

How Does the Human Brain Relearn to Understand Speech with a Cochlear Implant?

A Report from FENS Forum 2026

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A cochlear implant can restore the ability to understand spoken language to people with severe-to-profound hearing loss. What is happening in the human brain when this occurs? Cochlear implantation is now a well-established treatment worldwide, yet hearing through a cochlear implant and understanding speech are not the same thing. Because sound is delivered through a limited number of stimulating electrodes, the input is spectrally degraded, and it typically takes months for recipients to gradually learn to recognize this new kind of sound as language. This process is often described as "adaptation," but its neural basis is still not fully understood. As an otolaryngologist involved in cochlear implant care, I became fascinated by this question. In Professor Takuya Takahashi's laboratory in the Department of Physiology at Yokohama City University, I am investigating the synaptic plasticity that accompanies the recovery of speech understanding, focusing on changes in AMPA receptors.

With the support of a Travel Award from the JNS-FENS scientific exchange program, I attended FENS Forum 2026 in Barcelona from July 6 to 10. I presented our recent findings as a poster, hoping to get feedback from researchers with different backgrounds before submitting our manuscript.

FENS Forum is one of the largest international neuroscience meetings, bringing together more than 8,000 participants. Research ranging from molecular mechanisms to human brain function was presented and debated in one place, and I realized how broad neuroscience is as a field. What impressed me most was how eager many researchers were to discuss their work. I shared their excitement and enjoyed these conversations.

Here, let me briefly explain the background of my research. The search for the molecular basis of synaptic plasticity began with the discovery of long-term potentiation, or LTP, by Bliss and Lømo in 1973, and when Roberto Malinow and colleagues demonstrated that AMPA receptors are trafficked to the postsynaptic membrane, it became possible to study how experience changes the brain at the molecular level. Building on this line of work, the Takahashi laboratory has revealed experience-dependent synaptic delivery of AMPA

receptors in vivo, as well as cross-modal reorganization of the brain following sensory deprivation. My research attempts to extend this line of inquiry to the human brain. Patients who regain access to sound and learn to understand speech offer a rare opportunity to ask, in humans, what happens when sensory input is lost and then regained, or rather relearned.

In my poster, I presented a longitudinal study in which PET-based molecular imaging visualized cell-surface AMPA receptors in the human brain before and after hearing restoration, and related these changes to the recovery of speech perception. Interestingly, the changes in AMPA receptors were not confined to auditory-related regions. They were observed in association with progressively higher-order brain areas along the hierarchy of speech processing, from monosyllables to words to sentences.

What left the deepest impression on me, though, were the discussions with researchers from different backgrounds, which made me see my own work from new angles. Researchers working with animal models asked how the hierarchy of human speech processing might relate to brain functions studied in those models. They also asked to what extent changes in cell-surface AMPA receptors seen with PET in the human brain can really be interpreted as evidence of "synaptic plasticity." Researchers using fMRI and EEG asked how experience-dependent changes in AMPA receptor distribution might relate to changes in BOLD signals or electrophysiological responses, and what such changes might mean biologically.

These conversations made me realize how difficult it is to describe, in precise neuroscientific terms, a phenomenon that seems relatively familiar in clinical practice, namely a patient gradually adapting to a cochlear implant and becoming able to understand speech. They also made me think, once again, of a question I keep struggling with. How far, and in what way, should we interpret the results of imaging a single functional molecule in the living human brain?

It was a very rewarding week. My one regret is that, having spent every day at the venue from morning to evening despite jet lag, I fell fast asleep at my hotel and missed "Jump the FENS," the reception at Club Razzmatazz that I had been so looking forward to.

As an otolaryngologist who came to neuroscience from clinical medicine, I am especially grateful that this program welcomed someone with my background. The passion of the neuroscientists I met in Barcelona moved me deeply, and the Forum made me think again about the kind of researcher I hope to become. The answer is now clearer to me. I want to be

a researcher who bridges basic neuroscience and clinical medicine.

I would like to express my sincere gratitude to FENS and the Japan Neuroscience Society for making this program possible, and to my mentors for their continued guidance.



The main hall on the opening day



The author at the poster session