed campers into fall students, their video-bugs into bookworms. Advice is cheap and all too familiar: Clear a quiet work space. Stick to a homework schedule. Set goals. Set boundaries. Do not bribe (except in emergencies).

And check out the classroom. Does Junior's learning style match the new teacher's approach? Or the school's philosophy? Maybe the child isn't "a good fit" for the school.

Such theories have developed in part because of sketchy education research that doesn't offer clear guidance. Student traits and teaching styles surely interact; so do personalities and at-home rules. The trouble is, no one can predict how.

Yet there are effective approaches to learning, at least for those who are motivated. In recent years, cognitive scientists have shown that a few simple techniques can reliably improve what matters most: how much a student learns from studying.

The findings can help anyone, from a fourth grader doing long division to a retiree taking on a new language. But they directly contradict much of the common wisdom about good study habits, and they have not caught on.

For instance, instead of sticking to one study location, simply alternating the room where a person studies improves retention. So does studying distinct but related skills or concepts in one sitting, rather than focusing intensely on a single thing.

"We have known these principles for some time, and it's intriguing that schools don't pick them up, or that people don't learn them by trial and error," said Robert A. Bjork, a psychologist at the University of California, Los Angeles. "Instead, we walk around with all sorts of unexamined beliefs about what works that are mistaken."

Take the notion that children have specific learning styles, that some are "visual learners" and others are auditory; some are "left-brain" students, others "right-brain." In a recent review of the relevant research, published in the journal Psychological Science in the Public Interest, a team of psychologists found almost zero support for such ideas. "The contrast between the enormous popularity of the learning-styles approach within education and the lack of credible evidence for its utility is, in our opinion, striking and disturbing," the researchers concluded.

Ditto for teaching styles, researchers say. Some excellent instructors caper in front of the blackboard like summer-theater Falstaffs; others are reserved to the point of shyness. "We have yet to identify the common threads between teachers who create a constructive learning atmosphere," said Daniel T. Willingham, a psychologist at the University of Virginia and author of the book "Why Don't Students Like School?"

But individual learning is another matter, and psychologists have discovered that some of the most hallowed advice on study habits is flat wrong. For instance, many study skills courses insist that students find a specific place, a study room or a quiet corner of the library, to take their work. The research finds just the opposite. In one classic 1978 experiment, psychologists found that college students who studied a list of 40 vocabulary words in two different rooms — one windowless and cluttered, the other modern, with a view on a courtyard — did far better on a test than students who studied the words twice, in the same room. Later studies have confirmed the finding, for a variety of topics.

The brain makes subtle associations between what it is studying and the background sensations it has at the time, the authors say, regardless of whether those perceptions are conscious. It colors the terms of the Versailles Treaty with the wasted fluorescent glow of the dorm study room, say; or the elements of the Marshall Plan with the jade-curtain shade of the willow tree in the backyard. Forcing the brain to make multiple associations with the same material may, in effect, give that information more neural scaffolding.

"What we think is happening here is that, when the outside context is varied, the information is enriched, and this slows down forgetting," said Dr. Bjork, the senior author of the two-room experiment.

Varying the type of material studied in a single sitting — alternating, for example, among vocabulary, reading and speaking in a new language — seems to leave a deeper impression on the brain than does concentrating on just one skill at a time. Musicians have known this for years, and their practice sessions often include a mix of scales, musical pieces and rhythmic work. Many athletes, too, routinely mix their workouts with strength, speed and skill drills.

The advantages of this approach to studying can be striking, in some topic areas. In a study recently posted online by the journal Applied Cognitive Psychology, Doug Rohrer and Kelli Taylor of the University of South Florida taught a group of fourth graders four equations, each to calculate a different dimension of a prism. Half of the children learned by studying repeated examples of one equation, say, calculating the number of prism faces when given the number of sides at the base, then moving on to the next type of calculation, studying repeated examples of that. The other half studied mixed problem sets, which included examples all four types of calculations grouped together. Both groups solved sample problems along the way, as they studied.

A day later, the researchers gave all of the students a test on the material, presenting new problems of the same type. The children who had studied mixed sets did twice as well as the others, outscoring them 77 percent to 38 percent. The researchers have found the same in experiments involving adults and younger children.

"When students see a list of problems, all of the same kind, they know the strategy to use before they even read the problem," said Dr. Rohrer. "That's like riding a bike with training wheels." With mixed practice, he added, "each problem is different from the last one, which means kids must learn how to choose the appropriate procedure — just like they had to do on the test."

These findings extend well beyond math, even to aesthetic intuitive learning. In an experiment published last month in the journal Psychology and Aging, researchers found that college students and adults of retirement age were better able to distinguish the painting styles of 12 unfamiliar artists after viewing mixed collections (assortments, including works from all 12) than after viewing a dozen works from one artist, all together, then moving on to the next painter.

The finding undermines the common assumption that intensive immersion is the best way to really master a particular genre, or type of creative work, said Nate Kornell, a psychologist at Williams College and the lead author of the study. “What seems to be happening in this case is that the brain is picking up deeper patterns when seeing assortments of paintings; it’s picking up what’s similar and what’s different about them,” often subconsciously.

Cognitive scientists do not deny that honest-to-goodness cramming can lead to a better grade on a given exam. But hurriedly jam-packing a brain is akin to speed-packing a cheap suitcase, as most students quickly learn — it holds its new load for a while, then most everything falls out.

“With many students, it’s not like they can’t remember the material” when they move to a more advanced class, said Henry L. Roediger III, a psychologist at Washington University in St. Louis. “It’s like they’ve never seen it before.”

When the neural suitcase is packed carefully and gradually, it holds its contents for far, far longer. An hour of study tonight, an hour on the weekend, another session a week from now: such so-called spacing improves later recall, without requiring students to put in more overall study effort or pay more attention, dozens of studies have found.

No one knows for sure why. It may be that the brain, when it revisits material at a later time, has to relearn some of what it has absorbed before adding new stuff — and that that process is itself self-reinforcing.

“The idea is that forgetting is the friend of learning,” said Dr. Kornell. “When you forget something, it allows you to relearn, and do so effectively, the next time you see it.”

That’s one reason cognitive scientists see testing itself — or practice tests and quizzes — as a powerful tool of learning, rather than merely assessment. The process of retrieving an idea is not like pulling a book from a shelf; it seems to fundamentally alter the way the information is subsequently stored, making it far more accessible in the future.

Dr. Roediger uses the analogy of the Heisenberg uncertainty principle in physics, which holds that the act of measuring a property of a particle alters that property: “Testing not only measures knowledge but changes it,” he says — and, happily, in the direction of more certainty, not less.

In one of his own experiments, Dr. Roediger and Jeffrey Karpicke, also of Washington University, had college students study science passages from a reading comprehension test, in short study periods. When students studied the same material twice, in back-to-back sessions, they did very well on a test given immediately afterward, then began to forget the material.

But if they studied the passage just once and did a practice test in the second session, they did very well on one test two days later, and another given a week later.

“Testing has such bad connotation; people think of standardized testing or teaching to the test,” Dr. Roediger said. “Maybe we need to call it something else, but this is one of the most powerful learning tools we have.”

Of course, one reason the thought of testing tightens people’s stomachs is that tests are so often hard. Paradoxically, it is just this difficulty that makes them such effective study tools, research suggests. The harder it is to remember something, the harder it is to later forget. This effect, which researchers call “desirable difficulty,” is evident in daily life. The name of the actor who played Linc in “The Mod Squad”? Francie’s brother in “A Tree Grows in Brooklyn”? The name of the co-discoverer, with Newton, of calculus?

The more mental sweat it takes to dig it out, the more securely it will be subsequently anchored.

None of which is to suggest that these techniques — alternating study environments, mixing content, spacing study sessions, self-testing or all the above — will turn a grade-A slacker into a grade-A student. Motivation matters. So do impressing friends, making the hockey team and finding the nerve to text the cute student in social studies.

“In lab experiments, you’re able to control for all factors except the one you’re studying,” said Dr. Willingham. “Not true in the classroom, in real life. All of these things are interacting at the same time.”

But at the very least, the cognitive techniques give parents and students, young and old, something many did not have before: a study plan based on evidence, not schoolyard folk wisdom, or empty theorizing.

Lecture 2
Representation and Plasticity

The goal of this lecture is to introduce the most basic idea underlying cognitive processes and their scientific study––the mind, as we know and experience it, is based on "representing" information in the brain. In this framework, "cognitive processes" thus concern what information we represent, and how we transform, combine and use this information in thinking and acting.

The first point of order for the course is thus to understand what it means to "represent" information in general, and how information is represented in the brain, in particular. Importantly, this sets things up for the remainder of Part 1, wherein in the next 6 upcoming lectures we'll discuss the various different kinds of representations we have, such as information about our bodies, what we see, what we feel, what we remember, what scares us, and ultimately, our own self identity.

The first article assigned for Lecture 2, *New Tools to Help Patients Reclaim Damaged Senses*, makes the ideas of representation and the brain explicit by discussing how people who have lost a sensory ability (e.g., someone who has gone deaf or blind) can regain some of that lost ability through what's called "sensory substitution."

The second article assigned for lecture, *This Year, Change Your Mind*, supplements the first by speaking to the general idea of brain plasticity or *neuroplasticity* and how adaptive our brains can be over time as we learn and try new things. Again, the underlying key is to appreciate how we can represent information in very different, dynamic ways.

The New York Times
nytimes.com

November 23, 2004

New Tools to Help Patients Reclaim Damaged Senses

By SANDRA BLAKESLEE

Correction Appended

Cheryl Schiltz vividly recalls the morning she became a wobbler. Seven years ago, recovering from an infection after surgery with the aid of a common antibiotic, she climbed out of bed feeling pretty good.

"Then I literally fell to the floor," she said recently. "The whole world started wobbling. When I turned my head, the room tilted. My vision blurred. Even the air felt heavy."

The antibiotic, Ms. Schiltz learned, had damaged her vestibular system, the part of the brain that provides visual and gravitational stability. She was forced to quit her job and stay home, clinging to the walls to keep from toppling over.

But three years ago, Ms. Schiltz volunteered for an experimental treatment - a fat strip of tape, placed on her tongue, with an array of 144 microelectrodes about the size of a postage stamp. The strip was wired to a kind of carpenter's level, which was mounted on a hard hat that she placed on her head. The level determined her spatial coordinates and sent the information as tiny pulses to her tongue.

The apparatus, called a BrainPort, worked beautifully. By "buzzing" her tongue once a day for 20 minutes, keeping the pulses centered, she regained normal vestibular function and was able to balance.

Ms. Schiltz and other patients like her are the beneficiaries of an astonishing new technology that allows one set of sensory information to substitute for another in the brain.

Using novel electronic aids, vision can be represented on the skin, tongue or through the ears. If the sense of touch is gone from one part of the body, it can be routed to an area where touch sensations are intact. Pilots confused by foggy conditions, in which the horizon disappears, can right their aircraft by monitoring sensations on the tongue or trunk. Surgeons can feel on their tongues the tip of a probe inside a patient's body, enabling precise movements.

Sensory substitution is not new. Touch substitutes for vision when people read Braille. By tapping a cane, a blind person perceives a step, a curb or a puddle of water but is not aware of any sensation in the hand; feeling is experienced at the tip of the cane.

But the technology for swapping sensory information is largely the effort of Dr. Paul Bach-y-Rita, a neuroscientist in the University of Wisconsin Medical School's orthopedics and rehabilitation department. More than 30 years ago, Dr. Bach-y-Rita developed the first sensory substitution device, routing visual images, via a head-mounted camera, to electrodes taped to the skin on people's backs. The subjects, he found, could "see" large objects and flickering candles with their backs. The tongue, sensitive and easy to reach, turned out to be an even better place to deliver substitute senses, Dr. Bach-y-Rita said.

Until recently sensory substitution was confined to the laboratory. But electronic miniaturization and more powerful computer algorithms are making the technology less cumbersome. Next month, the first fully portable device will be tested in Dr. Bach-y-Rita's lab.

The BrainPort is nearing commercialization. Two years ago, the University of Wisconsin patented the concept and exclusively licensed it to Wicab Inc., a company formed by Dr. Bach-y-Rita to develop and market BrainPort devices. Robert Beckman, the company president, said units should be available a year from now.

Meanwhile, a handful of clinicians around the world who are using the BrainPort on an experimental basis are effusive about its promise.

"I have never seen any other device do what this one does," said Dr. F. Owen Black, an expert on vestibular disorders at the Legacy Clinical Research and Technology Center in Portland, Ore. "Our patients are begging us to continue using the device."

Dr. Maurice Ptito, a neuroscientist at University of Montreal School of Optometry, is conducting brain imaging experiments to explore how BrainPort works.

Dr. Eliana Sampaio, a neuroscientist at the National Conservatory of Arts and Métiers in Paris, is using the BrainPort to study brain plasticity. Sensory substitution is based on the idea that all sensory information entering the brain consists of patterns carried by nerve fibers.

In vision, images of the world pass through the retina and are converted into impulses that travel up the optic nerve into the brain. In hearing, sounds pass through the ear and are converted into patterns carried by the auditory nerve into the brain. In touch, nerve endings on skin translate touch sensations into patterns carried into the brain.

These patterns travel to special sensory regions where they are interpreted, with the help of memory, into seeing, hearing and touch. Patterns are also seamlessly combined so that one can see, hear and feel things simultaneously.

"We see with the brain, not with the eyes," Dr. Bach-y-Rita said. "You can lose your retina but you do not lose the ability to see as long as your brain is intact."

Most important, the brain does not seem to care if patterns come from the eye, ear or skin. Given the proper context, it will interpret and understand them. "For me, it happened automatically, within a few minutes," said Erik Weihenmayer, who has been blind since he was 13.

Mr. Weihenmayer, a 35-year-old adventurer who climbed to the summit of Mount Everest two years ago, recently tried another version of the BrainPort, a hard hat carrying a small video camera. Visual information from the camera was translated into pulses that reached his tongue.

He found doorways, caught balls rolling toward him and with his small daughter played a game of rock, paper and scissors for the first time in more than 20 years. Mr. Weihenmayer said that, with practice, the substituted sense gets better, "as if the brain were rewiring itself."

Ms. Schiltz, too, whose vestibular system was damaged by gentamicin, an inexpensive generic antibiotic used for Gram-negative infections, said that the first few times she used the BrainPort she felt tiny impulses on her tongue but still could not maintain her balance. But one day, after a full 20-minute session with the BrainPort, Ms. Schiltz opened her eyes and felt that something was different. She tilted her head back. The room did not move. "I went running out the door," she recalled. "I danced in the parking lot. I was completely normal. For a whole hour." Then, she said, the problem returned.

