

400 to 275 degrees C. Moreover, the hydride can store 9 percent of its weight as hydrogen, beating the oft-cited target of 6.5 percent. She hopes that HRL staffers can eventually identify a “Goldilocks” compound with sufficient adsorption capacity that will release hydrogen at 150 degrees C or even lower. Momoda admits, however, that the hydrogen pickup rate is still too slow; current

materials might take 30 minutes to refuel.

Practical onboard storage would, of course, constitute only half the formula for a successful hydrogen economy; the other half would be a large-scale hydrogen distribution and refueling network. Thankfully, solving the latter issue will not likely require major technical breakthroughs—only boatloads of cash.

LINGUISTICS

Math without Words

NUMERICAL REASONING SEEMS INDEPENDENT OF LANGUAGE BY PHILIP E. ROSS

Nineteenth-century German mathematician Carl Friedrich Gauss used to joke that he could calculate before he could talk. Maybe it was no joke. Recent work casts doubt on the notion that language underlies mathematical ability and perhaps other forms of abstract thinking.

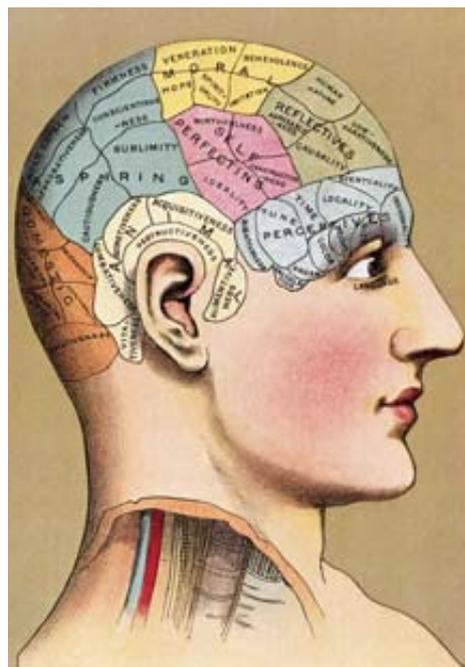
Writing in the March 1 *Proceedings of the National Academy of Sciences USA*, scientists from the University of Sheffield in England describe impressive mathematical abilities in three middle-aged men who had suffered severe damage to the language centers of their brains. “There had been case studies of aphasics who could calculate,” says study co-author Rosemary Varley. “Our new take was to try to identify roughly parallel mathematical and linguistic operations.”

Varley and her colleagues found that although the subjects could no longer grasp grammatical distinctions between, say, “The dog bit the boy” and “The boy bit the dog,” they could interpret mathematical formulas incorporating equivalent structures, such as “59 – 13” and “13 – 59.”

The researchers found ways to pose more abstract questions as well. For instance, to investigate the subjects’ understanding of number infinity, they asked them to write down a number bigger than 1 but smaller than 2, using hand motions for “bigger” and “smaller” and a flash of the eyebrow, indicating surprise, for “but.” Then they asked the subjects to make the

number bigger but still smaller than 2 and to reiterate the procedure. The subjects got the answer by various means, including the addition of a decimal place: 1.5, 1.55, 1.555 and so forth.

Although subjects easily answered simple problems expressed in mathematical symbols, words continued to stump them.



REGIONAL DIFFERENCES: The brain is not compartmentalized the way 19th-century phrenology maps showed, but it does process math and language abilities in different areas.

Even the written sentence “seven minus two” was beyond their comprehension. The results show quite clearly that no matter how helpful language may be to mathematicians—perhaps as a mnemonic device—it is not necessary to calculation, and it is processed in different parts of the brain.

The idea that language shapes abstract thought was most forcibly propounded 50 years ago in the posthumously published writings of American linguist Benjamin Lee Whorf. He argued, among other things, that the structure of the Hopi language gave its speakers an understanding of time vastly different from that of Europeans. Although Whorf’s hypothesis continues to inspire research, a good deal of his evidence has been discredited. Much more widely respected is the proposal, associated with linguist Noam Chomsky of the Massachusetts Institute of Technology, that language, mathematics and perhaps other cognition all depend on a deeper quality, sometimes called “mentalese.”

Chomsky suggested that the key part of this deeper quality might be a quite simple

and uniquely human power of “recursive” calculation. Recursion, he and his colleagues argue, may explain how the mind spins a limited number of terms into an infinite number of often complex statements, such as “The man I know as Joe ate my apple tree’s fruit.” Recursion could also generate mathematical statements, such as “ $3 \times (4/6 + 27)/4$.”

Chomsky’s theory may, perhaps, be reconciled with the new evidence. Some scholars have argued that the brain may build its mathematical understanding with language and that the structure may still stand after the scaffolding is removed. Indeed, the one subject in the Sheffield study who had had doctoral-level training in a mathematical science did no better than the others in arithmetic, but he outperformed them at algebra.

