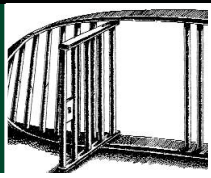

LETTERS

edited by Etta Kavanagh

New Scientific Society in Nicaragua

IN MARCH OF THIS YEAR, *SCIENCE* PUBLISHED AN Editorial entitled "Fighting tropical diseases" (J. D. Sachs and P. J. Hotez, 17 Mar., p. 1521) discussing science-based approaches to address the UN Millennium Development Goals. Additionally, in the past few months, *Science* has reported on recent efforts to improve Africa's capacity in science, including the creation of science academies in various African countries. Because the motivation behind all these efforts is, in part, the urgent need to address extreme poverty, other low-income countries such as Nicaragua could benefit from similar initiatives.

Within Latin America, Nicaragua is a latecomer in promoting the use of science as a tool for economic development. Although scientific councils were created in most countries in the 1960s, in Nicaragua, it wasn't until 2002 that such a council (CONICYT) was first established. Even so, the lack of funding and working ties with the scientific community has rendered the council ineffective.

Despite these difficulties, Nicaragua is currently experiencing a rapid period of scientific growth, particularly in the health sciences and biotechnology research. A recent report (*1*) by various members of the InterAmerican Network of Academies of Sciences (IANAS) praises the scientific achievements of Universidad Centroamericana and other Nicaraguan universities, but stresses that national planning and coordination are necessary for a stronger scientific enterprise.

> "The organized engagement of scientists to make their voices heard could **finally put science on Nicaragua's national agenda.**"
>
> —Huete-Pérez

In light of these recommendations and in an effort to build on this momentum, leading scientists have organized the Nicaraguan Society for Science as an essential step toward the creation of a Nicaraguan Academy of Sciences. In addition to providing independent advice to the government, such an academy would be able to help prepare a strategy to support science-based economic development.

For this effort to make headway, decision-makers will need to be persuaded of its value and be determined to allocate financial support. The organized engagement of scientists to make their voices heard could finally put science on Nicaragua's national agenda.

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Examining Knowledge of Geometry

IN THEIR REPORT "CORE KNOWLEDGE OF GEOmetry in an Amazonian indigene group" (20 Jan., p. 381), S. Dehaene *et al.* present evidence that an isolated Amazonian group, the Mundurukú, are able to understand geometric concepts. They state that geometry constitutes "a core set of intuitions present in all humans." I disagree with the basic concept of this investigation.

The central feature of Euclidean geometry is its demonstrative character and its logical structure, rather than graphical pictures of triangles, circles, etc. This logical system is built upon two pillars: (i) the concept of the "theoretical object," e.g., the abstract metaphysical idea of a circle, rather than a real constructed circle; and (ii) the deductive mathematical proof, based purely on axioms and postulates.

Other civilizations dealt with geometrical figures in a more intuitive way, and their activities cannot be characterized as geometry in the Euclidean sense. Ancient civilizations other than the Greeks did not develop a demonstrative geometry. For example, the ancient Chinese never developed a theoretical geometry (*1*–*3*).

The topic being investigated by Dehaene *et al.* is simply pattern recognition. It is by no means surprising that the people tested recognized different geometric figures, since they can recognize, e.g., human faces and identify different species of tree by their silhouettes.

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IN THEIR REPORT "CORE KNOWLEDGE OF GEOmetry in an Amazonian indigene group" (20 Jan., p. 381), S. Dehaene *et al.* present research documenting the Brazilian Mundurukú Indians' ability to understand concepts of geometry and to orient themselves spatially. This team, as well as the scholars mentioned in C. Holden's article "Hunter-gatherers grasp geometry" (News of the Week, 20 Jan., p. 317), might be interested to learn that over 200 years ago, the great Brazilian naturalist Alexandre Rodrigues Ferreira also observed this innate ability of indigenes. In his memoirs of Amazonian zoology and botany [published collectively as the *Viagem Filosófica* (*1*)], he posed the question "what would a European, brought up like an Indian and ignorant of geometry, geog-

CREDIT: S. DEHAENE *ET AL.*

Amazonian Mundurukú villager reading a map to identify a hidden object.

raphy and hydrology, do if asked about a river's direction, branching and neighboring villages?" (p. 93, my loose translation). Anticipating Dehaene *et al*., Ferreira conducted an experiment and asked this question of a Tapuio Indian, who by tying together several cords was able to create an approximate map of the local river and its tributaries, as well as point out the location of Indian villages. Further, Ferreira wrote that a Macuxí Indian he encountered not only drew an intelligible map of local river patterns and scaled hut outlines using a stick to trace lines in sand, but when presented with a pen and ink rendered the same idea on paper. Clearly, the naturalist understood native Brazilians not only to be reasoning individuals, but capable of understanding geometric and geographic concepts. Thus, on the basis of his own experiments, Ferreira would have agreed with Dehaene *et al*.'s conclusion that "geometrical knowledge arises in humans independently of instruction, experience with maps or measurement devices, or mastery of a sophisticated geometrical language."