She tried more sessions. Soon her balance was restored for three hours, then half a day. Now working with the BrainPort team at the University of Wisconsin, Ms. Schiltz wears the tongue unit each morning. Her balance problems are gone as long as she keeps to the regimen.

How the device produces a lasting effect is being investigated. The vestibular system instructs the brain about changes in head movement with respect to the pull of gravity. Dr. Bach-y-Rita speculated that in some patients, a tiny amount of vestibular tissue might survive and be reactivated by the BrainPort.

Dr. Black said he had seen the same residual effect in his own pilot study. "It decays in hours to days," he said, "but is very encouraging."

Blind people who have used the device do not report lasting effects. But they are amazed by what they can see. Mr. Weihenmayer said the device at first felt like candy pop rocks on his tongue. But that sensation quickly gave way to perceptions of size, movement and recognition.

Mr. Weihenmayer said that on several occasions he was able to find his wife, who was standing still in an outdoor park, but he admitted that he also once confused her with a tree. Another time, he walked down a sidewalk and almost went off a bridge.

Nevertheless, he is enthusiastic about the future of the device. Mr. Weihenmayer likes to paraglide, and he sees the BrainPort as a way to deliver sonar information to his tongue about how far he is from the ground.

Dr. Ptito is scanning the brains of congenitally blind people who, wearing the BrainPort, have learned to make out the shapes, learned from Braille, of capital letters like T, B or E. The first few times they wore the device, he said, their visual areas remained dark and inactive - not surprising since they had been blind since birth. But after training, he said, their visual areas lighted up when they used the tongue device. The study has been accepted for publication in the journal Brain.

Dr. Ptito says he would like to see if he could teach his subjects how to read drifting letters like those in advertising displays. Not seeing motion is a big problem for the blind, he said.

In another approach, Dr. Peter Meijer, a Dutch scientist working independently, has developed a system for blind people to see with their ears. A small device converts signals from a video camera into sound patterns delivered by stereo headset to the ears. Changes in frequency connote up or down. Changes in pixel brightness are sensed as louder or softer sounds.

Dr. Yuri Danilov, a neuroscientist and engineer who works with Dr. Bach-y-Rita, said the research team had thought of dozens of applications for the BrainPort, which he called a "USB port to the brain."

In one experiment, a leprosy patient who had lost the ability to experience touch with his fingers was outfitted with a glove containing contact sensors. These were coupled to skin on his forehead. Soon he experienced the data coming from the glove on his forehead, as if the feelings originated in his fingertips. He said he cried when he could touch and feel his wife's face.

The federal government has also shown interest in sensory substitution technology. The Navy is exploring the use of a tongue device to help divers find their way in dark waters at night, said Dr. Anil Raj, a research scientist at the Institute for Human and Machine Cognition at the University of West Florida in Pensacola.

The sensors detect water surges, informing Navy Seals if they are following the correct course. The Army is thinking about sending infrared signals from night goggles directly to the tongue, Dr. Raj said.

In another application, student pilots have been fitted with body sensors attached to aircraft instruments. When the airplane starts to pitch or change altitude, they can feel the movements on their chests.

Sensory substitution technology may eventually help millions of people overcome their sensory disabilities. But the devices may also have more frivolous uses: in video games, for example.

Dr. Raj said the tongue unit had already been tried out in a game that involved shooting villains. "In two minutes you stop feeling the buzz on your tongue and get a visual representation of the bad guy," he said. "You feel like you have X-ray vision. Unfortunately it makes the game boring."

Correction: *December 20, 2004, Monday:*

An article in Science Times on Nov. 23 about technology that substitutes one set of sensory information for another in the brain, helping people who have lost a sense like vision or touch, misstated the title of Dr. Anil Raj of the Institute for Human and Machine Cognition at the University of West Florida in Pensacola, who spoke about the technology. He is a research scientist, not the director.

Correction: *December 22, 2004, Wednesday:*

An article in Science Times on Nov. 23 about technology that substitutes one set of sensory information for another in the brain, helping people who have lost a sense like vision or touch, misstated the term for a device in aircraft that lets a pilot feel the movement of the plane without looking at instruments. It is a stimulator, not a sensor.

December 31, 2010

This Year, Change Your Mind

By OLIVER SACKS

NEW Year's resolutions often have to do with eating more healthfully, going to the gym more, giving up sweets, losing weight — all admirable goals aimed at improving one's physical health. Most people, though, do not realize that they can strengthen their brains in a similar way.

While some areas of the brain are hard-wired from birth or early childhood, other areas — especially in the cerebral cortex, which is central to higher cognitive powers like language and thought, as well as sensory and motor functions — can be, to a remarkable extent, rewired as we grow older. In fact, the brain has an astonishing ability to rebound from damage — even from something as devastating as the loss of sight or hearing. As a physician who treats patients with neurological conditions, I see this happen all the time.

For example, one patient of mine who had been deafened by scarlet fever at the age of 9, was so adept at lip-reading that it was easy to forget she was deaf. Once, without thinking, I turned away from her as I was speaking. "I can no longer hear you," she said sharply.

"You mean you can no longer see me," I said.

"You may call it seeing," she answered, "but I experience it as hearing."

Lip-reading, seeing mouth movements, was immediately transformed for this patient into "hearing" the sounds of speech in her mind. Her brain was converting one mode of sensation into another.

In a similar way, blind people often find ways of "seeing." Some areas of the brain, if not stimulated, will atrophy and die. ("Use it or lose it," neurologists often say.) But the visual areas of the brain, even in someone born blind, do not entirely disappear; instead, they are redeployed for other senses. We have all heard of blind people with unusually acute hearing, but other senses may be heightened, too.

For example, Geerat Vermeij, a biologist at the University of California-Davis who has been blind since the age of 3, has identified many new species of mollusks based on tiny variations in the contours of their shells. He uses a sort of spatial or tactile giftedness that is beyond what any sighted person is likely to have.

The writer Ved Mehta, also blind since early childhood, navigates in large part by using "facial vision" — the ability to sense objects by the way they reflect sounds, or subtly shift the air currents that reach his face. Ben Underwood, a remarkable boy who lost his sight at 3 and died at 16 in 2009, developed an effective, dolphin-like strategy of emitting regular clicks with his mouth and reading the resulting echoes from nearby objects. He was so skilled at this that he could ride a bike and play sports and even video games.

People like Ben Underwood and Ved Mehta, who had some early visual experience but then lost their sight, seem to instantly convert the information they receive from touch or sound into a visual image — "seeing" the dots, for instance, as they read Braille with a finger. Researchers using functional brain imagery have confirmed that in such situations the blind person activates not only the parts of the cortex devoted to touch, but parts of the visual cortex as well.

One does not have to be blind or deaf to tap into the brain's mysterious and extraordinary power to learn, adapt and grow. I have seen hundreds of patients with various deficits — strokes, Parkinson's and even dementia — learn to do things in new ways, whether consciously or unconsciously, to work around those deficits.

That the brain is capable of such radical adaptation raises deep questions. To what extent are we shaped by, and to what degree do we shape, our own brains? And can the brain's ability to change be harnessed to give us greater cognitive powers? The experiences of many people suggest that it can.

One patient I knew became totally paralyzed overnight from a spinal cord infection. At first she fell into deep despair, because she couldn't enjoy even little pleasures, like the daily crossword she had loved.

After a few weeks, though, she asked for the newspaper, so that at least she could look at the puzzle, get its configuration, run her eyes along the clues. When she did this, something extraordinary happened. As she looked at the clues, the answers seemed to write themselves in their spaces. Her visual memory strengthened over the next few weeks, until she found that she was able to hold the entire crossword and its clues in her mind after a single, intense inspection — and then solve it mentally. She had had no idea, she later told me, that such powers were available to her.

This growth can even happen within a matter of days. Researchers at Harvard found, for example, that blindfolding sighted adults for as few as five days could produce a shift in the way their brains functioned: their subjects became markedly better at complex tactile tasks like learning Braille.

Neuroplasticity — the brain's capacity to create new pathways — is a crucial part of recovery for anyone who loses a sense or a cognitive or motor ability. But it can also be part of everyday life for all of us. While it is often true that learning is easier in childhood, neuroscientists now know that the brain does not stop growing, even in our later years. Every time we practice an old skill or learn a new one, existing neural connections are strengthened and, over time, neurons create more connections to other neurons. Even new nerve cells can be generated.

I have had many reports from ordinary people who take up a new sport or a musical instrument in their 50s or 60s, and not only become quite proficient, but derive great joy from doing so. Eliza Bussey, a journalist in her mid-50s who now studies harp at the Peabody conservatory in Baltimore, could not read a note of music a few years ago. In a letter to me, she wrote about what it was like learning to play Handel's "Passacaille": "I have felt, for example, my brain and fingers trying to connect, to form new synapses. ... I know that my brain has dramatically changed." Ms. Bussey is no doubt right: her brain has changed.

Music is an especially powerful shaping force, for listening to and especially playing it engages many different areas of the brain, all of which must work in tandem: from reading musical notation and coordinating fine muscle movements in the hands, to evaluating and expressing rhythm and pitch, to associating music with memories and emotion.

Whether it is by learning a new language, traveling to a new place, developing a passion for beekeeping or simply thinking about an old problem in a new way, all of us can find ways to stimulate our brains to grow, in the coming year and those to follow. Just as physical activity is essential to maintaining a healthy body, challenging one's brain, keeping it active, engaged, flexible and playful, is not only fun. It is essential to cognitive fitness.

Oliver Sacks is the author of "The Mind's Eye."

Lecture 3
Body Representation

We start our examination of cognitive representations by considering the most basic of these––those associated with the body itself. The critical idea to pull away from this lecture is appreciating how something that we experience mentally as a single thing, our bodies, is actually the result of multiple, different representations.

This is a recurring theme throughout the remaining lectures of Part 1 of the course: any single sense (e.g., vision) or ability (e.g., language) is actually based on a host of different representations in the brain.

In today's first article, *Primal, Acute and Easily Duped: Our Sense of Touch*, we get a nice synopsis of how our skin senses work, how they differ from our other primary senses, and how our body representations are mapped in our brains. This should likely be review material from Psych 100.

In today's second article, *When the Brain Says, 'Don't Get Too Close'*, we learn about a different kind of body representation––those associated with sensing the physical dimensions of your body, such as the size of your hands or length of your legs. Of particular interest here is how flexible these representations are, leading us to have situations where we can feel as if our body is extending well beyond its physical boundaries.

In lecture, we'll discuss one particularly compelling consequence of having body representations, in the form of "phantom limb" sensations that can arise when a body part is lost but the representations for that body part remain intact in the brain. We'll also consider how we represent body movements, a topic illustrated by considering people suffering from *apraxia*, a form of movement disorder.

The New York Times
nytimes.com

December 9, 2008

BASICS

Primal, Acute and Easily Duped: Our Sense of Touch

By NATALIE ANGIER

Imagine you're in a dark room, running your fingers over a smooth surface in search of a single dot the size of this period. How high do you think the dot must be for your finger pads to feel it? A hundredth of an inch above background? A thousandth?

Well, take a tip from the economy and keep downsizing. Scientists have determined that the human finger is so sensitive it can detect a surface bump just one micron high. All our punctuation point need do, then, is poke above its glassy backdrop by 1/400,000th of an inch — the diameter of a bacterial cell — and our fastidious fingers can find it. The human eye, by contrast, can't resolve anything much smaller than 100 microns. No wonder we rely on touch rather than vision when confronted by a new roll of toilet paper and its Abominable Invisible Seam.

Biologically, chronologically, allegorically and delusionally, touch is the mother of all sensory systems. It is an ancient sense in evolution: even the simplest single-celled organisms can feel when something brushes up against them and will respond by nudging closer or pulling away. It is the first sense aroused during a baby's gestation and the last sense to fade at life's culmination. Patients in a deep vegetative coma who seem otherwise lost to the world will show skin responsiveness when touched by a nurse.

Like a mother, touch is always hovering somewhere in the perceptual background, often ignored, but indispensable to our sense of safety and sanity. "Touch is so central to what we are, to the feeling of being ourselves, that we almost cannot imagine ourselves without it," said Chris Dijkerman, a neuropsychologist at the Helmholtz Institute of Utrecht University in the Netherlands. "It's not like vision, where you close your eyes and you don't see anything. You can't do that with touch. It's always there."

Long neglected in favor of the sensory heavyweights of vision and hearing, the study of touch lately has been gaining new cachet among neuroscientists, who sometimes refer to it by the amiably jargony term of haptics, Greek for touch. They're exploring the implications of recently reported tactile illusions, of people being made to feel as though they had three arms, for example, or were levitating out of their bodies, with the hope of gaining insight into how the mind works.

Others are turning to haptics for more practical purposes, to build better touch screen devices and robot hands, a more well-rounded virtual life. "There's a fair amount of research into new ways of offloading information onto our tactile sense," said Lynette Jones of the Massachusetts Institute of Technology. "To have your cellphone buzzing as opposed to ringing turned out to have a lot of advantages in some situations, and the question is, where else can vibrotactile cues be applied?"

For all its antiquity and constancy, touch is not passive or primitive or stuck in its ways. It is our most active sense, our means of seizing the world and experiencing it, quite literally, first hand. Susan J. Lederman, a professor of psychology at Queen's University in Canada, pointed out that while we can perceive something visually or acoustically from a distance and without really trying, if we want to learn about something tactilely, we must make a move. We must rub the fabric, pet the cat, squeeze the

Charmin. And with every touchy foray, Heisenberg's Uncertainty Principle looms large. "Contact is a two-way street, and that's not true for vision or audition," Dr. Lederman said. "If you have a soft object and you squeeze it, you change its shape. The physical world reacts back."

Another trait that distinguishes touch is its widespread distribution. Whereas the sensory receptors for sight, vision, smell and taste are clustered together in the head, conveniently close to the brain that interprets the fruits of their vigils, touch receptors are scattered throughout the skin and muscle tissue and must convey their signals by way of the spinal cord. There are also many distinct classes of touch-related receptors: mechanoreceptors that respond to pressure and vibrations, thermal receptors primed to sense warmth or cold, kinesthetic receptors that keep track of where our limbs are, and the dread nociceptors, or pain receptors — nerve bundles with bare endings that fire when surrounding tissue is damaged.

