

Paris, October 13, 2004

Press release

Cognition and arithmetic capability : what the Mundurucus Indians can teach us

Is it possible to perform addition and subtraction if one does not possess the words to represent numbers? To answer this question and understand the relationship between arithmetic reasoning and language, CNRS and INSERM researchers (Pierre Pica, Cathy Lemer, Véronique Izard and Stanislas Dehaene¹) studied the example of the Mundurucus Indians from Brazilian Amazonia, whose vocabulary includes number words only up to four or five. Tests performed over several months among this population show that the Mundurucus cannot readily perform "simple" mathematical operations with exact quantities, but their ability to use approximate numbers is comparable to our own. This research, published in the October 15, 2004, issue of the journal *Science*, suggests that the human species' capacity for approximate arithmetic is independent of language, whereas precise computation seems to be part of the technological inventions that vary largely from one population to the next.

To shed light on the relationship between language and arithmetic, researchers need to be able to study computational ability in situations where the language of numbers is either absent or limited. The Mundurucus Indians represent an interesting indigenous population in this regard; as is the case with most Tupi indigenous peoples, their language only includes the words for the numbers one to five. This language is spoken by approximately 7,000 people living in an autonomous territory in the state of Para, Brazil.

Pierre Pica has been conducting linguistic research on Mundurucu territory since 1998. He thus was able to perform a series of numerical tests on 55 Mundurucus Indians, aiming to evaluate their precise and approximate computing ability. To serve as a control, the same tests were given to 10 French persons.

The first objective was to clearly determine the scope of the Mundurucu vocabulary for numbers – two, three, four, five or more – and analyze in detail, with the aid of mathematical tools, the arithmetical computation ability of this population.

Pierre Pica trained Mundurucus experimenters who carried out the series of tests on the Mundurucu territory, using the screen of a laptop computer that was recharged by solar panels.

In order to faithfully reflect the cultural, linguistic and geographic diversity of the Mundurucus, several distinct groups of participants were formed. A group of adults (men and women) and a group of children who speak only Mundurucu and have not received schooling were compared to other groups of adults and children who also speak some Portuguese or who have received some schooling.

¹ Pierre Pica is a CNRS *chargé de recherche* at the "Structure formelle du langage" Laboratory and Stanislas Dehaene is Director of INSERM Unit 562, "Cognitive Neuro-imaging."

A few examples of tests

- The first test required the Indian subjects to name the numbers for sets including from 1 to 15 points. This made it possible to study how they use the number names in their vocabulary.
- The second task was a comparative test in which the Indian subjects were shown two clouds of dots and had to judge which of the two sets was more numerous.
- For the third test, to evaluate approximate computation, they were shown short video clips illustrating simple operations. For example, 20 or so seeds fall into a box, to which are added 30 or so more, and the subject must say whether the total is more or less than another set (for example, of 40 or so seeds).
- Lastly, in a test of computing with exact numbers (also administered using a video), they were asked to give the result of a precise mathematical operation, for example, 6 seeds minus 4 seeds.

Surprising results...

The first result of these tests is that the vocabulary of numbers in Mundurucu clearly stops at 5. Various words exist for amounts over 5, but they are not routinely used. Even the numbers below 5 are used in a casual manner, comparable to how we might say "ten or so, twelve or so." The number 5, for example, which also means hand, is used to indicate between 4 and 10 objects.

The study also yielded a surprising result: regardless of which group they belong to, the Indians are not able to carry out arithmetic operations with quantities above 5. For example, they cannot calculate $6-4$ or $7-7$ with precision. However, they all have a cognitive capacity to approximate that is entirely comparable to our own and which serves as the basis of actual calculations. Mundurucus and French subjects obtain the same results on approximation tests.

The researchers concluded that numerical approximation ability is a basic cognitive ability that is common to all human beings, which could be independent of language. Their findings moreover run counter to the conclusions of research by American scientist Peter Gordon² conducted on the Pirahã, a population that is geographically near the Mundurucus. These conclusions hold that the Indians' capacities are "immeasurably" different from our own. They also contradict the assertion that the lack of names for numbers supports the hypothesis (Sapir/Whorf) put forward at the beginning of the century, holding that abilities vary largely from one population to the next, depending on the capacity for expression of their language.

For Pierre Pica and Stanislas Dehaene, the fact that Mundurucus experience difficulty in performing precise arithmetic computation could be explained by the way they count. They use a rudimentary technique, counting with fingers and toes. This does not allow them to associate a number name with a quantity greater than five. Yet it is precisely this operation (which Pierre Pica and Stanislas Dehaene call "number crystallization") that seems to allow the development of precise arithmetic similar to our own.

Pierre Pica and Stanislas Dehaene would now like to continue their research on the links between arithmetical systems and linguistic systems, based on new studies of this fragile, threatened population. They would also like to better understand the impact of their research on our understanding of the nature and the origin of the faculty of language, and on linguistic variation.

² Peter Gordon, University of Columbia (USA), forthcoming article.

References

Pierre PICA (CNRS), Cathy LEMER (INSERM), Véronique IZARD (INSERM) and Stanislas DEHAENE (INSERM).

Exact and approximate arithmetic in an Amazonian indigene group. Science

Photo captions



© CNRS Photothèque - Pierre PICA

A Mundurucu woman taking the comparison test (paper version) (Missão velha, 2003).



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Child taking a test on the computer under the supervision of Pierre Pica (Missão velha, 2003).



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Cacique (village chief) demonstrating Mundurucu precise computation using fingers and toes (Bom Jardim/Kaburuá, 2001).



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An elderly Mundurucu man demonstrating Mundurucu precise computation using his toes (Sai Cinza, 2001).

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Three films are available at the following address:

http://www.cnrs.fr/SHS/recherche/article.php?id_article=84

Footage available by contacting CNRS Images:

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