Studying the Well-Trained Mind

Buddhist monks and Western scientists are comparing notes on how the mind works and collaborating to test insights gleaned from meditation

CAMBRIDGE, MASSACHUSETTS—Matthieu Ricard is no ordinary Buddhist monk. He earned his Ph.D. in molecular biology at the Pasteur Institute in Paris before deciding 30 years ago to devote his life to the practice of Tibetan Buddhism. Now Ricard, a member of the Shechen Monastery in Nepal, is involved in science again, as both a subject and a collaborator in a neuroscience project at the University of Wisconsin, Madison. There he and neuroscientist Richard Davidson hope to learn whether the study of trained meditators can provide insights into the mechanisms of brain function or new therapeutic approaches for psychology.

Interdisciplinary research. Scientists (left) shared the stage at MIT with Buddhist scholars (right) and the Dalai Lama (fourth from right). They discussed attention, mental imagery, and emotion.

This unusual collaboration and others like it were catalyzed by the Mind and Life Institute, created in the 1980s by businessman Adam Engle and the late neuroscientist Francisco Varela to foster a dialogue between Buddhist scholars and Western scientists. Initially the institute sponsored small, private meetings held at the Dalai Lama's headquarters in Dharamsala, India. But last month the meetings went public for the first time, with a conference called Investigating the Mind, held here at the Massachusetts Institute of Technology and co-sponsored by MIT's McGovern Institute for Brain Research.

For 2 days, panels of neuroscientists and Buddhist scholars took the stage with the Dalai Lama before an audience of 1100 to discuss attention, mental imagery, and emotion—topics of interest to Buddhists and scientists. The atmosphere was casual; the Tibetan leader huddled with speakers over a laptop to follow their presentations and frequently interrupted with questions or comments.

Mind and Life co-founder Varela, who was director of research at CNRS's Cognitive Neurosciences and Brain Imaging Laboratory in Paris, held a deep conviction that Buddhists, with their 2500-year history of introspective inquiry into the nature of the mind, had much to offer to neuroscientists. A handful of neuroscientists such as Davidson who were familiar with Buddhism agreed. Others have come to the meetings out of curiosity but with less certainty of what the Buddhists could contribute. "I have to confess that some of the scientists came to the table looking at the Buddhists almost as specimens," says cognitive neuroscientist Jonathan Cohen of Princeton University, who participated in the MIT meeting. "It was like, 'Here are these people who claim to be able to do unusual things. Let us get our electrodes on them.' … It took a round [of discussion] for the scientists to come to respect that the Buddhists had some very interesting things to say."

A Buddhist science of the mind

Some scientists made that transition through learning more about meditation. The practice is often viewed by Westerners as merely a form of relaxation whose benefits are limited to stress relief or lowered blood pressure. It is actually a rigorous system of mind training and observation of mental processes, what Buddhists consider to be their own "science of the mind." "From its outset, [Buddhism] has had a very strong emphasis on refining the attention, enhancing attention skills, and developing very sophisticated means for investigating the nature of the mind from a first-person perspective," says Buddhist scholar and former monk B. Alan Wallace, president of the Santa Barbara Institute for the Interdisciplinary Study of Consciousness.

What's more, Wallace adds, the Buddha himself told his followers not to take his teachings on faith but to test them for themselves. That spirit of inquiry makes some Buddhist practitioners eager to participate in neuroscience studies.

The time is ripe for Buddhists' input, says Clifford Saron, a researcher at the Center for Mind and Brain at the University of California (UC), Davis. The tools with which cognitive neuroscientists measure brain activity have grown so sensitive, Saron says, that scientists can observe differences in brain activity between individuals doing the same task or even between different trials with the same individual. There is information in that variation, but it requires the input of the subject to decipher it. "Most people have very little training to report how they did a task," Saron says, but meditators who are trained to observe their own minds should be able to describe in detail whether their attention was more stable in one trial versus another, whether they prepared themselves in a slightly different way, or even what kinds of fleeting emotions or images might have passed through their mind.

Buddhists say they hope the interaction will lead to several things—first of all, "a healthier world," according to Buddhist monk and meeting participant Ajahn Amaro of the Abhayagiri Monastery in Redwood Valley, California. Beyond that, they want the opportunity to test their first-person insights with Western research techniques and understand better the mental states they achieve through meditation. There has been a fair amount of "shlock science" done toward this end, Davidson says, but the Mind and Life Institute has approached the issue "in a very different way, involving the very best people in their respective areas," he adds.