The signals from the various touch receptors converge on the brain and sketch out a so-called somatosensory homunculus, a highly plastic internal representation of the body. Like any map, the homunculus exaggerates some features and downplays others. Looming largest are cortical sketches of those body parts that are especially blessed with touch receptors, which means our hidden homunculus has a clownishly large face and mouth and a pair of Paul Bunyan hands. "Our hands and fingers are the tactile equivalent of the fovea in vision," said Dr. Dijkerman, referring to the part of the retina where cone cell density is greatest and visual acuity highest. "If you want to explore the tactile world, your hands are the tool to use."

Our hands are brilliant and can do many tasks automatically — button a shirt, fit a key in a lock, touch type for some of us, play piano for others. Dr. Lederman and her colleagues have shown that blindfolded subjects can easily recognize a wide range of common objects placed in their hands. But on some tactile tasks, touch is all thumbs. When people are given a raised line drawing of a common object, a bas-relief outline of, say, a screwdriver, they're stumped. "If all we've got is contour information," Dr. Lederman said, "no weight, no texture, no thermal information, well, we're very, very bad with that."

Touch also turns out to be easy to fool. Among the sensory tricks now being investigated is something called the Pinocchio illusion. Researchers have found that if they vibrate the tendon of the biceps, many people report feeling that their forearm is getting longer, their hand drifting ever further from their elbow. And if they are told to touch the forefinger of the vibrated arm to the tip of their nose, they feel as though their nose was lengthening, too.

Some tactile illusions require the collusion of other senses. People who watch a rubber hand being stroked while the same treatment is applied to one of their own hands kept out of view quickly come to believe that the rubber prosthesis is the real thing, and will wince with pain at the sight of a hammer slamming into it. Other researchers have reported what they call the parchment-skin illusion. Subjects who rubbed their hands together while listening to high-frequency sounds described their palms as feeling exceptionally dry and papery, as though their hands must be responsible for the rasping noise they heard. Look up, little Pinocchio! Somebody's pulling your strings.

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nytimes.com

July 13, 2004

When the Brain Says, 'Don't Get Too Close'

By SANDRA BLAKESLEE

A century ago, neurologists noticed that when ladies wearing big feathered hats ducked through entryways, they would align their bodies just so. It was as if they could feel the tops of doors with the tips of the feathers.

From this and other observations, the scientists concluded that each person holds within the brain a mental representation of the body and its parts -- even the clothing it wears -- as it moves through space.

Those early scientists could not explain how the brain creates such sensations, or body schemas. But using modern methods for probing brains, researchers are uncovering the cells and circuits that are responsible.

For example, research has found that brain cells become active as objects approach the space around the body. These cells will fire when, say, you see an insect fly toward your face. This so-called peripersonal space extends to arm's length; people with longer arms have a bigger peripersonal space. And when they use a tool, a rake, a joystick or an automobile, their body schema and peripersonal space expand to include it.

Moreover, perceptions change as the body schema changes in response to outside stimuli. A hill looks steeper when you wear a backpack than when you do not.

The findings, from laboratories worldwide, offer tantalizing biological explanations for many phenomena, including anorexia and syndromes in which stroke patients neglect one side of the body. They may explain why people are sucked into video games, and even why drivers get so upset when their car is dented.

''To act efficiently, we need to locate objects in the space around our bodies,'' said Dr. Angelo Maravita, a psychology professor at the University of Milan. ''We need to hold a constantly updated report on the body's shape and posture.''

The new research draws on the principle that the brain forms internal maps of the external world; groups of cells hold mental models of everything a person sees, hears, feels and knows. The brain also forms a mental map of the body itself. Clumps of brain tissue represent each hand, foot, trunk or lip. If someone touches your hand, cells in the brain's ''hand area'' become active.

Neurons respond to both vision and touch in at least six brain areas. For example, a cell will fire when the right hand is touched, or when the person sees an object moving toward it. The closer the object, the faster the cell fires.

Such cells encode the space around the body, within arm's reach. It is as if you walked around in your own private soap bubble. But the brain also has cells to map space farther away.

Dr. Atsushi Iriki, a cognitive neuroscientist at the Riken Institute in Japan, was one of the first to explore body schema using modern techniques. He inserted single electrodes into monkey brains and identified single cells that responded to both a touch on the hand and visual space next to the hand. Then he gave the monkeys a rake and for three weeks trained them to pull in food pellets with the tool. After training, he found that the cells that represented the hand and arm, as well as space around the arm, changed their firing pattern to include the rake and the space around it.

The moving tool was incorporated into the monkey's body schema, Dr. Iriki said. When the monkey held the tool passively, its body schema shrank to normal size.

In another experiment, Dr. Iriki allowed the monkeys to see a virtual hand on a video monitor while the monkey's real hand, hidden from view, operated a joystick. When he made the image of the hand larger, the monkey's brain treated the virtual hand as if it were an enlarged version of its own; the brain's hand area blew up like a cartoon character's hand. When he put the image of a spider or snake on the screen and made it approach the image of the hand in the monitor, the monkey suddenly retracted its own hand.

These neurons may constitute the neural basis of a person's feeling a sense of reality when playing video games, Dr. Iriki said. People say they can feel the joystick touching objects in the monitor as they extend their bodies into far space.

Stroke patients who neglect one side of their body also reveal changes in body maps. Dr. Anna Berti, a psychologist and physician at the University of Turin in Italy, asked a patient to indicate the midpoint of a line held in front of her body. She put the mark way to the right of the midpoint. But when the same line was shown to her in far space, beyond her reach, she found the midpoint with a laser pointer. The neglect caused by the stroke extended only to the space around her body.

But when Dr. Berti asked the patient to find the midpoint with a stick in the distant line, she made the earlier mistake. Using a tool extended her neglect further into space.

Dr. Berti also tested a stroke patient who denied that the wedding rings on her left hand were hers. But when she was shown the rings in front of her or on her right hand, she described how she came to own them. Dr. Berti concluded that objects closely associated with a hand are part of the body map.

People do not notice they have a body schema until they lose it or feel it is permanently altered, said Dr. Michael S.A. Graziano, a psychology professor at Princeton. Certain kinds of brain damage result in a sensation of floating outside one's body. The feeling can be induced in healthy people by bombarding a region of their brains with a powerful magnetic force.

In a condition called body dysmorphic disorder, people perceive a normal part of their body, like the nose, ears or buttocks, as grotesquely large. And there is recent evidence that anorexia is partly a disorder of the body schema, Dr. Graziano said.

Social psychologists have long studied how personal space expands or shrinks depending on personality, culture and circumstances, although they do not know the underlying mechanisms. For example, when a person is threatened or anxious, body space expands in an effort to keep others away. A conversation with someone from a different culture can produce the feeling that his face is uncomfortably close, though it may be the same distance as that of someone from the same culture. Dr. Dennis Proffitt, a psychologist at the University of Virginia, studies how the body schema affects our perception of the environment. For example, just about everyone overestimates the inclines of hills so that a 5-degree hill looks like a 20-degree hill. But people who are encumbered, tired, out of shape or elderly and in declining health may perceive the incline as 25 or 30 degrees.

Finally, researchers say that large machines can become part of the body map. The lines between parking spaces appear closer together from a Humvee than from a Miata, Dr. Graziano said. An automobile is automatically absorbed into peripersonal space. And that helps explain why a minor dent in a fender can provoke a major blowup. The driver's body space has been harmed.

Meanwhile, expert riders describe how their body space becomes integrated with the horse's. Imagine what that does to the ego.

Photo: Women wearing feathered hats provided an early clue to one of the mysteries of the brain. (Photo by Michael Nicolson/Photo Researchers) Drawing (Illustrations by Al Granberg) Chart: ''Monkey See: Adjusting the Brains Perception of Space'' Japanese macaques were trained to use a small rake to reach food beyond arm's length. Scientists then measured brain activity and determined that the monkey's mental map of their bodies had widened. BEFORE TOOL USE Certain brain cells map touch and vision in or around the hand. Cells map touch and vision everywhere the arm can reach. AFTER TOOL USE The map enlarges to include space from the hand to the tip of the tool. The map expands to include the space now accessible with the rake. (Sources by Dr. Atsushi Iriki, Riken Brain Institute, Tokyo)

Lecture 4
Visual Representation

Today's lecture introduces a theme we will see over and over for the remainder of the course: our thinking and behaviors are constantly affected by information and representations that we're not consciously aware of.

This idea is wonderfully highlighted in the first assigned article, *Blind, Yet Seeing: The Brain's Subconscious Visual Sense*, which concerns the phenomenon of "blindsight", where people who are blind due to brain damage can still maintain the ability to use some visual information even though they can't "see" it.

In lecture, we'll see a second example of unconscious visual processing when we look at how the brain separates visual representations associated with recognizing objects (which we're consciously aware of) from visual representations used to reach out and grasp things we're looking at (which we're not consciously aware of).

These two different "streams" of visual processing in the brain are referred to as the "What" and "How" pathways, respectively. We'll go over this carefully in lecture.

In today's second article, *Just Another Face in the Crowd, Indistinguishable Even if It's Your Own*, we explore more closely the nature of visual representations in the "What" pathway. In this case we learn about *prosopagnosia*, a neurological disorder wherein people lose the ability to recognize faces.

To highlight the distinction between conscious "What" pathway representations and unconscious "How" pathway representations, we'll finish lecture by looking at an *associative agnosia* patient who has lost his ability to recognize objects he's looking at, but his hands "know" how to precisely grab them.

The New York Times
nytimes.com

December 23, 2008

Blind, Yet Seeing: The Brain's Subconscious Visual Sense

By BENEDICT CAREY

The man, a doctor left blind by two successive strokes, refused to take part in the experiment. He could not see anything, he said, and had no interest in navigating an obstacle course — a cluttered hallway — for the benefit of science. Why bother?

When he finally tried it, though, something remarkable happened. He zigzagged down the hall, sidestepping a garbage can, a tripod, a stack of paper and several boxes as if he could see everything clearly. A researcher shadowed him in case he stumbled.

"You just had to see it to believe it," said Beatrice de Gelder, a neuroscientist at Harvard and Tilburg University in the Netherlands, who with an international team of brain researchers reported on the patient on Monday in the journal Current Biology. A video is online at www.beatricedegelder.com/books.html.

The study, which included extensive brain imaging, is the most dramatic demonstration to date of so-called blindsight, the native ability to sense things using the brain's primitive, subcortical — and entirely subconscious — visual system.

Scientists have previously reported cases of blindsight in people with partial damage to their visual lobes. The new report is the first to show it in a person whose visual lobes — one in each hemisphere, under the skull at the back of the head — were completely destroyed. The finding suggests that people with similar injuries may be able to recover some crude visual sense with practice.

"It's a very rigorously done report and the first demonstration of this in someone with apparent total absence of a striate cortex, the visual processing region," said Dr. Richard Held, an emeritus professor of cognitive and brain science at the Massachusetts Institute of Technology, who with Ernst Pöppel and Douglas Frost wrote the first published account of blindsight in a person, in 1973.

The man in the new study, an African living in Switzerland at the time, suffered the two strokes in his 50s, weeks apart, and was profoundly blind by any of the usual measures. Unlike people suffering from eye injuries, or congenital blindness in which the visual system develops abnormally, his brain was otherwise healthy, as were his eyes, so he had the necessary tools to process subconscious vision. What he lacked were the circuits that cobble together a clear, conscious picture.

The research team took brain scans and magnetic resonance images to see the damage, finding no evidence of visual activity in the cortex. They also found no evidence that the patient was navigating by echolocation, the way that bats do. Both the patient, T. N., and the researcher shadowing him walked the course in silence.

The man himself was as dumbfounded as anyone that he was able to navigate the obstacle course.

"The more educated people are," Dr. de Gelder said, "in my experience, the less likely they are to believe they have these resources that they are not aware of to avoid obstacles. And this was a very educated person."

Scientists have long known that the brain digests what comes through the eyes using two sets of circuits. Cells in the retina project not only to the visual cortex — the destroyed regions in this man — but also to subcortical areas, which in T. N. were intact. These include the superior colliculus, which is crucial in eye movements and may have other sensory functions; and, probably, circuits running through the amygdala, which registers emotion.

In an earlier experiment, one of the authors of the new paper, Dr. Alan Pegna of Geneva University Hospitals, found that the same African doctor had emotional blindsight. When presented with images of fearful faces, he cringed subconsciously in the same way that almost everyone does, even though he could not consciously see the faces. The subcortical, primitive visual system apparently registers not only solid objects but also strong social signals.

Dr. Held, the M.I.T. neuroscientist, said that in lower mammals these midbrain systems appeared to play a much larger role in perception. In a study of rats published in the journal Science last Friday, researchers demonstrated that cells deep in the brain were in fact specialized to register certain qualities of the environment.

They include place cells, which fire when an animal passes a certain landmark, and head-direction cells, which track which way the face is pointing. But the new study also found strong evidence of what the scientists, from the Norwegian University of Science and Technology in Trondheim, called “border cells,” which fire when an animal is close to a wall or boundary of some kind.

All of these types of neurons, which exist in some form in humans, may too have assisted T. N. in his navigation of the obstacle course.

In time, and with practice, people with brain injuries may learn to lean more heavily on such subconscious or semiconscious systems, and perhaps even begin to construct some conscious vision from them.

“It’s not clear how sharp it would be,” Dr. Held said. “Probably a vague, low-resolution spatial sense. But it might allow them to move around more independently.”

July 18, 2006

Just Another Face in the Crowd, Indistinguishable Even if It's Your Own

By NICHOLAS BAKALAR

Some people never forget a face. Heather Sellers never remembers one.

She finds it almost impossible to recognize people simply by looking at them. She remembers the books she reads as well as anyone else, but movies and TV shows are impossible to follow because all of the actors' faces seem so similar. She can recall a name or a telephone number with ease, but she is unable to remember her own face well enough to pick it out in a group photograph.

Dr. Sellers, a professor of English at Hope College in Holland, Mich., has a disorder called prosopagnosia, or face blindness, and she has had it since birth. "I see faces that are human," she said, "but they all look more or less the same. It's like looking at a bunch of golden retrievers: some may seem a little older or smaller or bigger, but essentially they all look alike."

Face blindness can be a rare result of a stroke or a brain injury, but a study published in the July issue of The American Journal of Medical Genetics Part A is the first report of the prevalence of a congenital or developmental form of the disorder.

The researchers say the phenomenon is much more common than previously believed: they found that 2.47 percent of 689 randomly selected students in Münster, Germany, had the disorder.

