Cracking the brain's numerical code

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By carefully observing and analyzing the pattern of activity in the brain, researchers have found that they can tell what number a person has just seen. They can similarly tell how many dots a person has been presented with, according to a report published online on September 24th in *Current Biology*.

These findings confirm the notion that numbers are encoded in the brain via detailed and specific activity patterns and open the door to more sophisticated exploration of humans' high-level numerical abilities. Although "number-tuned" neurons have been found in monkeys, scientists hadn't managed to get any farther than particular brain regions before now in humans.

"It was not at all guaranteed that with functional imaging it would be possible to pick this up," said Evelyn Eger of INSERM in France. "In the monkey, neurons preferring one or the other numerosity appear highly intermixed among themselves as well as with neurons responding to other things, so it might seem highly unlikely that with fMRI [functional magnetic resonance imaging] at 1.5 mm resolution—where one voxel contains many thousands of neurons—one would be able to detect differences in activity patterns between individual numbers. The fact that this worked means that there is probably a somewhat more structured layout of preferences for individual numbers that has yet to be revealed by neurophysiological methods."

The researchers presented ten study participants with either number symbols or dots while their brains were scanned with fMRI. They then used a multivariate analysis method to devise a way of decoding the numbers or number of dots people had observed.

Although the brain patterns corresponding to number symbols differed somewhat from those for the same number of objects, the numerosity of dot sets can be predicted above chance from the brain activation patterns evoked by digits, the researchers show. That doesn't work the other way around, however.

At least for small numbers of dots, the researchers did find that the patterns change gradually in a way that reflects the ordered nature of the numbers—allowing one to conclude that 6 is between 5 and 7, for instance. In the case of digits, the researchers could not detect that same gradual change, suggesting that their methods are not yet sensitive enough or that digits are in fact coded as more precise, discrete entities.

The methods used in the new study may ultimately help to unlock how the brain makes more sophisticated calculations, the researchers say.

"With these codes, we are only beginning to access the most basic building blocks that symbolic math probably relies on," Eger said. "We still have no clear idea of how these number representations interact and are combined in mathematical operations, but the fact that we can resolve them in humans gives hope that at some point we can come up with paradigms that let us address this."

Source: Cell Press (news : web)