One hot topic at the MIT meeting was the role of introspection, or reporting personal mental experience, in science. Although introspection has formed the basis

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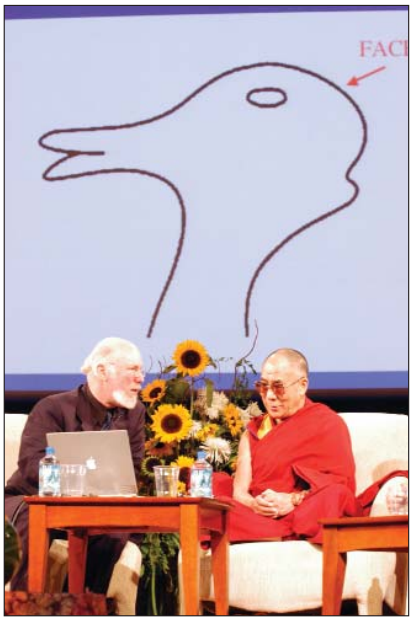
of the Buddhist investigation of the mind, Harvard University psychologist Daniel Gilbert notes that "a lot of scientists have a hard time getting their heads around the idea that introspection can be a form of data." Indeed, Harvard psychologist Stephen Kosslyn spent part of his presentation illustrating ways in which subjects' reports on the mental strategy they used to solve a problem could be misleading.

Despite such caveats, neuroscience has already begun using first-person insights to help frame questions, says neuroscientist G. Ron Mangun, director of UC Davis's Center for Mind and Brain. "When you are talking about something like human cognition, if you don't use introspection to guide you, it is a bit difficult to get anywhere," Mangun says. "We use introspection all the time in our research. We are just trained to be very careful with how we use it."



Dialogue. Stephen Kosslyn explains a psychological test to the Dalai Lama.

Some Buddhists' introspections directly challenge views held by neuroscientists. For instance, trained meditators claim to be able to hold their attention on a single object for hours, or to shift attention rapidly as many as 17 times in the span of a finger-snap. These claims contradict Western reports that attention cannot be held that long or switched that fast. Whether such claims prove to be precisely true or not, MIT neuroscientist Nancy Kanwisher is eager to see whether monks who have spent years training their attention are better on standard attention tests than the average person. "Training the attention has barely been touched by cognitive neuroscience," says Kanwisher.

Soon that may change. UC Davis's Mangun and Saron are planning a collaboration with the Santa Barbara Institute's Wallace to test the attention skills of trained meditators. They plan to enroll two dozen volunteers in a 3-month, intensive, full-time program in shamatha, a form of Buddhist contemplative training that is aimed at enhancing attention skills. In exchange for the training, the meditators will agree to be subjects for psychological and brain-imaging studies of attention.

Because subjects will be tested before, during, and after their training, the study avoids certain pitfalls of working with established meditators, such as the possibility that any observed differences might reflect not training but the fact that subjects drawn to meditation may have had unusual brains to begin with.

Hold that image

Whereas some Buddhist practitioners specialize in attention, others devote themselves to the demanding practice of visual imagery, meditating on an image held in the mind as a means to purge the mind of value judgments. It may take decades for a monk to develop prowess in imagery. Some virtuosos claim to be able to hold in their minds a detailed image such as a complex mandala, a symbolic depiction of the universe, for many minutes or even hours.

These claims are also contradicted by Western neuroscience. "Based on my understanding of how the brain works, that should not be possible," says Harvard's Kosslyn, who studies mental imagery. Kosslyn has found that mental images are fleeting—necessarily so, he reasons, because mental imagery uses the same brain areas that serve vision, and visual images fade quickly from the brain to prevent the appearance of smearing as our eyes move.

"Do you have plans to conduct experiments on monks?" the Dalai Lama asked Kosslyn. "If they are different, how will it change your theory?" Kosslyn replied that he is eager to test his theory with trained meditators, and he has already set up experiments to test the holding of an image over time, and the vividness of images. If he were to find differences with trained meditators, he said, he would scan their brains for unusual activity that might explain the disparity, using functional magnetic resonance imaging.