Dr. Thomas Grüter, a co-author of the paper, said there were reasons to believe that the condition was equally common in other populations. "First," he said, "our population was not selected in terms of cognition deficits. And second, a study done by Harvard University with a different diagnostic approach yielded very similar figures."

Dr. Grüter is himself prosopagnosic. His wife and co-author, Dr. Martina Grüter of the Institute for Human Genetics at the University of Münster, did not realize he was face blind until she had known him more than 20 years. The reason, she says, is he was so good at compensating for his deficits.

"How do you recognize a face?" she asked. "For most people, this is a silly question. You just do. But people who have prosopagnosia can tell you exactly why they recognize a person. Thomas consciously looks for the details that others notice unconsciously."

Dr. Thomas Grüter's experience in this respect is typical of people with face blindness. They develop alternate strategies for identifying people — they remember their clothes, mannerisms, gait, hairstyle or voice, and by using such techniques, many can compensate quite well.

This may be one reason why cases of prosopagnosia have so rarely been reported — people simply do not know they have it. For face-blind people, adaptations like these are the only choice; there is no known cure.

“Until very recently, not remembering faces was not considered to be a medical condition,” Dr. Thomas Grüter said. “It was not even known to most physicians as such. The term ‘prosopagnosia’ was not taught to students of medicine or psychology.” Most people “would consider it a bad habit,” he said, “much like forgetting the names of people you are introduced to, or being unable to find your way around town.”

Dr. Martina Grüter said many considered her husband and his father, who is also face blind, to be simply “absent-minded professors” who occasionally may not recognize someone because they are preoccupied with higher thoughts.

People with face blindness can typically understand facially expressed emotions — they know whether a face is happy or sad, angry or puzzled. They can detect subtle facial cues, determine gender and even agree with everyone else about which faces are attractive and which are not. In other words, they see the face clearly, they just do not know whose face they are looking at, and cannot remember it once they stop looking.

Even familiar faces can be unrecognizable. Dr. Sellers, for example, said she could summon no picture in her mind of her own mother’s face.

Dr. Sellers discovered her own problem only a year ago, at the age of 40. She was doing research for a novel involving a character with schizophrenia. “I kept coming across the term ‘face recognition,’ ” she said. “It kept ringing a bell, although the phenomenon is quite different for people with schizophrenia. But once I had the term, I searched for it on the Internet. The minute I knew the concept of face blindness existed, I knew I had it.”

The phenomenon has been investigated with functional MRI brain scans, a form of imaging that shows in real time which parts of the brain are active, and it is known that a part of the brain called the fusiform gyrus responds much more strongly to faces than to other objects.

Researchers have detected differing responses in this part of the brain among people with face blindness compared with normal subjects.

“If you show a normal person two different faces in a row,” said Bradley Duchaine, a lecturer in psychology at University College London, “their brain response is different with each one. With some prosopagnosics, you don’t see this different response. It looks like something is not working in those areas of the brain involved with faces.”

Dr. Duchaine and Ken Nakayama, a psychology professor at Harvard, published a review of developmental prosopagnosia in the April issue of Current Opinion in Neurobiology. They run a Web site devoted to the disorder (www.faceblind.org).

Face blindness differs from pervasive cognitive disorders like autism because it usually involves only one specific symptom. Still, face blindness is sometimes accompanied by other problems, especially difficulty in finding one’s way around or, for example, distinguishing one car or dog from another.

Although the specific gene for the disorder has not been found, evidence is mounting that the trait is inherited. “All pedigrees that we’ve been able to establish so far were compatible with autosomal dominant inheritance,” Dr. Thomas Grüter said.

If this turns out to be true, it means that everyone with the disorder will have at least one affected parent, that men and women will be equally likely to inherit the trait, and that the risk for each child of an affected parent will be one in two.

“But we haven’t found the gene, yet,” Dr. Grüter said, “so we can’t be 100 percent sure.”

Lecture 5
Emotional Representation

With this lecture we make the segue from considering basic sensory representations, and instead start looking at representations that are not tied to any particular sense.

In the case of emotional representations, they can be triggered in any number of ways--by what you see, what you hear, what you think, etc. And like visual representations in the "How" pathway, emotional representations are not necessarily something that we're always consciously aware of.

The first article for today, *In Battle, Hunches Prove to Be Valuable Assets*, makes this glaringly clear. In the story, we learn how soldiers "gut" responses to what they see in the streets and roads of Iraq have been greatly helping the detection of roadside bombs. These "gut" reactions are actually low-level emotional responses, and are triggered outside overt, conscious awareness via a "threat pathway."

In lecture, we'll look at how the so-called "threat pathway" works, wherein we can have rapid, unconscious emotional responses to things we don't necessarily "see."

The second article for today, *Is Hysteria Real? Brain Images Say Yes*, looks at stronger kinds of emotional responses, and in particular, responses that can cause things like paralysis and blindness. Of additional interest here is how our emerging understanding of how emotional representations work is shedding new light on old psychiatric problems.

In lecture, we'll see several video clips of patients who have abnormal emotional representations, one who has problems with excessively-strong emotional responses, and one who has problems tied to an absence of normal emotional responses.

July 28, 2009

BRAIN POWER

In Battle, Hunches Prove to Be Valuable Assets

By BENEDICT CAREY

The sight was not that unusual, at least not for Mosul, Iraq, on a summer morning: a car parked on the sidewalk, facing opposite traffic, its windows rolled up tight. Two young boys stared out the back window, kindergarten age maybe, their faces leaning together as if to share a whisper.

The soldier patrolling closest to the car stopped. It had to be hot in there; it was 120 degrees outside. “Permission to approach, sir, to give them some water,” the soldier said to Sgt. First Class Edward Tierney, who led the nine-man patrol that morning.

“I said no — no,” Sergeant Tierney said in a telephone interview from Afghanistan. He said he had an urge to move back before he knew why: “My body suddenly got cooler; you know, that danger feeling.”

The United States military has spent billions on hardware, like signal jamming technology, to detect and destroy what the military calls improvised explosive devices, or I.E.D.’s, the roadside bombs that have proved to be the greatest threat in Iraq and now in Afghanistan, where Sergeant Tierney is training soldiers to foil bomb attacks.

Still, high-tech gear, while helping to reduce casualties, remains a mere supplement to the most sensitive detection system of all — the human brain. Troops on the ground, using only their senses and experience, are responsible for foiling many I.E.D. attacks, and, like Sergeant Tierney, they often cite a gut feeling or a hunch as their first clue.

Everyone has hunches — about friends’ motives, about the stock market, about when to fold a hand of poker and when to hold it. But United States troops are now at the center of a large effort to understand how it is that in a life-or-death situation, some people’s brains can sense danger and act on it well before others’ do.

Experience matters, of course: if you have seen something before, you are more likely to anticipate it the next time. And yet, recent research suggests that something else is at work, too.

Small differences in how the brain processes images, how well it reads emotions and how it manages surges in stress hormones help explain why some people sense imminent danger before most others do.

Studies of members of the Army Green Berets and Navy Seals, for example, have found that in threatening situations they experience about the same rush of the stress hormone cortisol as any other soldier does. But their levels typically drop off faster than less well-trained troops, much faster in some cases.

In the past two years, an Army researcher, Steven Burnett, has overseen a study into human perception and bomb detection involving about 800 military men and women. Researchers have conducted exhaustive interviews with experienced fighters. They have administered personality tests and measured depth perception, vigilance and related abilities. The troops have competed to find bombs in photographs, videos, virtual reality simulations and on the ground in mock exercises.

The study complements a growing body of work suggesting that the speed with which the brain reads and interprets sensations like the feelings in one’s own body and emotions in the body language of others is central to avoiding imminent threats.

“Not long ago people thought of emotions as old stuff, as just feelings — feelings that had little to do with rational decision making, or that got in the way of it,” said Dr. Antonio Damasio, director of the Brain and Creativity Institute at the University of Southern California. “Now that position has reversed. We understand emotions as practical action programs that work to solve a problem, often before we’re conscious of it. These processes are at work continually, in pilots, leaders of expeditions, parents, all of us.”

Seeing What Others Miss

The patrol through Mosul’s main marketplace never became routine, not once, not after the 10th time or the 40th. A divot in the gravel, a slight shadow in a ditch, a pile of discarded cans; any one could be deadly; every one raised the same question: Is there something — anything — out of place here?

Clearing a road of bombs is one of the least glamorous and most dangerous jobs on the planet. It is also one of the most important. In May, coalition forces found 465 of them in Afghanistan and 333 in Iraq. The troops foiled more than half the traps over all — but about 10 percent of the bombs killed or maimed a soldier or a Marine.

“We had indicators we’d look for, but you’d really have to be aware of everything, every detail,” said Sergeant Tierney, whose unit was working with the Iraqi police in that summer of 2004.

In recent years, the bombs have become more powerful, the hiding places ever more devious. Bombs in fake rocks. Bombs in poured concrete, built into curbs. Bombs triggered by decoy bombs.

“On one route sweep mission, there was a noticeable I.E.D. in the middle of the road, but it was a decoy,” said Lt. Donovan Campbell, who in 2004 led a Marine platoon for seven months of heavy fighting in Ramadi and wrote a vivid book, “Joker One,” about the experience. “The real bomb was encased in concrete, a hundred meters away, in the midst of rubble. One of my Marines spotted it. He said, ‘That block looks too symmetrical, too perfect.’ ”

Lieutenant Campbell had the area cleared and the bomb destroyed.

“Unless you know what rubble in that part of Iraq looks like, there’s no way you’d see that,” he said. “I had two guys, one we called Hound Dog, who were really good at spotting things that didn’t fit.”

The men and women who performed best in the Army’s I.E.D. detection study had the sort of knowledge gained through experience, according to a preliminary analysis of the results; but many also had superb depth perception and a keen ability to sustain intense focus for long periods. The ability to pick odd shapes masked in complex backgrounds — a “Where’s Waldo” type of skill that some call anomaly detection — also predicted performance on some of the roadside bomb simulations.

“Some of these things cannot be trained, obviously,” said Jennifer Murphy, a psychologist at the Army Research Institute and the principal author of the I.E.D. study. “But some may be; these are fighters who become very sensitive to small changes in the environment. They’ll clear the same road every day and notice ridiculously subtle things: this rock was not here yesterday.”

In a study that appeared last month, neuroscientists at Princeton University demonstrated just how sensitive this visual ability is — and how a gut feeling may arise before a person becomes conscious of what the brain has registered.

They had students try to pick out figures — people or cars — in a series of photos that flashed by on a computer screen. The pictures flashed by four at a time, and the participants were told to scan only two of them, either those above and below the center point, or those to the left and right. Eye-tracking confirmed that they did just that.

But brain scans showed that the students’ brains registered the presence of people or cars even when the figures appeared in photos that they were not paying attention to. They got better at it, too, with training.

Some people’s brains were almost twice as fast at detecting the figures as others’. “It appears that the brain primes the whole visual system to be strongly sensitive to categories of visual input,” kinds of things to look for, said Marius V. Peelen, a neuroscientist at Princeton and a co-author of the study with Li Fei-Fei and Sabine Kastner. “And apparently some people’s visual system processes things much faster than others’.”

Something in the Air

A soldier or Marine could have X-ray vision and never see most I.E.D.’s, however. Veterans say that those who are most sensitive to the presence of the bombs not only pick up small details but also have the ability to step back and observe the bigger picture: extra tension in the air, unusual rhythms in Iraqi daily life, oddities in behavior.

“One afternoon I remember turning down a road in Baghdad we were very familiar with, and there’s no one out — very creepy for that time of day,” said Sgt. Don Gomez, a spokesman for the Iraq and Afghanistan Veterans of America, who took part in the invasion and later, in 2005, drove a general in and around Baghdad.

Trash was heaped in a spot along the street where Sergeant Gomez and other drivers in the convoy had not seen it before, so they gave it a wide berth.

“We later called it in to an explosives team and, sure enough, they found one and detonated it — the thing left a huge crater,” he said.

As the brain tallies cues, big and small, consciously and not, it may send out an alarm before a person fully understands why.

In a landmark experiment in 1997, researchers at the University of Iowa had people gamble on a simple card game. Each participant was spotted $2,000 and had to choose cards from any of four decks. The cards offered immediate rewards, of $50 or $100, and the occasional card carried a penalty. But the game was rigged: the penalties in two of the decks were modest and in the other two decks were large.

The pattern was unpredictable, but on average the players reported “liking” some decks better than others by the 50th card to the 80th card drawn before they could fully explain why. Their bodies usually tensed up — subtly, but significantly, according to careful measures of sweat — in a few people as early as about the 10th card drawn, according to the authors, Dr. Damasio; his wife, Dr. Hanna Damasio; Dr. Antoine Bechara; and Dr. Daniel Tranel.

In a study published in May, researchers at King’s College in London did brain scans of people playing the gambling game used in the University of Iowa study. Several brain regions were particularly active, including the orbitofrontal cortex, which is involved in decision making, and the insula, where the brain is thought to register the diverse sensations coming from around the body and interpret them as a cohesive feeling — that cooling sensation of danger. In some brains, the alarm appears to sound earlier, and perhaps more intensely, than average.

Gut feelings about potential threats or opportunities are not always correct, and neuroscientists debate the conditions under which the feeling precedes the conscious awareness of the clues themselves. But the system evolved for survival, and, in some people, is apparently exquisitely sensitive, the findings suggest.

Mastering the Fear

One thing did not quite fit on the morning of Sergeant Tierney’s patrol in Mosul. The nine soldiers left the police station around 9 a.m., but they did not get their usual greeting. No one shot at them or fired a rocket-propelled grenade. Minutes passed, and nothing.

The soldiers walked the road in an odd silence, scanning the landscape for evidence of I.E.D.’s and trying to stay alert for an attack from insurgents. In war, anxiety can run as high as the Iraqi heat, and neuroscientists say that the most perceptive, observant brain on earth will not pick up subtle clues if it is overwhelmed by stress.

In the Army study of I.E.D. detection, researchers found that troops who were good at spotting bombs in simulations tended to think of themselves as predators, not prey. That frame of mind by itself may work to reduce anxiety, experts say.

The brains of elite troops also appear to register perceived threats in a different way from the average enlistee, said Dr. Martin P. Paulus, a psychiatrist at the University of California, San Diego, and the V.A. San Diego Healthcare System. At the sight of angry faces, members of the Navy Seals show significantly higher activation in the insula than regular soldiers, according to a just-completed study.

“The big question is whether these differences perceiving threat are natural, or due to training,” Dr. Paulus said.