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Response

WULFF CONTRASTS PROCESSES OF DEDUCTIVE reasoning based on the axioms and postulates of Euclidean geometry with processes of visual pattern recognition, and he suggests that the latter processes underlie performance on our tests of geometrical categorization and map use. Our tasks were designed to assess geometrical concepts at a higher level of representation. Recognition of visual patterns is orientation-specific (*1*), yet both our tasks required that the Mundurukú abstract geometrical relations from figures that varied in orientation. The Mundurukú's globally high performance, particularly in the map task which requires a transformation from two to three dimensions, cannot plausibly be attributed to low-level processes of visual pattern recognition and implies extraction of genuine geometrical invariants.

Our tasks also do not depend on processes of deductive reasoning. Although geometry now appears as a beautiful logical construction, logic and deduction are neither necessary nor sufficient to account for core human geometrical concepts and intuitions. The central intuitions of Euclidean geometry cannot be deduced from simpler axioms, as the history of mathematics and physics attests (*2*): Absent the problematic and unprovable parallel postulate, Euclid's axioms and postulates support an infinite family of geometries at odds with human intuition. Geometrical intuitions nevertheless come naturally to the human mind and continue to guide commonsense reasoning about space, even in scientists who have come to believe, by deduction and experiment, that the classical three-dimensional view of space fails to capture the structure of the universe (*3*).

We thank Delson for drawing our attention to Alexandre Rodrigues Ferreira's report. His informal observations on map-making appear to antedate ours by two centuries. Insofar as his observations were found to be general, they would confirm that the capacity to understand maps predates the most serious intrusions of Western culture. Caution is required in evaluating such ancient reports, but both Ferreira's report and our research suggest that all human cultures share an approximate arithmetic and intuitive geometry, which are highly stable over variations in education, language, and intercultural contact. On this point, we distance ourselves from claims of a radical "incommensurability" of cognitive functions in other cultures such as the Pirahã (*4*, *5*), which are sometimes lumped together with our own views.

Research on core knowledge of geometry is at an early stage. How do geometrical concepts emerge in children? Are these concepts unique to humans or shared by other animals? What accounts for the distinctive profile of geometrical abilities shown both by indigenous tribes and by urban Americans? Converging studies across species, ages, and cultures, using methods of psychology and neuroscience, can begin to address these questions.

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Ecological Revitalization of Chinese Villages

I READ R. STONE'S ARTICLE "VILLAGERS DRAFTED into China's model of 'sustainability'" (News of the Week, 7 Apr., p. 36) with great interest. In my 16 years investigating long-term ecological changes in rural China, I have witnessed numerous governmental programs aiming to link improved rural livelihoods with ecological revitalization of village landscapes (*1*–*3*). Energy self-sufficiency and improved land management have been central to all of these programs, which have combined national and provincial policy and organizational efforts with demonstration villages, townships, counties, and even provinces. Although often only modestly successful, China's efforts to improve rural environments are an absolute triumph when compared with those of most rural developing countries and compare well with those of many developed countries during their own industrial transition.

The convergence of national and international environmental agendas on a single rural village will inevitably cause conflict. And Huangbaiyu will probably end up as have other village experiments: Temporary improvements will ultimately be dwarfed by the needs of local people to adapt to the developments going on around them. Although local demonstration projects might therefore be avoided, these can help to highlight and fix problems before more extensive programs are implemented. Regardless, the failings of a single village experiment should be presented as a minor part of the main story. China and the Chinese continue to make major efforts, by many means, to make the best of what is arguably the greatest environmental challenge any human population has ever faced (*4*).

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Stereotype Threat: A Clarification

THE REVIEW BY D. LEWIS (24 JUNE 2005, P. 1871) of the book *Gender Differences in Mathematics* (*1*) inadvertently perpetuates misinformation that has appeared elsewhere (*2*–*4*) about a key finding in our study of stereotype threat on an Advanced Placement calculus test (*5*, *6*).

The study investigated whether asking women to record their gender immediately before taking the test elicited stereotype threat and thereby adversely affected their test performance. A quote in the review from a chapter in the book (*4*) cites an erroneous statistic from our initial technical