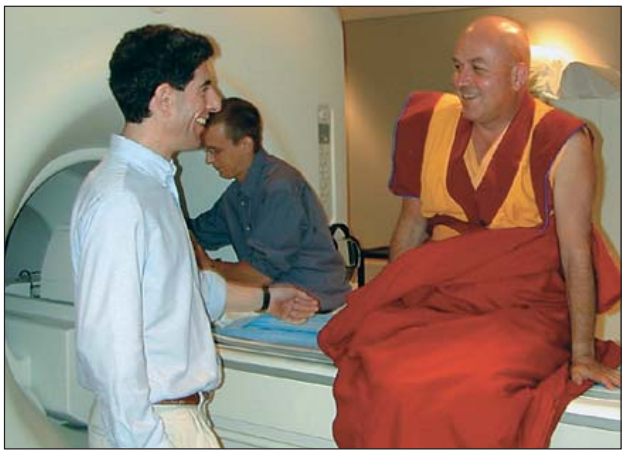
There is an impediment to doing such experiments: Very few monks are truly accomplished in visual imagery, and, says Ricard, "they are contemplative hermits. None of them is ready to come to the lab." Ricard says he hopes to find some moderately accomplished monks who are willing to travel.

Accentuate the positive

The collaboration between Buddhists and neuroscientists has borne the most fruit to date in the study of emotions. Buddhist meditation fosters "virtuous" mental states that are said to promote well-being, such as compassion, joy, and "loving-kindness." UC Berkeley psychologist Dacher Keltner says this is a radically different approach from Western psychology, which focuses mainly on negative mental states such as anger, fear, or depression.

A growing number of Western psychologists are investigating the potential of Buddhist meditation training to shift the brain into positive emotional states. Wisconsin's Davidson is collaborating with Ricard to study the brain activity associated with positive emotions in Buddhist monks. Davidson and his colleagues have demonstrated repeatedly that activity in the frontal region of the brain reflects a person's emotional state. A high ratio of activity in the left versus the right frontal areas marks either a fleeting positive mood or what Davidson calls a positive "affective style," which is the quality of mood that persists over time. Subjects gripped in a negative mood, or with generally negative affective styles, rank lower on the left-to-right ratio. And when researchers trigger a negative emotion, for example by showing subjects a disturbing news photo, those negative emotions fade more quickly in people with more left-frontal brain activity.

Using such techniques, Davidson and postdoc Antoine Lutz are studying Ricard and other monks with many years of meditation experience. Their first subject, while



Collaborators. Richard Davidson (left) and Matthieu Ricard after a brain-imaging experiment.

CREDITS: (LEFT TO RIGHT) DONNA COVENEY/MIT; R. DAVIDSON/W. M. KECK LABORATORY FOR FUNCTIONAL BRAIN IMAGING AND BEHAVIOR, UNIV. OF WISCONSIN

not meditating, showed a left-right brain activity ratio higher than that of any of the 150 non-Buddhist subjects the team had previously tested. The team has tested six monks so far. The data are still being analyzed, but Davidson reported at the MIT meeting that when the monks were instructed to meditate on compassion, they showed a greater shift toward left-frontal activation than control subjects who were not trained meditators but who were given instructions to meditate on compassion.

Such a study can't rule out the possibility that the monks' brains were unusual even before they began their training. So Davidson's team took another approach. It recruited employees of Promega, a Madison-based biotech company, to go through 8 weeks of basic meditation training. Volunteers were randomly assigned to receive the training or not. The team recently reported in *Psychosomatic Medicine* that, compared with controls, those trained to meditate showed an increase in left-prefrontal activation both at rest and in response to an emotional challenge.

"This was not in any shape or form a definitive study," says Davidson. But it is not the only pilot project to have produced tantalizing preliminary results. A study called the Cultivating Emotional Balance project has also suggested that meditation training can promote emotional health in Westerners. UC San Francisco psychologist Paul Ekman conceived of the project after participating in one of the Mind and Life meetings in Dharamsala and developed it with Wallace and UCSF health psychologist Margaret Kemeny. For the pilot study, 15 school teachers underwent a 5-week intensive course in meditation that includes meditation on compassion and loving-kindness, integrated with strategies and techniques selected from modern Western emotion research.

