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Words help people form mathematical concepts

February 7, 2011

Language may play an important role in learning the meanings of numbers, scholars at the University of Chicago report.

A study based on research on deaf people in Nicaragua who never learned formal sign language showed that people who communicate using self-developed gestures, called homesigns, were unable to comprehend the value of numbers greater than three because they had not learned a language containing symbols used for counting.

By contrast, deaf people who acquire conventional sign language as children can learn the meaning of large numbers. Researchers believe this is because conventional sign language, like spoken languages, imparts a counting routine early in childhood.

The study illustrates the complexity of learning the symbolic relationships embedded in language, including seemingly simple numerical concepts. The work may help researchers learn more about how language shapes the way children learn early mathematical concepts, and how that crucial process can go awry in the preschool years.

"It's not just the vocabulary words that matter, but understanding the relationships that underlie the words — — the fact that 'eight' is one more than 'seven' and one less than 'nine.' Without having a set of number words to guide them, deaf homesigners in the study failed to understand that numbers build on each other in value," said Susan Goldin-Meadow, the Bearsdley Ruml Distinguished Service Professor in Psychology at the University.

The findings are reported in the paper, "Number Without a Language Model," published in the current issue of the Proceedings of the National Academy of Sciences. The lead author is University researcher Elizabet Spaepen, a 2008 Ph.D. graduate in psychology who did field work in Nicaragua as part of the study.

Inability to think rather than communicate about numbers

Scholars have previously found that people in isolated cultures do not learn the value of large numbers when they are not part of the local language. Two groups studied in the Amazon, for instance, do not have words for numbers greater than five and are unable to match two rows of checkers containing more than five items. Their local culture does not require the use of exact large numbers, which could explain the Amazonians' difficulty with them.

However, most Nicaraguans do use exact numbers in everyday monetary transactions. Although the deaf homesigners in the UChicago study understood the relative worth of different currency items, they apparently had an incomplete understanding of their numerical values because they had never been taught number words, Spaepen said.

For the study, scholars gave homesigners a series of tasks to determine how well they could recognize money. They were shown 10-unit and 20-unit bills and asked which had more value. When asked if nine 10-unit coins had more or less value than a 100-unit bill, each of the homesigners was able to determine the money's relative value.

"The coins and bills used in Nicaraguan currency vary in size and color according to value, which give clues to their value, even if the user has no knowledge of numbers," Spaepen said. The deaf homesigners could learn about currency based on its color and shape without fully understanding its numerical value.

To see if the homesigners could express numerical value outside of the context of money, the scholars showed them animated videos in which numbers were an important part of the plot. They then asked the deaf individuals to retell the video to a friend or relative using homesigns. As the

numbers grew, the homesigners became increasingly less able to produce an accurate gesture for the number with their fingers.

They were then shown cards with different numbers of items on them, and asked to give a gesture that represented the number of items. The homesigners were accurate only up to the number 3. In addition, they had difficulty making a second row of checkers match a target row when there were more than three checkers in the target, despite the fact that this task did not require any comprehension or production of number gestures. Their difficulty in understanding large numbers therefore did not stem from an inability to communicate about large numbers, but rather from an inability to think about them, the researchers concluded.

Researchers performed the tests on hearing, unschooled Nicaraguans, as well as deaf individuals trained in American Sign Language. Both groups outperformed the Nicaraguan homesigners in the study.

Other authors on the paper are Marie Coppola, Assistant Professor in Psychology at the University of Connecticut; Elizabeth Spelke, the Marshall L. Berkman Professor of Psychology at Harvard University; and Susan Carey, Professor of Psychology at Harvard.

The work was supported with grants from the National Science Foundation and the National Institutes of Health.

Tags: national academy of sciences, numerical concepts, proceedings of the national academy of sciences, Psychology, sign, susan goldin meadow, unit, university researcher, vocabulary words

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