That morning in Mosul, Sergeant Tierney gave the command to fall back. The soldier who had asked to approach the car had just time enough to turn before the bomb exploded. Shrapnel clawed the side of his face; the shock wave threw the others to the ground. The two young boys were gone: killed in the blast, almost certainly, he said.

Since then, Sergeant Tierney has often run back the tape in his head, looking for the detail that tipped him off. Maybe it was the angle of the car, or the location; maybe the absence of an attack, the sleepiness in the market: perhaps the sum of all of the above.

“I can’t point to one thing,” he said. “I just had that feeling you have when you walk out of the house and know you forgot something — you got your keys, it’s not that — and need a few moments to figure out what it is.”

He added, “I feel very fortunate none of my men were killed or badly wounded.”

The New York Times
nytimes.com

September 26, 2006

Is Hysteria Real? Brain Images Say Yes

By ERIKA KINETZ

Correction Appended

Hysteria is a 4,000-year-old diagnosis that has been applied to no mean parade of witches, saints and, of course, Anna O.

But over the last 50 years, the word has been spoken less and less. The disappearance of hysteria has been heralded at least since the 1960's. What had been a Victorian catch-all splintered into many different diagnoses. Hysteria seemed to be a vanished 19th-century extravagance useful for literary analysis but surely out of place in the serious reaches of contemporary science.

The word itself seems murky, more than a little misogynistic and all too indebted to the theorizing of the now-unfashionable Freud. More than one doctor has called it "the diagnosis that dare not speak its name."

Nor has brain science paid the diagnosis much attention. For much of the 20th century, the search for a neurological basis for hysteria was ignored. The growth of the ability to capture images of the brain in action has begun to change that situation.

Functional neuroimaging technologies like single photon emission computerized tomography, or SPECT, and positron emission tomography, or PET, now enable scientists to monitor changes in brain activity. And although the brain mechanisms behind hysterical illness are still not fully understood, new studies have started to bring the mind back into the body, by identifying the physical evidence of one of the most elusive, controversial and enduring illnesses.

Despite its period of invisibility, hysteria never vanished — or at least that is what many doctors say.

"People who say it is vanished need to come and work in some tertiary hospitals where they will see plenty of patients," Kasia Kozlowska, a psychiatrist at the Children's Hospital at Westmead in Sydney, Australia, and the author of a 2005 review of the subject in The Harvard Review of Psychiatry, wrote in an e-mail message.

But it did change its name. In 1980, with the publication of the third edition of its Diagnostic and Statistical Manual of Mental Disorders, the American Psychiatric Association officially changed the diagnosis of "hysterical neurosis, conversion type" to "conversion disorder."

"Hysteria, to me, has always been a pejorative term, because of its association with women," said Dr. William E. Narrow, the associate director of the research division of the American Psychiatric Association. "I think the fact we got rid of that word is a good thing."

Unofficially, a host of inoffensive synonyms for "hysterical" have appeared: functional, nonorganic, psychogenic, medically unexplained.

"Medically unexplained" and "functional" encompass a broader swath of distress than just conversion disorder — by some accounts, patients with medically unexplained symptoms account for up to 40 percent of all primary care consultations. But clinicians seeking to avoid the wrath of patients who do not appreciate being told that their debilitating seizures are hysterical in origin also use these blander terms.

Throughout that cloud of shifting nomenclature, people have kept getting sick. "The symptoms themselves have never changed," said Patrik Vuilleumier, a neurologist at the University of Geneva. "They are still common in practice."

Common, perhaps. Well studied, no. There is still no consensus on how conversion disorder should be classified, and not all physicians agree on diagnostic criteria. The epidemiology is hazy; one commonly cited statistic is that conversion disorder accounts for 1 percent to 4 percent of all diagnoses in Western hospitals. In addition, patients have heterogeneous symptoms that affect any number of voluntary sensory or motor functions, like blindness, paralysis or seizures.

The two things all patients have in common are, first, that they are not faking the illness and, second, that despite extensive testing, doctors can find nothing medically wrong with them. The scientific studies that have been conducted on conversion disorder generally have small sample sizes and methodological differences, complicating the comparison of results from different scientific teams and making general conclusions difficult.

"It's one of those woolly areas, and it has this pejorative association," said Peter W. Halligan, a professor of neuropsychology at Cardiff University in Wales and the director of Cardiff's new brain imaging center. "Some people say, 'That's a Freudian throwback, let's go into real science.' "

Hysteria actually predates Freud. The word itself derives from "hystera," Greek for uterus, and ancient doctors attributed a number of female maladies to a starved or misplaced womb. Hippocrates built on the uterine theory; marriage was among his recommended treatments.

Then came the saints, the shamans and the demon-possessed. In the 17th century, hysteria was said to be the second most common disease, after fever. In the 19th century, the French neurologists Jean-Martin Charcot and Pierre Janet laid the groundwork for contemporary approaches to the disease. Then Charcot's student, a young neurologist named Sigmund Freud, radically changed the landscape and, some argue, popularized hysteria.

Freud's innovation was to explain why hysterics swooned and seized. He coined the term "conversion" to describe the mechanism by which unresolved, unconscious conflict might be transformed into symbolic physical symptoms. His fundamental insight — that the body might be playing out the dramas of the mind — has yet to be supplanted.

"Scores of European doctors for generations had thought hysteria was something wrong with the physical body: an unhappy uterus, nerves that were too thin, black bile from the liver," said Mark S. Micale, an associate professor at the University of Illinois at Urbana-Champaign and the author of "Approaching Hysteria" (Princeton University Press, 1994). "Something somatic rooted in the body is giving rise to fits, spells of crying, strange aches and pains. Freud reverses that direction of causality. He says what the cases on his couch in Vienna are about is something in the psyche or the mind being expressed physically in the body."

For neuroscientists now, there is no such division between the physical brain and the mind. The techniques allow scientists to see disruptions in brain function, which lets them sketch a physical map of what might be going on in the minds of modern-day hysterics. Many questions remain unanswered, but the results have begun to suggest ways in which emotional structures in the brain might modulate the function of normal sensory and motor neural circuits.

In the last decade, a number of brain imaging studies have been done on patients suffering from hysterical paralysis. Patients with hysterical paralysis have healthy nerves and muscles. Their problem is not structural but functional: something has apparently gone wrong in the higher reaches of the human mind that govern the conception of movement and the will to move. The dumb actors in this dance are fine; it's the brilliant but complex director that has a problem.

Movement is the product of a multistage process. There is initiation ("I want to move my arm"); then planning, in which the muscles prepare for coordinated action; and finally execution, in which you actually move your arm. In theory, paralysis could result from a malfunction at any stage of this process. (Charcot had a similar idea back in the 1890's.)

In a 1997 paper published in the journal Cognition, Dr. Halligan, of Cardiff, and John C. Marshall and their colleagues analyzed the brain function of a woman who was paralyzed on the left side of her body. First they spent large amounts of money on tests to ensure that she had no identifiable organic lesion.

When the woman tried to move her “paralyzed leg,” her primary motor cortex was not activated as it should have been; instead her right orbitofrontal and right anterior cingulate cortex, parts of the brain that have been associated with action and emotion, were activated. They reasoned that these emotional areas of the brain were responsible for suppressing movement in her paralyzed leg.

“The patient willed her leg to move,” Dr. Halligan said. “But that act of willing triggered this primitive orbitofrontal area and activated the anterior cingulate to countermand the instruction to move the leg. She was willing it, but the leg would not move.”

Subsequent studies have bolstered the notion that parts of the brain involved in emotion may be activated inappropriately in patients with conversion disorder and may inhibit the normal functioning of brain circuitry responsible for movement, sensation and sight.

Such imaging studies may one day be useful as diagnostic tools. Conversion disorder has long been a troubling diagnosis because it hinges on negative proof: if nothing else is wrong with you, maybe you’ve got it.

This has led to some obvious problems. For one thing, it means hysteria has been a dumping ground for the unexplained. A number of diseases, including epilepsy and syphilis, once classified as hysterical, have with time and advancing technology acquired biomedical explanations.

Such specious history makes patients skeptical of the diagnosis, even though the rates of misdiagnosis have gone down. (One widely cited 1965 study reported that over half of the patients who received a diagnosis of conversion disorder would later be found to have a neurological disease; more recent studies put the rate of misdiagnosis between 4 percent and 10 percent.)

“It helps to have some information from functional imaging to support the diagnosis,” Dr. Vuilleumier said. “That helps make the treatment and the diagnosis in the same language. The patient is coming to you with bodily language. The patient is not saying, ‘I’m afraid.’ It’s ‘I’m paralyzed.’ If you can go to the patient with bodily language, it helps.”

Such physical evidence might help hack away at prejudice among medical practitioners too. “Hysterical patients take a bad rap in the medical profession,” said Deborah N. Black, an assistant professor of neurology at the University of Vermont.

“We don’t like them,” Dr. Black said. “Somewhere deep down inside, we really think they’re faking it. When we see a patient with improbable neurological signs, the impulse is to say: ‘Come on, get off it. Sure you can move that leg.’ The other reason we don’t like them is they don’t get better, and when we can’t do well by them we don’t like them.”

The embodiment of distress is common across cultures, and the suffering tend to find acceptable manifestations for their pain. The “jinn” (evil spirits) in Oman are thought to cause convulsions. In Nigeria and India, common somatic symptoms include hot, peppery sensations in the head, hands or feet. Among Caribbean women, “ataque de nervios” — headache, trembling, palpitations, upset stomach — is a common complaint. One study of British veterans found that over the course of the 20th century, post-traumatic disorders did not disappear, but rather changed form: the gut replaced the heart as the most common locus of weakness.

Both its persistence and its pervasiveness suggest that hysteria may be derived from an instinctual response to threat. Total shutdown, in the form of paralysis, for example, is not an entirely untoward or unheard of response to an untenable situation. (Think of deer in the headlights.)

But the broadest consensus within the scientific community does not pertain to what is known about hysteria, but instead to how much remains unknown. “We’re only at the beginning,” Dr.

Halligan said.

Correction: Sept. 30, 2006

A picture in Science Times on Tuesday with an article about new research into hysteria was published in error, based on information from the photo agency. It showed an ancient bas-relief depicting Asclepius, the god of healing and medicine. It was not of Hippocrates, who suggested marriage as a treatment for hysteria.

Lecture 6
Memory Representation

In Lecture 6 we consider some of the more complex forms of memory representation, beyond the classic dichotomies of short- vs. long-term memory and semantic vs. episodic memories discussed in Psych 100, as well as factors influencing the strength of memory representations.

For example, continuing the theme of conscious vs. unconscious representations, memory representations can be either "explicit"/"declaraitve" or "implicit"/"procedural"––the former concern memories for things that can be verbalized, while the later concerns memories for things like how actions are performed.

The first assigned article, *H. M., an Unforgettable Amnesiac, Dies at 82*, helps to highlight this dichotomy of memory types. Specifically, we learn about the famous amnesic H. M., who lost his ability to recall events more than a few minutes old, but was able to learn and maintain information about how to do things like ride bikes, navigate through familiar buildings, and the like.

In the second article for today, *In One Ear and Out the Other*, the focus is on some of the factors influencing how well we remember (or don't remember) things. Critical here is understanding how the strength of memories relates to patterns of information, and why we remember things better that are more easily organized.

In lecture we'll also talk about other, less commonly discussed aspects of memory representations, such as things like the sense of familiarity or "knowing" something to be a fact.

The New York Times
nytimes.com

December 5, 2008

H. M., an Unforgettable Amnesiac, Dies at 82

By BENEDICT CAREY

He knew his name. That much he could remember.

He knew that his father's family came from Thibodaux, La., and his mother was from Ireland, and he knew about the 1929 stock market crash and World War II and life in the 1940s.

But he could remember almost nothing after that.

In 1953, he underwent an experimental brain operation in Hartford to correct a seizure disorder, only to emerge from it fundamentally and irreparably changed. He developed a syndrome neurologists call profound amnesia. He had lost the ability to form new memories.

For the next 55 years, each time he met a friend, each time he ate a meal, each time he walked in the woods, it was as if for the first time.

And for those five decades, he was recognized as the most important patient in the history of brain science. As a participant in hundreds of studies, he helped scientists understand the biology of learning, memory and physical dexterity, as well as the fragile nature of human identity.

On Tuesday evening at 5:05, Henry Gustav Molaison — known worldwide only as H. M., to protect his privacy — died of respiratory failure at a nursing home in Windsor Locks, Conn. His death was confirmed by Suzanne Corkin, a neuroscientist at the Massachusetts Institute of Technology, who had worked closely with him for decades. Henry Molaison was 82.

From the age of 27, when he embarked on a life as an object of intensive study, he lived with his parents, then with a relative and finally in an institution. His amnesia did not damage his intellect or radically change his personality. But he could not hold a job and lived, more so than any mystic, in the moment.

"Say it however you want," said Dr. Thomas Carew, a neuroscientist at the University of California, Irvine, and president of the Society for Neuroscience. "What H. M. lost, we now know, was a critical part of his identity."

At a time when neuroscience is growing exponentially, when students and money are pouring into laboratories around the world and researchers are mounting large-scale studies with powerful brain-imaging technology, it is easy to forget how rudimentary neuroscience was in the middle of the 20th century.

When Mr. Molaison, at 9 years old, banged his head hard after being hit by a bicycle rider in his neighborhood near Hartford, scientists had no way to see inside his brain. They had no rigorous understanding of how complex functions like memory or learning functioned biologically. They could not explain why the boy had developed severe seizures after the accident, or even whether the blow to the head had anything do to with it.

Eighteen years after that bicycle accident, Mr. Molaison arrived at the office of Dr. William Beecher Scoville, a neurosurgeon at Hartford Hospital. Mr. Molaison was blacking out frequently, had devastating convulsions and could no longer repair motors to earn a living.

After exhausting other treatments, Dr. Scoville decided to surgically remove two finger-shaped slivers of tissue from Mr. Molaison's brain. The seizures abated, but the procedure — especially cutting into the hippocampus, an area deep in the brain, about level with the ears — left the patient radically changed.

Alarmed, Dr. Scoville consulted with a leading surgeon in Montreal, Dr. Wilder Penfield of McGill University, who with Dr. Brenda Milner, a psychologist, had reported on two other patients' memory deficits.

Soon Dr. Milner began taking the night train down from Canada to visit Mr. Molaison in Hartford, giving him a variety of memory tests. It was a collaboration that would forever alter scientists' understanding of learning and memory.