The teachers performed a battery of psychological tests before and after the training. They were wired for physiological measures such as heart rate and blood pressure, and they were videotaped so that psychologists could monitor them for nonverbal reactions that show feelings such as contempt or acceptance. The subjects showed more positive emotional responses after training than before. Based on that result, the researchers are planning a larger study—this time with a control group.

Kemeny notes that the Cultivating Emotional Balance project differs from other studies in that the focus of its training is on emotions such as compassion and empathy that generate a positive feeling toward others, and in its measurement of changes in the subjects' reactions to other people. "We want to understand the psychological effects" of such training, she says.

That is a question for which the Dalai Lama has a ready answer. In his closing remarks, he repeated his faith in the power of science and encouraged collaboration between Buddhists and scientists, ending with a confident exhortation to his audience to "encourage positive emotions, discourage negative. Then you will be more happy." If the Buddhists and neuroscientists can put their heads together and figure out how we can all do that, maybe Ajahn Amaro will get his wish for a healthier world.

–MARCIA BARINAGA

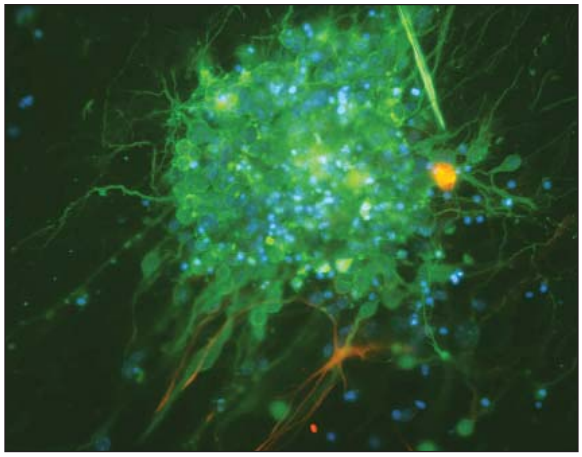
Meeting American Chemical Society

Molecular Scaffolding Helps Raise a Crop of Neurons

From 7 to 11 September, 14,000 chemists, physicists, and engineers gathered in New York City for ACS's 226th National Meeting. Among the highlights: nerve-healing nanofibers and carbohydrate microarrays.

For decades biomedical researchers have dreamed of regrowing damaged nerve cells. Now chemists may be getting a handle on the trick by extending a technique first used to promote bone growth.

At the ACS meeting, Samuel Stupp, a chemist at Northwestern University in Evanston, Illinois, reported that his group had designed molecules that assemble themselves into tiny rods that spur the growth of neural tissue in rats. If the strategy works equally well in humans, self-assembling molecules could offer new hope to victims of spinal cord injury and other types of nerve damage. Says Robert Grubbs, a chemist at the California Institute of Technology in Pasadena: "It's a very promising approach."



Right track. Nanofibers (not shown) encourage neural progenitor cells to become neurons (green) instead of astrocytes.

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It's one that Stupp and colleagues have been honing for several years. Recently, the team designed two-part molecules called peptide-amphiphiles (PAs) that assemble themselves into rigid fibers. The peptides, or short protein fragments, that decorated the outside of the nanofibers contained amino acids that encouraged the growth of hydroxyapatite crystals, a basic constituent in bone (*Science*, 23 November 2001, p. 1635).

For their new work, Stupp, postdoc Gabriel Silva, and graduate student Krista Niece changed the outermost peptide groups on the PAs in hopes of promoting the growth of neurons. Other researchers had shown that proteins called laminins bind to neurons and encourage the growth of neurites, arms that extend out from the central cell body. Laminins contain a five–amino acid sequence known as IKVAV (for the sequence isoleucine, lysine, valine, alanine, and valine). So the Northwestern researchers designed their PA molecules to end with the IKVAV sequence.

The two-part PA molecules contain oily hydrocarbon chains connected to the peptides. When placed in a watery solution, the hydrocarbon chains seek to crowd together to avoid the energetically costly association with water. The negatively charged peptides at the other end normally repel one another, keeping the molecules apart. But the researchers overcame that repulsion by adding the PAs to a cell culture medium that contained positive ions. The ions surrounded the negative charges and allowed the oily hydrocarbon tails to