Rochel Gelman, co-director of the Rutgers University Center for Cognitive Science, says that the brain-lesion studies offer much clearer evidence than can be obtained from the more common technique of functional brain scanning. “Pop someone in a scanner and ask a question, and you may get a lot of

NEED TO KNOW: WORD HELP

Despite using different brain circuitry, language can still lend a helping hand to mathematical thought. People quickly pick up simple arithmetic, in part because the natural numbers map easily to the single words used for counting, says Rochel Gelman, co-director of the Rutgers University Center for Cognitive Science. But, she notes, they have much more difficulty grasping the rational numbers (fractions), which do not map onto anything readily at hand.

Mysteries of the Ancient Ones

SAVE UP
TO 20%

What was life really like thousands of years ago?

NOW, Scientific American takes you on a fascinating journey to the ancient world, in this one-time only special edition.

Bulk copies of this special issue are now available.
\$10.95 each, s&h included
\$13.95 outside the U.S., s&h included

SAVE ON ALL BULK ORDERS!

Order online: www.sciam.com/orderissues, by fax 1-515-699-3738 or make check payable to Scientific American and mail your order to:
SCIENTIFIC AMERICAN
DEPT. ANCIENT
P.O. Box 10067
Des Moines, IA 50340-0067
U.S.A.

This SPECIAL ISSUE is not included with your regular subscription and is sure to sell out fast!



Are you up to the *Mathematica*[®] challenge?

Wolfram Research’s *Mathematica* technology stands behind many of the most important scientific discoveries and technical innovations of the last two decades. In our continuing commitment to revolutionizing the technology and science of computation, we now have unique new opportunities in our world-class team at both junior and senior levels.

If you’re skilled with *Mathematica*, clear-thinking, pragmatic, and excited about transforming the way today’s most innovative people work, go to careers.wolfram.com and get ready for the challenge of a lifetime.

WOLFRAMRESEARCH

New Tools = New Science = New Technology

An Equal Opportunity Employer



If you can't give Dad the original Mona Lisa, give him the original Rabbit.

Dad may have a broken lever corkscrew in a drawer somewhere. But it's not the original Rabbit Corkscrew. And chances are it has no warranty, while the Rabbit's is good for ten years. Even if you could afford to give Mona Lisa to Dad, she can't open wine in three seconds like the Rabbit. Her inscrutable smile, however, may be due to the wine she drank while sitting for her portrait.

Where To Go Rabbit Hunting:
Sur La Table, Crate & Barrel,
Bloomingdale's, Marshall Field's,
Sherry Lehmann,
Total Wine
& More,
Beverages
& More



activation in language areas," she points out. "But it could be just because the subject is talking through the problem—recruiting language, although it's not a crucial component."

The recent work, together with studies of animals and of children, strongly

supports the independence of language and mathematics, Gelman says. "There are cases of kids who are bad with numbers and good with words and bad with words and good with numbers, a double dissociation that provides converging evidence."

EVOLUTION

Desert Island

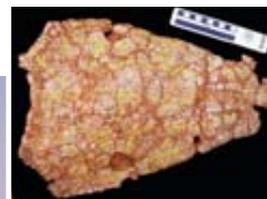
HOW CLIMATE CAN PROMOTE SPECIATION BY KATE WONG

A bedrock tenet of biogeography holds that organisms separated from their ancestral population will set off on their own evolutionary trajectory. Continental drift provides one such isolating mechanism, illustrated perhaps most spectacularly by the unique flora and fauna found on the island of Madagascar, which broke off from the southern supercontinent of Gondwana some 90 million years ago. Mountain upheaval and river formation can also divide populations. But a new study reveals that the barriers need not be physical. Paleontologists have unearthed fossils of giant amphibians that indicate that climate, too, can effective-

ly isolate organisms and thereby foster endemism.

In a paper published in the April 14 *Nature*, paleontologist Christian A. Sidor of the New York College of Osteopathic Medicine and his colleagues announced their discovery of two new species of amphibian that lived some 250 million years ago in what is now northern Niger. The salamanderlike beasts, *Nigerpeton ricqlesi* and *Saharastega moradiensis*, are surprising not so much for their impressive size (think crocodile proportions) but because they are different from other creatures that lived at the time.

For decades, sci-



SAHARAN SANDS entomb the fossils from a giant amphibian called *Saharastega* (inset), one of two new species recently found. The creatures inhabited oases dotting a similar desert landscape 250 million years ago, feeding on fish as well as other aquatic tetrapods.

CHRISTIAN A. SIDOR, New York College of Osteopathic Medicine