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RESEARCH AT THE UNIVERSITY OF MARYLAND

DAVID POEPPEL

Biological Foundations of Language

Our senses have a remarkable way of converting phenomena outside our bodies into biological messages that we finally interpret as something—a color, a scent, a melody—distinct and even evocative. The recognition happens so quickly, yet *how* it happens, at least in the case of hearing, remains a mystery. How do we recognize a word? How does something mechanical—a set of vibrations in the ear—end up as an abstraction in the brain?

The more ambitious question that animates David Poeppel, a University of Maryland professor with appointments in both linguistics and biology, is: "How is the brain organized so that you can do these remarkable things, such as talk to each other?" At a basic level, how does the brain convert the physical phenomenon of sound into meaning?

Language and Cognition

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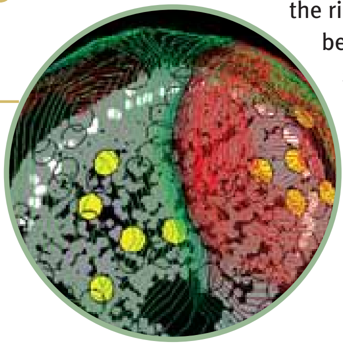
As a brain scientist and a linguist, Poeppel usually addresses questions from two different perspectives, by probing the brain as an organ as well as by testing cognitive abilities through experimental psychology. With these approaches, he tries to learn how the brain works as well as how language works. To study the brain, he relies on imaging techniques such as functional magnetic resonance imaging, or fMRI, which perceives changes in blood flow and oxygenation levels in the brain. This method gives detailed anatomical pictures, but doesn't resolve events in time as effectively as a technique that directly detects electromagnetic signals, such as magnetoencephalography, or MEG. The University of Maryland is one of the few academic institutions in the world with a sophisticated MEG laboratory, which allows Poeppel and other researchers to distinguish impulses that occur milliseconds apart.

"The challenge is that the cognitive science of language processing has a particular vocabulary, and neuroimaging has another vocabulary," says Poeppel. The puzzle is how to relate concepts in linguistics with concepts in neuroscience. Poeppel believes that translating the language of both disciplines into computational terms can help make the two fields intelligible to each other.

As to the specific problem of how sounds are converted into words, Poeppel says, "It's one of those conceptually simple but technically difficult questions." The answer to this fundamental scientific question could also have practical applications. Ideas gleaned from biology could help in the development of technology for recognizing speech, for instance, with the "brain's tricks" for decoding speech possibly encoded in speech recognition software, Poeppel says.



Poeppel had seen scattered evidence that the right hemisphere of the brain might be enriched for cells that integrate sounds at relatively long time-scales compared with the left hemisphere. For example, babies are known to prefer more slowly spoken syllabic sounds, and research has shown that the right hemisphere develops earlier than the left in infants. These lines of evidence suggested to Poeppel that the brain's right hemisphere might be specialized to respond to slower, syllabic sounds. By slower sounds, he means ones that span hundreds of milliseconds—windows of time that can convey tonal changes—such as the rise and fall of pitch that allow a single word (such as the word *yes*) to have different meanings (an affirmation, a question). The brain also needs to process sounds on shorter time scales—tens of milliseconds—to distinguish the order of certain sounds within syllables, for example to tell the difference between the words *pest* and *pets*.

"In our research, we asked: do populations of cells in the brain have preferred windows of operation?" Poeppel explains. He determined it might be possible to address this question, using fMRI and psychological experiments, if the left and right hemispheres respond asymmetrically to sounds played at different time-scales. In fact, his research team found that cells in the right hemisphere light up preferentially when exposed to slower syllabic sounds, and the left hemisphere responds preferentially to sounds that need to be resolved on a shorter time-scale. The evidence from both linguistics and neuroscience now suggests that syllables are fundamental units of perception. "It seems that there are mechanisms that are particularly tuned to dealing with information of that size," says Poeppel.

This kind of insight—the idea that one can recognize a word by combining the outputs of two different time-scales—could easily be implemented in automatic speech recognition developed by engineers or computer scientists. Poeppel believes that interacting with these other disciplines is also an important part of basic research. "Much of the strength of the University of Maryland lies in the different points of view that computer scientists and brain and cognitive scientists are able to bring to the same problem," he says. Different ways of looking at the same problems can yield unexpected solutions. *—Karin Jegalian*

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Impact Profile is a supplement to *Impact*, a quarterly research digest from the University of Maryland. To learn more about research at Maryland, go to www.umresearch.umd.edu.

Produced by the Office of University Publications for the Vice President for Research, University of Maryland.