"He was a very gracious man, very patient, always willing to try these tasks I would give him," Dr. Milner, a professor of cognitive neuroscience at the Montreal Neurological Institute and McGill University, said in a recent interview. "And yet every time I walked in the room, it was like we'd never met."

At the time, many scientists believed that memory was widely distributed throughout the brain and not dependent on any one neural organ or region. Brain lesions, either from surgery or accidents, altered people's memory in ways that were not easily predictable. Even as Dr. Milner published her results, many researchers attributed H. M.'s deficits to other factors, like general trauma from his seizures or some unrecognized damage.

"It was hard for people to believe that it was all due" to the excisions from the surgery, Dr. Milner said.

That began to change in 1962, when Dr. Milner presented a landmark study in which she and H. M. demonstrated that a part of his memory was fully intact. In a series of trials, she had Mr. Molaison try to trace a line between two outlines of a five-point star, one inside the other, while watching his hand and the star in a mirror. The task is difficult for anyone to master at first.

Every time H. M. performed the task, it struck him as an entirely new experience. He had no memory of doing it before. Yet with practice he became proficient. "At one point he said to me, after many of these trials, 'Huh, this was easier than I thought it would be,' " Dr. Milner said.

The implications were enormous. Scientists saw that there were at least two systems in the brain for creating new memories. One, known as declarative memory, records names, faces and new experiences and stores them until they are consciously retrieved. This system depends on the function of medial temporal areas, particularly an organ called the hippocampus, now the object of intense study.

Another system, commonly known as motor learning, is subconscious and depends on other brain systems. This explains why people can jump on a bike after years away from one and take the thing for a ride, or why they can pick up a guitar that they have not played in years and still remember how to strum it.

Soon "everyone wanted an amnesic to study," Dr. Milner said, and researchers began to map out still other dimensions of memory. They saw that H. M.'s short-term memory was fine; he could hold thoughts in his head for about 20 seconds. It was holding onto them without the hippocampus that was impossible.

"The study of H. M. by Brenda Milner stands as one of the great milestones in the history of modern neuroscience," said Dr. Eric Kandel, a neuroscientist at Columbia University. "It opened the way for the study of the two memory systems in the brain, explicit and implicit, and provided the basis for everything that came later — the study of human memory and its disorders."

Living at his parents' house, and later with a relative through the 1970s, Mr. Molaison helped with the shopping, mowed the lawn, raked leaves and relaxed in front of the television. He could navigate through a day attending to mundane details — fixing a lunch, making his bed — by drawing on what he could remember from his first 27 years.

He also somehow sensed from all the scientists, students and researchers parading through his life that he was contributing to a larger endeavor, though he was uncertain about the details, said Dr. Corkin, who met Mr. Molaison while studying in Dr. Milner's laboratory and who continued to work with him until his death.

By the time he moved into a nursing home in 1980, at age 54, he had become known to Dr. Corkin's M.I.T. team in the way that Polaroid snapshots in a photo album might sketch out a life but not reveal it whole.

H. M. could recount childhood scenes: Hiking the Mohawk Trail. A road trip with his parents. Target shooting in the woods near his house.

"Gist memories, we call them," Dr. Corkin said. "He had the memories, but he couldn't place them in time exactly; he couldn't give you a narrative."

He was nonetheless a self-conscious presence, as open to a good joke and as sensitive as anyone in the room. Once, a researcher visiting with Dr. Milner and H. M. turned to her and remarked how interesting a case this patient was.

"H. M. was standing right there," Dr. Milner said, "and he kind of colored — blushed, you know — and mumbled how he didn't think he was that interesting, and moved away."

In the last years of his life, Mr. Molaison was, as always, open to visits from researchers, and Dr. Corkin said she checked on his health weekly. She also arranged for one last research program. On Tuesday, hours after Mr. Molaison's death, scientists worked through the night taking exhaustive M.R.I. scans of his brain, data that will help tease apart precisely which areas of his temporal lobes were still intact and which were damaged, and how this pattern related to his memory.

Dr. Corkin arranged, too, to have his brain preserved for future study, in the same spirit that Einstein's was, as an irreplaceable artifact of scientific history.

"He was like a family member," said Dr. Corkin, who is at work on a book on H. M., titled "A Lifetime Without Memory." "You'd think it would be impossible to have a relationship with someone who didn't recognize you, but I did."

In his way, Mr. Molaison did know his frequent visitor, she added: "He thought he knew me from high school."

Henry Gustav Molaison, born on Feb. 26, 1926, left no survivors. He left a legacy in science that cannot be erased.

March 17, 2009

BASICS

In One Ear and Out the Other

By NATALIE ANGIER

By all accounts, my grandfather Nathan had the comic ambitions of a Jack Benny but the comic gifts of a John Kerry. Undeterred, he always kept a few blank index cards in his pocket, so that if he happened to hear a good joke, he'd have someplace to write it down.

How I wish I knew where Nathan stashed that deck.

Like many people, I can never remember a joke. I hear or read something hilarious, I laugh loudly enough to embarrass everybody else in the library, and then I instantly forget everything about it — everything except the fact, always popular around the dinner table, that "I heard a great joke today, but now I can't remember what it was."

For researchers who study memory, the ease with which people forget jokes is one of those quirks, those little skids on the neuronal banana peel, that end up revealing a surprising amount about the underlying architecture of memory.

And there are plenty of other similarly illuminating examples of memory's whimsy and bad taste — like why you may forget your spouse's birthday but will go to your deathbed remembering every word of the "Gilligan's Island" theme song. And why you must chop a string of data like a phone number into manageable and predictable chunks to remember it and will fall to pieces if you are in Britain and hear a number read out as "double-four, double-three." And why your efforts to fill in a sudden memory lapse by asking your companions, "Hey, what was the name of that actor who starred in the movie we saw on Friday?" may well fail, because (what useless friends!) now they've all forgotten, too.

Welcome to the human brain, your three-pound throne of wisdom with the whoopee cushion on the seat.

In understanding human memory and its tics, Scott A. Small, a neurologist and memory researcher at Columbia, suggests the familiar analogy with computer memory.

We have our version of a buffer, he said, a short-term working memory of limited scope and fast turnover rate. We have our equivalent of a save button: the hippocampus, deep in the forebrain is essential for translating short-term memories into a more permanent form.

Our frontal lobes perform the find function, retrieving saved files to embellish as needed. And though scientists used to believe that short- and long-term memories were stored in different parts of the brain, they have discovered that what really distinguishes the lasting from the transient is how strongly the memory is engraved in the brain, and the thickness and complexity of the connections linking large populations of brain cells. The deeper the memory, the more readily and robustly an ensemble of like-minded neurons will fire.

This process, of memory formation by neuronal entrainment, helps explain why some of life's offerings weasel in easily and then refuse to be spiked. Music, for example. "The brain has a strong propensity to organize information and perception in patterns, and music plays into that inclination," said Michael Thaut, a professor of music and neuroscience at Colorado State University. "From an acoustical perspective, music is an overstructured language, which the brain invented and which the brain loves to hear."

A simple melody with a simple rhythm and repetition can be a tremendous mnemonic device. "It would be a virtually impossible task for young children to memorize a sequence of 26 separate letters if you just gave it to them as a string of information," Dr. Thaut said. But when the alphabet is set to the tune of the ABC song with its four melodic phrases, preschoolers can learn it with ease.

And what are the most insidious jingles or sitcom themes but cunning variations on twinkle twinkle ABC?

Really great jokes, on the other hand, punch the lights out of do re mi. They work not by conforming to pattern recognition routines but by subverting them. "Jokes work because they deal with the unexpected, starting in one direction and then veering off into another," said Robert Provine, a professor of psychology at the University of Maryland, Baltimore County, and the author of "Laughter: A Scientific Investigation." "What makes a joke successful are the same properties that can make it difficult to remember."

This may also explain why the jokes we tend to remember are often the most clichéd ones. A mother-in-law joke? Yes, I have the slot ready and labeled.

Memory researchers suggest additional reasons that great jokes may elude common capture. Daniel L. Schacter, a professor of psychology at Harvard and the author of "The Seven Sins of Memory," says there is a big difference between verbatim recall of all the details of an event and gist recall of its general meaning.

"We humans are pretty good at gist recall but have difficulty with being exact," he said. Though anecdotes can be told in broad outline, jokes live or die by nuance, precision and timing. And while emotional arousal normally enhances memory, it ends up further eroding your attention to that one killer frill. "Emotionally arousing material calls your attention to a central object," Dr. Schacter said, "but it can make it difficult to remember peripheral details."

As frustrating as it can be to forget something new, it's worse to forget what you already know. Scientists refer to this as the tip-of-the-tongue phenomenon, when you know something but can't spit it out, and the harder you try the more noncompliant the archives.

It's such a virulent disorder that when you ask friends for help, you can set off so-called infectious amnesia. Behind the tying up of tongues are the too-delicate nerves of our brain's frontal lobes and their sensitivity to anxiety and the hormones of fight or flight. The frontal lobes that rifle through stored memories and perform other higher cognitive tasks tend to shut down when the lower brain senses danger and demands that energy be shunted its way.

For that reason anxiety can be a test taker's worst foe, and the anxiety of a pop quiz from a friend can make your frontal lobes freeze and your mind go blank. That is also why you'll recall the frustratingly forgotten fact later that night, in the tranquillity of bed.

Memories can be strengthened with time and practice, practice, practice, but if there's one part of the system that resists improvement, it's our buffers, the size of our working memory on which a few items can be temporarily cached. Much research suggests that we can hold in short-term memory only five to nine data chunks at a time.

The limits of working memory again encourage our pattern-mad brains, and so we strive to bunch phone numbers into digestible portions and could manage even 10-digit strings when they had area codes with predictable phrases like a middle zero or one. But with the rise of atonal phone numbers with random strings of 10 digits, memory researchers say the limits of working memory have been crossed. Got any index cards?

Lecture 7
Language Representation

Language is perhaps the most diverse and complex of all cognitive processes, and involves a myriad of different underlying representations to operate normally. In Lecture 7 we'll touch on a few key ideas concerning these representations, as well as how they influence our thoughts and perceptions.

The first article for today, *Workings of Split Brain Challenge Notions of How Language Evolved*, highlights how different aspects of language––in this case, speaking and understanding language vs. reading and writing it––are controlled by different representations housed in different parts of the brain. Critical to pull away from the article is what this appears to tell us about the evolution of language-related abilities.

In terms of what various representations makeup our language abilities, we'll look at a few different neurological patients, all of whom have difficulties with very specific aspects of language stemming from the selective loss of representations due to brain damage/disease.

For example, we'll see an *anomia* patient, someone who has problems with representing just the names of things, and a *semantic dementia* patient, someone who has problems with the meanings of words.

In the second article for today, *When Language Can Hold the Answer*, we transition to a particularly interesting aspect of language, namely: How does language itself shape how we think and how we structure and organize our perceptions of the world.

In lecture, we'll go over several of the studies discussed in this second article, and outline how language does vs. doesn't influence thought and perception.

Workings of Split Brain Challenge Notions of How Language Evolved

By SANDRA BLAKESLEE
Published: Tuesday, November 26, 1996

LAST year, a 43-year-old woman who had suffered from terrible seizures since she was 16 underwent surgery to cut the thick band of fibers connecting the left and right hemispheres of her brain. The treatment worked as hoped, stopping epileptic seizures from spreading throughout her brain, and protecting her from the head injuries and burns she had suffered from falls when she suddenly lost all muscle control.

There was only one problem. After the surgery, the woman, identified in research reports only as V. J., could no longer write -- not her name, not familiar phrases, not at all. But she could speak and understand spoken language with no difficulty.

Splitting the two halves of the brain surgically has given neuroscientists many insights into the workings of the two hemispheres. This particular accident of surgery, says a prominent neuroscientist, challenges standard theories about how language abilities -- speaking, reading and writing -- evolved and are organized in the brain.

What is significant in V. J.'s case is that her writing activity seems to be controlled completely by the right brain hemisphere. The prevailing theory, supported by earlier findings in patients with the two hemispheres separated, is that with very few exceptions virtually all language abilities are found in the left hemisphere, said Dr. Michael Gazzaniga, head of the cognitive neuroscience program at Dartmouth College in Hanover, N.H.

This is true even for people who are left-handed, like V. J., even thought the muscular activity of writing with the left hand is controlled by the right brain hemisphere. This is the first time that speaking has been shown to lie on one side of the brain and writing on the other, Dr. Gazzaniga said. V. J. apparently has some reading ability on both sides of the brain.

This dissociation, described at a Society for Neuroscience meeting in Washington last week, has thus far been shown only in this one person, but may well apply more broadly to other left-handed people, Dr. Gazzaniga said. In the brain sciences, he said, insights from one case have often led to general principles.

The study of V. J. was carried out by Dr. Gazzaniga and a colleague, Dr. Kathleen Baynes, an assistant professor of neurology at the University of California at Davis Center for Neuroscience.

That talking is in the left and writing in the right side of the brain in this woman is "really fascinating," said Dr. Steven Pinker, a linguist at the Massachusetts Institute of Technology. It suggests that reading and writing arose separately from spoken language and may be wired up in the brain wherever there are "spare areas," he said. In this case, the hookups for writing were made in the right hemisphere.

"It's a very interesting observation," said Dr. Marcus Raichle, an expert on brain imaging at Washington University in St. Louis. There has never been a systematic effort to study left-handed people using brain imaging techniques, he said, and so no one has really tried to ferret out the circuitry for writing as opposed to reading and speaking.

The standard theory has been that language evolved about 100,000 years ago, and the improved communication helped those individuals who had it thrive. The ability to speak thus spread quickly through the human species. Reading and writing arose less than 10,000 years ago, presumably as a cultural invention taking advantage of an underlying biological ability that was already in place, not as part of biological evolution.

The predominant idea has been that reading and writing were laid on top of speech in the left hemisphere, tightly interconnected. But the new research suggests that these human inventions can hop around in the brain, even to the opposite side, Dr. Gazzaniga said.

In all people, the right side of the brain controls the left half of the body. The left side of the brain handles the right side of the body. Similarly, in vision, the right hemisphere receives information from the eyes about all objects and movements detected in the left visual field, the space to the left side of the head. Information from the right visual field is transmitted to the left hemisphere. Both halves share and integrate information to give a complete picture of the world.

In most humans, including congenitally deaf people who use sign language, all language abilities -- speaking, reading and writing -- are grounded in the left hemisphere.

