Medical Xpress

Decoding the statistical language of the brain

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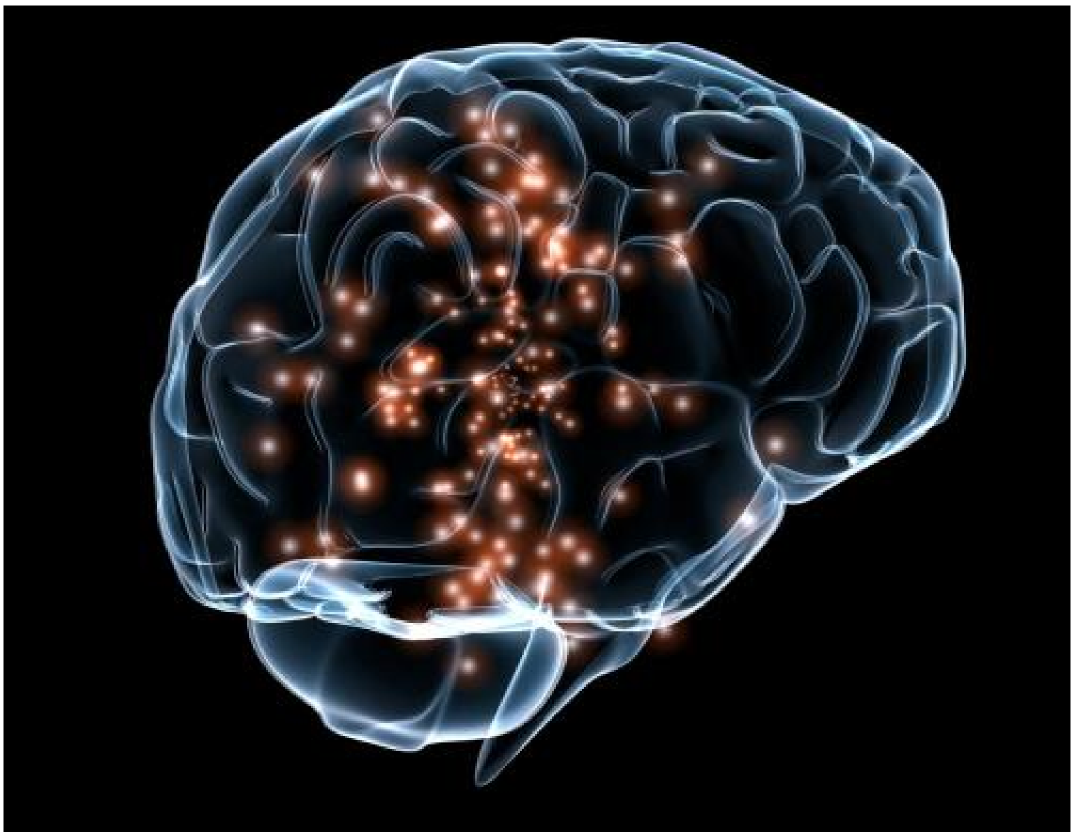

Credit: Wikimedia Commons

Let's make a bet. You will throw a dart 10 feet and – if you hit a two-inch circular target on the wall across the room – I will give you a dollar. Otherwise, you pay me a dollar.

Does that bet make you feel uncomfortable? In all likelihood, yes—because you have a pretty good idea that you are probably going to miss the target. Well, how about a four-inch target? Still no? But you felt better about your chances of success, right? How about a 60-inch target? Hmmm?

We can measure your chances of success by letting you practice for a few days (until you stop getting better) and then having you throw the dart a few thousand times. We plot the distribution of your end points, a cloud of points that we hope are centered on the target (you did aim at the target?). This "cloud" is the objective probability density function (pdf) of your visuo-motor error, and now that we know what it is, we can easily compute the proportion of time you would have hit inside the targets of different diameters by simply counting the number end points inside each of the targets.

But you decided you wouldn't take the bet with a two-inch target. And the 60-inch target was tempting, wasn't it? How did you estimate your chances of success for each target and – at the moment in time when you decided – how accurate were your estimates of the chances of success? Research in the past decade indicates that – in planning movement – we have a subjective pdf analogous to the objective and we use it in deciding when and how to act. Human performance is so good that our subjective pdfs cannot be off by much. They are very likely based on our previous experience.

Still, the burden of maintaining a neural estimate of the pdf for every possible movement we might make is daunting. When we cross the street, swing at a baseball, jump a puddle, or press a doorbell, do we really have access not just to the movement we plan but a shadowy subjective "cloud" of the movements that might happen instead?

Now, as reported in the journal *Nature Neuroscience*, researchers at New York University have developed ways to measure both the objective pdfs for a simple motor task and the corresponding subjective pdfs.

In each of three experiments, participants first practiced hitting targets on a touchscreen within a brief time limit. Then, on each trial in the second part of the experiment, participants were shown two irregularly shaped targets and asked to judge which of the two targets they would prefer to attempt to hit. They did not attempt to hit either target. The participant's choice tells us only which target they thought they had a better chance of hitting. They knew that – at the end of the experiment – they would have the chance to attempt some of their chosen targets and take home their winnings – if any. Given this information, the researchers could estimate the subjective pdf implicit in the participant's decisions and compare it the objective pdfs measured in the earlier part of the experiment.

And the outcome was not what the researchers expected.

The objective pdfs were two-dimensional bell-shaped Gaussian distributions (think jellyfish) typically found in motor tasks. The subjective pdfs in contrast had several peaks and seemed to be made of mixture of smaller distributions separated in space (a family of jellyfish of different sizes distributed along the beach). The researchers conjecture that by adjusting the heights and locations of the mixture distributions, the nervous system can parsimoniously represent a wide range of different pdfs. If so, the mixture distributions act as letters used to build words in the statistical language of the brain.

Provided by New York University

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