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Abstractions

LAST AUTHOR

To reach a decision, the brain processes information as it arrives — on the fly. But scientists didn't understand why a person would change their mind after making a decision. Michael Shadlen, a neuroscientist at the University of Washington in Seattle, and his colleagues have now discovered that a lag of several tenths of a second from the time a decision is made to the time the brain finishes processing all available information has a key role in the process. During this time, if new information in the brain's processing pipeline contradicts the original decision, a person is likely to change their mind (see page 263). Shadlen tells *Nature* more.

Under what conditions is someone most likely to change their mind?

When they're correcting an error they made in their original decision, and when the difficulty level of that original decision was intermediate. You might think you'd change your mind when the decision is most difficult, but here the processing pipeline doesn't furnish the contradictory information you need to reverse your initial choice. And when the difficulty level is low, you're confident in your first choice, so you don't change your mind then either.

How did this project come about?

My co-author Daniel Wolpert studies the computational principles that underlie the control of movement — for example, how we move body parts when we are uncertain about their position or goals. The mathematics involved in such studies are similar to those I use to explain inference, perception and decision-making. So we decided we'd spend a year working on connecting movement with decision-making. The change-of-mind study naturally followed; it's the cognitive equivalent of revising an action after initiation.

Where was the study conducted?

At Daniel's lab at the University of Cambridge, UK, while I was on sabbatical there. During my stay, I was appointed as a visiting fellow commoner at Trinity College. I didn't understand what a great privilege this was until Daniel described the benefits, including, 'You get to walk on the grass!'

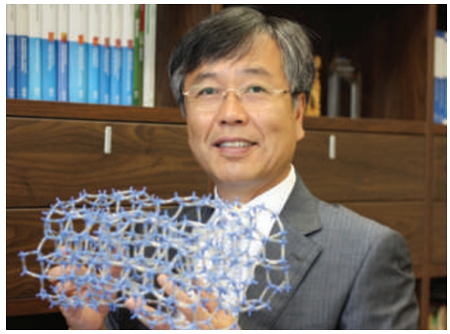
Will your finding benefit human health?

It may help us to understand brain disorders. If you have leg weakness, neurologists can determine the nerves involved, how they control the muscles and so on. But if you can't follow a book or conversation, we don't know enough about the brain's normal function to understand what's going on. By studying relatively simple forms of decision-making, we hope to gain insight into principles and neural mechanisms of higher brain function. ■

MAKING THE PAPER

Ryong Ryoo

A change in synthesis boosts an important catalyst's activity.



Zeolite crystals form three-dimensional honeycomb-like structures containing ordered arrays of tiny pores. Many zeolites occur naturally as minerals; others are synthesized commercially for specific uses, such as catalysis. "A nice example of their catalytic activities is in the 'cracking' of heavy oil into gasoline," says Ryong Ryoo, a chemist at the KAIST Institute for the Nano-Century in Daejeon, South Korea.

That particular reaction is carried out by a zeolite called MFI (or ZSM-5), one of the most important catalysts in the petrochemicals industry. Ryoo and his colleagues have developed a new synthesis that greatly increases MFI's performance (see page 246) — and the same approach could be applied to the synthesis of other zeolites to improve their functions.

The 'honeycomb' framework of most zeolites contains silicon, aluminium and oxygen. Cations, water and other molecules sit within the pores, where catalytic conversion of substrates of appropriate size and shape occurs. The assembly of zeolites is typically guided by organic cations that function as structure-directing agents. "Usually people use quaternary ammonium ions," says Ryoo. "These interact with silicate minerals in aqueous solution to help them undergo polymerizations."

One problem with traditional zeolite synthesis is that the size of the pores that form — less than 1 nanometre in diameter — makes it difficult for substrates to diffuse along the crystal structure of the zeolite and gain access to all of the sites of catalysis. The challenge, Ryoo says, has been to "increase diffusion without changing the micropore diameter of the zeolite".

One way to accomplish this is to reduce the thickness of the zeolite crystal, thereby decreasing the lengths of the diffusion paths. "Many people had already tried this approach, but, as far as I know, no one had succeeded in reaching a single-unit-cell thickness," says Ryoo. He thought that he could succeed by changing the make-up of the structure-directing agent.

In attempts to direct the synthesis of MFI, researchers had typically used a surfactant containing a quaternary ammonium group (tetrapropylammonium) at one end. "We needed a more powerful structure-directing agent," says Ryoo, who predicted, on the basis of earlier work, that such an agent would contain two quaternary ammonium groups.

Ryoo first instructed Minkee Choi, one of the graduate students in his lab, to put a diquaternary ammonium group between two long hydrocarbon chains. But this compound didn't work in zeolite synthesis, so Ryoo suggested shortening one of the chains. "I guessed that the probability of success would be no more than 10% — not a small probability — and that is what I told my students," he says.

He asked another graduate student, Kyungsu Na, to help with the synthesis. "Surprisingly, Kyungsu's first try was quite successful," says Ryoo. The resultant zeolite consisted of 2-nanometre-thick sheets, he recalls.

Having successfully synthesized a new MFI zeolite structure, Ryoo's group spent about two years looking for interesting properties. One of their more exciting discoveries was that when the zeolite is used to transform methanol into gasoline, the catalytic longevity is greatly increased. "I expected a long catalytic lifetime, but I was surprised by the result. It was much longer than I expected," he says. ■

FROM THE BLOGOSPHERE

Noted authors and scientists have chosen the shortlist for the Royal Society's 2009 Prizes for Science Books. Ruth Francis, *Nature*'s head press officer, is reviewing one book a week on the Great Beyond blog until the winner is announced on 15 September (http://blogs.nature.com/news/thegreatbeyond/2009/09/ruths_reviews_bad_science).

Francis applauds Leonard Mlodinow's tale-weaving in *The Drunkard's Walk*, saying his stories are "a tool rather than a stumbling block, intertwined with the numbers … to elucidate his points". His flickering between tale and theory "serves to draw the reader on to the reveal," she notes, clearly hooked on this exploration of chance and causality.

She also gives high marks to fossil hunter Neil Shubin's adventurous *Your Inner Fish*, as well as Jo Marchant's *Decoding the Heavens* on cracking the the Antikythera mechanism, an early computer thought to hail from ancient Greece. However, Francis sniffs at the choice of Avery Gilbert's *What the Nose Knows*, saying, "My curiosity was not sated … and my understanding was unimproved." ■

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