About 10 percent of people are left-handed, Dr. Gazzaniga said. Eighty percent of them have all language abilities localized in the left hemisphere, just like righties. Studies have shown that the motor ability of the left hand (and right hemisphere) for writing is still dependent on the left hemisphere's language ability.

The other lefties fall into two groups, Dr. Gazzaniga said. Some are completely flipped in terms of hemispheric dominance -- all language functions are in the right side and spatial abilities are in the left side. And the last group has shown a puzzling mixed pattern, perhaps like that of V. J. But nobody has tracked these exceptions carefully enough to analyze where, exactly, language abilities lay, until this case, Dr. Gazzaniga said.

V. J. is the first person to shed real light on the problem, said Dr. Baynes, Dr. Gazzaniga's colleague. Dr. Baynes put V. J. in front of a screen onto which words -- nouns, verbs and adjectives -- were flashed to each side of her brain independently. Her hands rested below the screen, shielded so that her eyes could not see them. Each hand held a pen over a tablet of paper.

"When a word appeared, V. J. was instructed to write what she saw on the screen and to tell us what she saw," Dr. Baynes said.

When a word was shown to the left hemisphere -- the one with spoken language -- she could read the word, say it and spell it out loud, Dr. Baynes said. But she could not write it down. Attempts at writing were illegible.

(Because her brain was disconnected, she would have to make an effort to use her right hand to try to write what she saw in this part of the experiment, Dr. Baynes said. It was difficult to imagine this, but her left side and left hand were totally unaware of what was going on.)

When words were shown to the right hemisphere, V. J. was stumped, Dr. Baynes said. She would look at the word and say, "Um, I think there's something there but I can't tell what it is." She could not read, speak or spell the words. But amazingly she could write them down.

"She'd pick up the pencil and boom, write out the words, no problem," Dr. Gazzaniga said. "It is just astounding. Here is the executive writing system acting outside the system that can actually speak with all the usual phonological mechanisms.

"At what level is the right hemisphere able to do this?" Dr. Gazzaniga continued. "It may be simple copying and not a real expression of normal writing." But in further tests, not yet submitted for publication, it appears that the true writing system is involved, he said.

The next step will be to test V. J. in more detail, Dr. Gazzaniga said, "to see what she can and cannot do." It would also be nice to begin testing left-handed people with functional magnetic resonance imaging, which detects individual differences in brain wiring, he said. V. J. may be a very rare case or she may be proof of a larger phenomenon -- that newer linguistic skills like writing will be laid down wherever the brain has spare room.

Diagram: "Language on Two Sides of the Brain" The case of a left-handed woman who had the halves of her brain surgically separated has challenged notions of where in the brain the capacity for language resides. When a word was presented to her right visual field and thus processed by the left half of her brain she could say it, but not write it. When a word was presented to her left visual field and thus processed by the right half of her brain she could write it, but not say it. Researchers say this is the first clear evidence that in some people the capacities for spoken and written language may be located in different halves of the brain. (Source: Dr. Michael S. Gazzaniga)

A version of this article appeared in print on Tuesday, November 26, 1996, on section C page 3 of the New York edition.

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April 22, 2008

When Language Can Hold the Answer

By CHRISTINE KENNEALLY

Faced with pictures of odd clay creatures sporting prominent heads and pointy limbs, students at Carnegie Mellon were asked to identify which “aliens” were friendly and which were not.

The students were not told that the aliens fell naturally into two groups, although the differences were subtle and not easy to describe.

Some had somewhat lumpy, misshapen heads. Others had smoother domes. After students assigned each alien to a category, they were told whether they had guessed right or wrong, learning as they went that smooth heads were friendly and lumpy heads were not.

The experimenter, Dr. Gary Lupyan, who is now doing postdoctoral research at Cornell, added a little item of information to one test group. He told the group that previous subjects had found it helpful to label the aliens, calling the friendly ones “leebish” and the unfriendly ones “grecious,” or vice versa.

When the participants found out whether their choice was right or wrong, they were also shown the appropriate label. All the participants eventually learned the difference between the aliens, but the group using labels learned much faster. Naming, Dr. Lupyan concluded, helps to create mental categories.

The finding may not seem surprising, but it is fodder for one side in a traditional debate about language and perception, including the thinking that creates and names groups.

In stark form, the debate was: Does language shape what we perceive, a position associated with the late Benjamin Lee Whorf, or are our perceptions pure sensory impressions, immune to the arbitrary ways that language carves up the world?

The latest research changes the framework, perhaps the language of the debate, suggesting that language clearly affects some thinking as a special device added to an ancient mental skill set. Just as adding features to a cellphone or camera can backfire, language is not always helpful. For the most part, it enhances thinking. But it can trip us up, too.

The traditional subject of the tug of war over language and perception is color. Because languages divide the spectrum differently, researchers have asked whether language affected how people see color. English, for example, distinguishes blue from green. Most other languages do not make that distinction. Is it possible that only English speakers really see those colors as different?

Past investigations have had mixed results. Some experiments suggested that color terms influenced people in the moment of perception. Others suggested that the language effect kicked in only after some basic perception occurred.

The consensus was that different ways to label color probably did not affect the perception of color in any systematic way.

Last year, Lera Boroditsky and colleagues published a study in The Proceedings of the National Academy of Sciences showing that language could significantly affect how quickly perceptions of color are categorized. Russian and English speakers were asked look at three blocks of color and say which two were the same.

Russian speakers must distinguish between lighter blues, or goluboy, and darker blues, siniy, while English speakers do not have to, using only “blue” for any shade. If the Russians were shown three blue squares with two goluboy and one siniy, or the other way around, they picked the two matching colors faster than if all three squares were shades from one blue group. English makes no fundamental distinction between shades of blue, and English speakers fared the same no matter the mix of shades.

In two different tests, subjects were asked to perform a nonverbal task at the same time as the color-matching task. When the Russians simultaneously carried out a nonverbal task, they kept their color-matching advantage. But when they had to perform a verbal task at the same time as color-matching, their advantage began to disappear. The slowdown suggested that the speed of their reactions did not result just from a learned difference but that language was actively involved in identifying colors as the test was happening. Two other recent studies also demonstrated an effect of language on color perception and provided a clue as to why previous experimental results have been inconclusive. In The Proceedings of the National Academy of Sciences, Dr. Paul Kay of the International Computer Science Institute at Berkeley and colleagues hypothesized that if language is dominant on the left side of the brain, it should affect color perception in the right visual field. (The right visual field is connected to the left side of the brain, and vice versa.)

English-speaking subjects were shown a ring of 12 small squares that were all the same color except an odd one on the left or the right. If the odd square was shown to the right visual field and it was from a completely different color category in English, like a green square compared to the ring of blue squares, then subjects were quick to identify it as different. If the odd square shown to the right visual field was the same basic color as the ring of squares, perhaps just being a different shade of blue, subjects were not as fast to recognize the difference. If the odd square was shown to the left visual field, it didn’t matter if it was a different color or only a different shade.

The extent to which language affected color perception depended on the side of the brain being used.

Dr. Lupyan has also investigated how quickly the effects of language might come into play. In one experiment, he asked students to look at a computer screen that had “2” once and “5” many times in a circle. Over hundreds of trials where the positions of the numbers changed, the students were asked to “find the target” or “find the ‘two.’ ”

Whenever subjects heard the word “two,” they always found the numeral faster. They found the “2” even faster when instructed to “ignore the 5s,” as opposed to “ignore the distracters.” In these cases, Dr. Lupyan suggested, language is “greasing the wheels of perception.”

Language also has a significant role in seeing and remembering where objects are in space. Dr. Dedre Gentner at Northwestern and her colleagues conducted experiments on the spatial reasoning of hearing children and children who “home-sign.”

Home-signers have hearing parents, but they are congenitally deaf and have never been taught a sign language, according to Susan Goldin-Meadow, an expert in homesign. The gestural language they develop is invented solely by themselves. In the past, Dr. Gentner and her colleagues had observed that children who home-sign did not appear to invent gestures for locations spontaneously.

The children were shown two side-by-side boxes. Internally, each box was divided in three. In each space was a card.

During each trial, the experimenter took a card from the first box and showed the child that it had a special star on the back. Replacing it in the first box in the same space, the experimenter asked the child to find where the special card would be in the second box. Essentially, the children were asked to map the position of the target card in the first box to the same position in the second.

The researchers found that children without words for spatial relationships, whether young or home-signers, had much more trouble finding the special card in the second box than older hearing children who had learned the relevant words.

For young hearing children, exposure to spatial language in the experiment strongly influenced the success rate. If the experimenter used spatial terms when speaking to a child, saying, “I’m putting the card in the top” (or “middle” or “bottom”), as opposed to, “I’m putting the card here,” the children were much likelier to find the correct spot in the second box.

The effect lasted not just through the experiment, but until at least two days later, when the children were retested.

“By giving us a framework for marshaling our thoughts, language does a lot for us,” Professor Gentner said. “Because spatial language gives us symbols for spatial patterns, it helps us carve up the world in specific ways.”

There is other evidence that a lack of spatial language is not a handicap in solving spatial problems. In 2006, scientists published an experiment that investigated the ability of the Amazonian Munduruku tribe to understand and manipulate geometric relationships for which their language has no words. The Munduruku performed about the same as Americans whose language is rich with spatial terms.

This separation of language and thought is emphasized in a recent book by Steven Pinker, at Harvard University, a skeptic of “neo-whorfianism.” In “The Stuff of Thought: Language as a Window Into Human Nature,” Pinker explores the complicated ways that language and thought relate to each other. He cautions against confusing the “many ways in which language connects to thought.” “Language surely affects thought,” he writes, but he argues that there is little evidence for the claims that language can force people to have particular thoughts or make it impossible for them to think in certain ways. With numbers, the importance of language evidence is much clearer. It appears that the ability to count is necessary to deal with large, specific numbers. And the only way to count past a certain point is with language.

Elizabet Spaepen, a doctoral student at the University of Chicago, examined the ability of home-signing adults in Nicaragua to use numbers. Ms. Spaepen emphasized that although the subjects had never been taught a formal sign language, including counting, they were fully integrated in society. They have jobs and they are paid as much as hearing or signing adults.

Ms. Spaepen asked the home-signers to match an array of objects laid out before them. For example, she placed plastic discs on a table and encouraged the subjects to lay out the same number of discs. If the number was small, as in one, two or three, the home-signers got it right all the time.

If the number was larger, the home-signers got it right just approximately. If Ms. Spaepen laid out four discs, the subjects might lay out five or six. Although they were never quite right, they were never completely wrong. The home-signers would not lay out one or 15 discs in response to four.

Scientists have shown that the understanding of small, specific numbers is a trait with long evolutionary history. Monkeys and other animals can compute the exact number of a small set of objects at a glance without explicitly counting. The ability is called subitization.

Ms. Spaepen suggests that when home-signers correctly use small numbers, they are relying on this innate trait. The count list we learn with most languages (some languages do not have a count list or words for specific numbers greater than three) has enabled humans to build on this heritage, taking the specific and uniform gap between “one” and “two” and “two” and “three,” and extending it out through four and higher, theoretically to infinity.

In another experiment, Dr. Lupyan showed subjects a series of chairs and tables using pictures from the Ikea catalog. Some subjects were asked to press a button indicating that the picture was of a table or a chair. Other subjects pressed a button to make a nonverbal judgment about the pictures, for example, to indicate whether they liked them or not. Dr. Lupyan found that the subjects who used words to label the objects had more trouble remembering whether they'd seen a specific chair before than subjects who had only pressed a button in a nonverbal task.

Language helps us learn novel categories, and it licenses our unusual ability to operate on an abstract plane, Dr. Lupyan said. The problem is that after a category has been learned, it can distort the memory of specific objects, getting between us and the rest of the nonabstract world.

Lecture 8
Self Representation

In Lecture 8, we conclude our study of basic cognitive representations by looking at perhaps the most interesting ones of all––those associated with our sense of who we are. We'll approach this topic from two different angles.

In the first article for today, *After Injury, Fighting to Regain a Sense of Self*, we learn about a young university student who sustained a serious brain injury via a motorcycle accident. In addition to manifesting symptoms of Capgras' Syndrome (as discussed in Lecture 5), he has trouble understanding who he is. So in this sense, we see how we can have representations associated with self identity.

Expanding on this form of "self" representation in class, we'll consider a case of *mirror self-misidentification*, as taken from the movie *Finding Nemo*, as we'll as an example of *alien hand syndrome.* These problems illustrate how our sense of self includes not just our own identify, but recognizing who we are and that we are actually the owners of our body and all of our body parts.

In the second article, *Out-of-Body Experience? Your Brain Is to Blame*, we explore a second core aspect of self representation. In this case, it concerns how our sense of a single, unified physical self is actually the result of combining or "integrating" a myriad of different representations, such as those associated with our bodies (Lecture 3) and vision (Lecture 4). In the article, we'll learn how we can have all kinds of odd experiences when our visual representations of where our bodies are in space don't match up with where our bodies actually are in space.

In lecture, we'll highlight this idea by looking at a phantom limb patient (as first seen in Lecture 3) and learning how pain in his phantom limb can be mitigated by tricking his brain into thinking it actually sees the missing limb.

August 9, 2009

BRAIN POWER

After Injury, Fighting to Regain a Sense of Self

By BENEDICT CAREY

WEEDSPORT, N.Y. — Adam Lepak looked over at his mother and said, "You're fake."

It was a Tuesday in July, late, and Cindy Lepak could see that her 19-year-old son was exhausted. Long days like this one, with hours of physical therapy and memory drills — I had a motorcycle accident, I hit my head and have trouble remembering new things, I had a motorcycle accident — often left him making these accusations.

"What do you mean 'fake,' Adam?" she said.

He hung his head. "You're not my real mom," he said. His voice changed. "I feel sorry for you, Cindy Lepak. You live in this world. You don't live in the real world."

Doctors have known for nearly 100 years that a small number of psychiatric patients become profoundly suspicious of their closest relationships, often cutting themselves off from those who love them and care for them. They may insist that their spouse is an impostor; that their grown children are body doubles; that a caregiver, a close friend, even their entire family is fake, a duplicate version.

Such delusions are often symptoms of schizophrenia. But in the last decade or so, researchers have documented similar delusions in hundreds of people who are not schizophrenic but have neurological problems including dementia, brain surgery and traumatic blows to the head.

A small group of brain scientists is now investigating misidentification syndromes, as the delusions are called, for clues to one of the most confounding problems in brain science: identity. How and where does the brain maintain the "self"?

What researchers are finding is that there is no single "identity spot" in the brain. Instead, the brain uses several different neural regions, working closely together, to sustain and update the identities of self and others. Learning what makes identity, researchers say, will help doctors understand how some people preserve their identities in the face of creeping dementia, and how others, battling injuries like Adam's, are sometimes able to reconstitute one.

"When I wrote up my first case like this back in 1987, no one was much interested; it was a curiosity," said Dr. Todd E. Feinberg, a neurologist and psychiatrist at the Albert Einstein College of Medicine and Beth Israel Medical Center, who just published a book on the topic, "From Axons to Identity." (Axons are nerve fibers.)

"Now there's an explosion of interest in these cases," Dr. Feinberg said, "because of their relation to the self, to the neurobiology of identity — to what it means to be human."

Who Is That?

"Who is that, Adam?" a physical therapist named Mike said on a recent morning, supporting the young man's lean frame in front of a full-length mirror; a nurse supported him from the other side. "Who do you see there?"

"Mike."

"That's right," said Pat Taisey, the nurse, who spends most days with him at home when the Lepaks are at work. "But who else do you see in the mirror, Adam?"

"You. Pat."

"Yes, but who else?" she said.

An uncertain smile creased Adam's face.

Two years ago, it was not a hard question to answer. He was a first-year college student with a girlfriend, a tight group of buddies. A vegetarian; a fitness nut; a master of sarcasm, of the lunatic prank. He was the drummer for Sacred Pledge, a "straight edge" band (no drugs, no alcohol, no promiscuous sex) in the Syracuse area.

After his senior year of high school in Weedsport, he climbed into a van and drove with the band across the country, playing clubs and parties, sleeping on people's floors, Dumpster diving for food, sleeping on the beach in California.

"I was so happy we let him go," Ms. Lepak said. "He decided that that life wasn't for him." He enrolled at Cayuga Community College in nearby Auburn, N.Y.

He was running late to class in October 2007, flying over a slight rise on Weedsport Sennett Road on a Honda Interceptor motorcycle, when he saw — too late — a car in his lane, stopped to make a turn. He dodged the car; he was wearing a helmet, but he lost the bike and tumbled hard over the asphalt. He spent most of the next six months in a near-vegetative state, mute and virtually immobile.

The diagnosis was diffuse axonal injury. "The textbook definition is essentially a blow that shuts down the bundle of wires responsible for keeping us conscious," said Dr. Jonathan Fellus, a neurologist at Kessler Institute for Rehabilitation in West Orange, N.J., who has overseen Adam's gradual recovery. "It's as if the major highways have taken a hit, and now the brain has to use back roads to function. But every brain responds differently. I have given up making predictions."

Researchers who have taken images of the brain as it processes information related to personal identity have noticed that several areas are particularly active. Called cortical midline structures, they run like an apple core from the frontal lobes near the forehead through the center of the brain.

These frontal and midline areas communicate with regions of the brain that process memory and emotion, in the medial temporal lobe, buried deep beneath each ear. And studies strongly suggest that in delusions of identity, these emotion centers are either not well connected to frontal midline areas or not providing good information. Mom looks and sounds exactly like Mom, but the sensation of her presence is lost. She seems somehow unreal.

The classic delusion of identification is called Capgras syndrome, after the French psychiatrist Dr. Jean Marie Joseph Capgras, who with Dr. Jean Reboul-Lachaux described in 1923 the case of a 53-year-old patient "who transformed everyone in her entourage, even those closest to her, such as her husband and daughter, into various and numerous doubles."

In an analysis of such cases published in January in the journal Neurology, Dr. Orrin Devinsky, a neurologist at New York University, documented that people with the delusion typically have more damage to their right hemisphere than their left. Linear reasoning and language tend to be predominantly left-hemisphere functions, while holistic judgments — of intonation, of emphasis — tend to be processed more in the right. Dr. Devinsky argues that when people lack a familiar emotional glow in the company of a parent or loved one, the left hemisphere, unchecked by a damaged right, resolves the conflict with its categorical logic. The person must be an impostor.

"And if you have other damage in the cortical areas that check reality, that make judgments about what's right and wrong, then you have no way to correct that error," Dr. Devinsky said.

On good days, like that morning in physical therapy, Adam's emotional centers appeared to be joining the working circuits of his brain. As he stared into the mirror, his smile changed from uncertain to mischievous, and he answered the question.

"Me?" he said.

Brother, Friend and Son

After the accident, Adam's younger brother, Nick, helped out as much as he could, and one way to do that, experts say, is simply to act like a brother again. Nick did his best.

"I got him down on the floor in the kitchen the other day, and held an ice cube over his head and let it drip on his forehead; kind of a Chinese water torture thing," Nick said. "He went crazy, he was so mad. He had a great day after that, though."

No one knows what treatments or exercises will drive an injured brain to preserve or reconstruct a coherent identity — to pave its neural back roads. But neuroscientists generally agree that it can do so. The brain is "plastic," recent research suggests; intact areas can recruit nearby, healthy brain tissue to bypass damage and compensate for lost function.

It does not seem to happen, however, without effort; to reroute signal traffic down back channels, the brain needs traffic, scientists say. It needs to be active, solving problems, meeting social expectations.

For people recovering from a severe brain injury, several recent experiments suggest that there is some promise in hitting it hard with what it has lost, contact with its familiar, social environment. In one 2005 brain imaging study, neuroscientists in New York found that the sound of a loved one's voice activated widely distributed circuits in the brains of two severely brain-injured patients who were only occasionally able to respond to commands. Last year, a team of Spanish neuroscientists duplicated the finding.

In studies of dementia, researchers have found that some people who are lucid until a very old age have brains that appear riddled with Alzheimer's disease. Many of them remain social to the end, engaged in regular card games or debates with friends who make mental demands of them.

During his first six months at Kessler in New Jersey, as he lay mute, Adam heard many familiar voices. His mother was at his side every day; his father made the four-hour drive from New York every weekend. His girlfriend, Sarah Huey, visited with her mother every other weekend. His friends came in groups. In time he began to move his thumb in response to questions and commands — a sure sign that he had entered a minimally conscious state, a necessary transition to recovering full conscious awareness. "It was very tough at the beginning," said his father, Mike Lepak. "You just hope you can somehow jump-start his brain."

At home he has experienced another kind of familiarity and begun to walk, unsteadily, and talk, so far in brief sentences. His mother has handled much of the hard labor of caring for him at home: memory drills, the constant questions, the hiring of daytime care, haggling with insurers. The Lepaks have made do with a combination of private insurance and state and federal aid. His father built a small addition to the house to make it easier for Adam to navigate; he still spends much of his time in a wheelchair.

Yet as much as possible, the people in his life have begun to treat him like Adam. "I figure this is my opportunity to get back for all the stuff he did to me," Nick said. "He's my brother."

His friends frequently drop by and take him out to get lunch, to crack him up.

Sitting around the dining room table on a recent afternoon, eight of them told stories about the years just before the accident. The center of attention seemed sullen at first. He stirred after hearing a few familiar stories. The one about nabbing bags of stale doughnuts from a local coffee shop and whipping them at taxis. The time he knocked a friend off a chair with a well-placed firecracker. The laughter escalated with each story, Adam showed a smile, and then, after a while, the group grew quiet.

"You got a story, Adam?" said one friend, Sean Steinbacher.

"Yeah, speak up," said another, Shane DiRisio. He was not kidding. "What's wrong with you, Adam? You don't have a story?"

He did not. He had a comment. He looked up at them affectionately. "These guys," he said with a smile, "all suck."

Starting Over

Dr. Feinberg of Albert Einstein sees delusions of identification as primitive psychological defenses, as a result of injuries in the right frontal lobes that most such patients are struggling with. Such defenses include denial of a disability, the projection of the problem onto others or the fantasy that daily life is somehow unreal.

"These are the defenses of a child of age 3 to 8," Dr. Feinberg said. "But it's important to understand that these defenses are a positive adaptation. The brain is fighting for survival."

The ability to inhibit those defenses, to understand that not everyone shares them, is evidence that the frontal areas of the brain are coming back online, he said.

In recent weeks, Adam has been having fewer delusions. On an hourlong drive in July to a ranch in Groton, N.Y., that offers horseback riding for people with disabilities, Adam's mind was churning. "Ma," he asked repeatedly. "What happened to me?"

“You tell me, Ad,” his mother said at one point. “You just told me a minute ago. You know what happened. You know.”

“I don’t want to tell you,” he said.

“Why not?”

“Because you’ll think I’m crazy,” he said.

“No I won’t. Tell me.”

“No,” said Adam Lepak, and he looked out the window for a while, seemingly lost in thought.

“Ma?” he said, still staring out the window.

“Yes, Ad.”

“I think I had a motorcycle accident.”

The New York Times
nytimes.com

October 3, 2006

Out-of-Body Experience? Your Brain Is to Blame

By SANDRA BLAKESLEE

They are eerie sensations, more common than one might think: A man describes feeling a shadowy figure standing behind him, then turning around to find no one there. A woman feels herself leaving her body and floating in space, looking down on her corporeal self.

Such experiences are often attributed by those who have them to paranormal forces.

But according to recent work by neuroscientists, they can be induced by delivering mild electric current to specific spots in the brain. In one woman, for example, a zap to a brain region called the angular gyrus resulted in a sensation that she was hanging from the ceiling, looking down at her body. In another woman, electrical current delivered to the angular gyrus produced an uncanny feeling that someone was behind her, intent on interfering with her actions.

The two women were being evaluated for epilepsy surgery at University Hospital in Geneva, where doctors implanted dozens of electrodes into their brains to pinpoint the abnormal tissue causing the seizures and to identify adjacent areas involved in language, hearing or other essential functions that should be avoided in the surgery. As each electrode was activated, stimulating a different patch of brain tissue, the patient was asked to say what she was experiencing.

Dr. Olaf Blanke, a neurologist at the École Polytechnique Fédérale de Lausanne in Switzerland who carried out the procedures, said that the women had normal psychiatric histories and that they were stunned by the bizarre nature of their experiences.

The Sept. 21 issue of Nature magazine includes an account by Dr. Blanke and his colleagues of the woman who sensed a shadow person behind her. They described the out-of-body experiences in the February 2004 issue of the journal Brain.

There is nothing mystical about these ghostly experiences, said Peter Brugger, a neuroscientist at University Hospital in Zurich, who was not involved in the experiments but is an expert on phantom limbs, the sensation of still feeling a limb that has been amputated, and other mind-bending phenomena.

“The research shows that the self can be detached from the body and can live a phantom existence on its own, as in an out-of-body experience, or it can be felt outside of personal space, as in a sense of a presence,” Dr. Brugger said.

Scientists have gained new understanding of these odd bodily sensations as they have learned more about how the brain works, Dr. Blanke said. For example, researchers have discovered that some areas of the brain combine information from several senses. Vision, hearing and touch are initially processed in the primary sensory regions. But then they flow together, like tributaries into a river, to create the wholeness of a person’s perceptions. A dog is visually recognized far more quickly if it is simultaneously accompanied by the sound of its bark.

These multisensory processing regions also build up perceptions of the body as it moves through the world, Dr. Blanke said. Sensors in the skin provide information about pressure, pain, heat, cold and similar sensations. Sensors in the joints, tendons and bones tell the brain where the body is positioned in space. Sensors in the ears track the sense of balance. And sensors in the internal organs, including the heart, liver and intestines, provide a readout of a person’s emotional state.

Real-time information from the body, the space around the body and the subjective feelings from the body are also represented in multisensory regions, Dr. Blanke said. And if these regions are directly simulated by an electric current, as in the cases of the two women he studied, the integrity of the sense of body can be altered.

As an example, Dr. Blanke described the case of a 22-year-old student who had electrodes implanted into the left side of her brain in 2004.

“We were checking language areas,” Dr. Blanke said, when the woman turned her head to the right. That made no sense, he said, because the electrode was nowhere near areas involved in the control of movement. Instead, the current was stimulating a multisensory area called the angular gyrus.

Dr. Blanke applied the current again. Again, the woman turned her head to the right. “Why are you doing this?” he asked.

The woman replied that she had a weird sensation that another person was lying beneath her on the bed. The figure, she said, felt like a “shadow” that did not speak or move; it was young, more like a man than a woman, and it wanted to interfere with her.

When Dr. Blanke turned off the current, the woman stopped looking to the right, and said the strange presence had gone away. Each time he reapplied the current, she once again turned her head to try to see the shadow figure.

When the woman sat up, leaned forward and hugged her knees, she said that she felt as if the shadow man was also sitting and that he was clasping her in his arms. She said it felt unpleasant. When she held a card in her right hand, she reported that the shadow figure tried to take it from her. “He doesn’t want me to read,” she said.

Because the presence closely mimicked the patient’s body posture and position, Dr. Blanke concluded that the patient was experiencing an unusual perception of her own body, as a double. But for reasons that scientists have not been able to explain, he said, she did not recognize that it was her own body she was sensing.

The feeling of a shadowy presence can occur without electrical stimulation to the brain, Dr. Brugger said. It has been described by people who undergo sensory deprivation, as in mountaineers trekking at high altitude or sailors crossing the ocean alone, and by people who have suffered minor strokes or other disruptions in blood flow to the brain.

Six years ago, another of Dr. Blanke’s patients underwent brain stimulation to a different multisensory area, the angular gyrus, which blends vision with the body sense. The patient experienced a complete out-of-body experience.

When the current flowed, she said: “I am at the ceiling. I am looking down at my legs.”

When the current ceased, she said: “I’m back on the table now. What happened?”

Further applications of the current returned the woman to the ceiling, causing her to feel as if she were outside of her body, floating, her legs dangling below her. When she closed her eyes, she had the sensation of doing sit-ups, with her upper body approaching her legs.

Because the woman’s felt position in space and her actual position in space did not match, her mind cast about for the best way to turn her confusion into a coherent experience, Dr. Blanke said. She concluded that she must be floating up and away while looking downward.

Some schizophrenics, Dr. Blanke said, experience paranoid delusions and the sense that someone is following them. They also sometimes confuse their own actions with the actions of other people. While the cause of these symptoms is not known, he said, multisensory processing areas may be involved.

When otherwise normal people experience bodily delusions, Dr. Blanke said, they are often flummoxed. The felt sensation of the body is so seamless, so familiar, that people do not realize it is a creation of the brain, even when something goes wrong and the brain is perturbed.

Yet the sense of body integrity is rather easily duped, Dr. Blanke said.

And while it may be tempting to invoke the supernatural when this body sense goes awry, he said the true explanation is a very natural one, the brain's attempt to make sense of conflicting information.