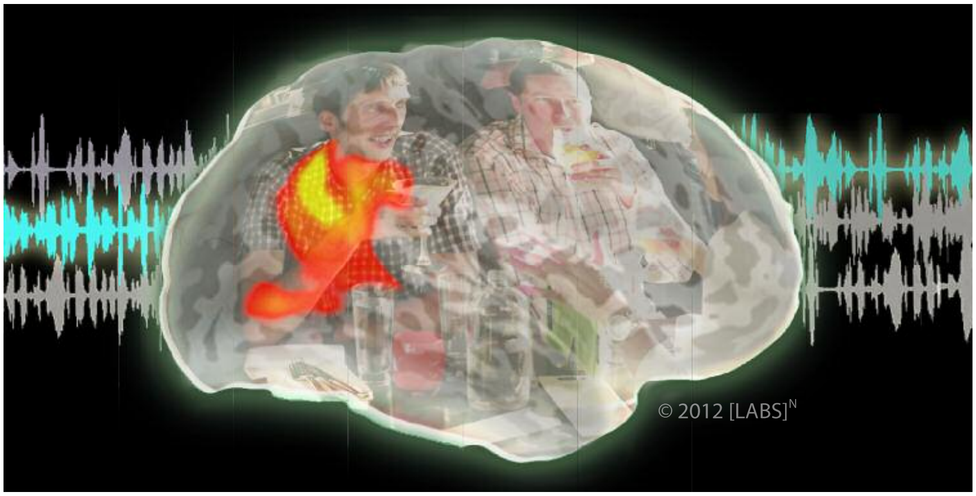
# Brain attending a cocktail party: A special session discussing cortical neuroimaging techniques

*Adrian KC Lee*




*In our laboratory at the University of Washington, we combine MEG and EEG measurements with anatomical information measured using magnetic resonance imaging to capture brain dynamics associated with different auditory perceptual and cognitive tasks. In this illustration, a spatiotemporal cortical activation cluster corresponding to the right temporoparietal junction (RTPJ) is shown to highlight its participation in aiding us to switch auditory attention in a cocktail party environment. In our recent neuroimaging studies, we found that brain activity in the RTPJ cluster was significantly stronger when subjects were instructed to switch spatial attention than when they had to maintain attention on one sound stream in the presence of another competing stream. Furthermore, we observed a significant correlation between differential RTPJ activation and behavioral performance in switch versus maintain attention trials. [Artwork provided by Michelle Drews].*

I remember using this very title for a term paper a few years ago. At that time, I was studying psychoacoustics under the mentorship of Prof. Barbara Shinn-Cunningham while being trained as a graduate student in the Speech and Hearing Bioscience and Technology program (then part of the Harvard-MIT Division of Health Sciences and Technology). I was fascinated by how we can selectively "tune in" to a sound of interest and "tune out" everything else in a crowded environment—just like how one can focus in a conversation at a cocktail party (this effect was first coined by E. Colin Cherry in 1953). However, above all, how our brain can so seamlessly pull this off captures my imagination, and to the end of better understanding this process, I invited some of the world's experts in brain imaging to discuss this topic in a special psychological and physiological acoustics session at the Acoustics 2012 Hong Kong meeting (and in return introduced them to some of the most crowded and noisy restaurants from my birthplace).

There are many neuroimaging tools that allow us to take snapshots of our brain performing this amazing feat; each technique offers a different, unique window into how our cortex participates in auditory tasks. Many people are familiar with a technique known as functional magnetic resonance imaging (fMRI), wherein brain activity is measured by detecting the associated changes in blood flow (using blood-oxygen-level-dependent, a.k.a. BOLD, contrast). This brain imaging tool provides very good spatial resolution (~1 mm), but trades off precise temporal information (~1 s). In the special P&P session, Prof. Chris Stecker (University of Washington) presented how his laboratory uses this technique to probe the coding of interaural differences of level and time—important binaural cues that we rely on to segregate sounds in a noisy mixture—in the human auditory cortex. fMRI can also be used to investigate how the brain processes other auditory features by incorporating advanced statistical approaches, and Dr. Annika Linke (University of Western Ontario) showed us how multivariate pattern analysis methods can uncover distributed neural networks associated with auditory perception and attention.

While a shortcoming of the fMRI technique is its coarse temporal resolution—a lot of acoustical variations can happen in one second—other brain imaging techniques, such as electroencephalography (EEG) or magnetoencephalography (MEG), can detect neuroelectric activities with millisecond precision while trading off some spatial resolution (~1 cm). Prof. Lin Chen (University of Science and Technology of China) shared how his laboratory uses EEG to investigate how humans process pitch information in the cortex. It has long been hypothesized that our left hemisphere is specialized for speech whereas the right for music, but it remains elusive whether the division of labor between the two hemispheres is determined by function or by acoustic properties of stimuli. This is apropos of the meeting's Hong Kong setting because the local dialect (Cantonese) and its lingua franca (Mandarin) are both examples of tonal languages, whereby pitch is used to

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convey lexical or grammatical meaning. Pitch is also an important cue to help us selectively attend to one voice amongst others (whether the cocktail party is held in China or in Australia), and thus using tonal language to disentangle how we use pitch information is an especially fascinating approach.

Another advantage of using a neuroimaging technique with high temporal resolution is that the sampling rate is fast enough to resolve high frequency neural oscillations. Prof. Barbara Shinn-Cunningham (Boston University) and her colleagues used combined MEG and EEG to show that the brain activities more faithfully follow an attended stream in the presence of a competing sound stream (revealed by amplitude-modulating each of the auditory streams at different frequencies). Interestingly, the attended-stream modulation frequency drives phase-locked responses in left, but not right Frontal Eye Fields—a cortical region associated with control over eye gaze and spatial attention. This left the audience wondering: are there key regions in the brain outside of the auditory cortical areas that are involved in auditory attention which are not actively discussed within our community? Finally, Priv.-Doz. Alexander Gutschalk (Heidelberg University Hospital) discussed the benefits and limitations of combining MEG and fMRI to study correlates of perception in the auditory cortex. This talk provided the session participants great discussion points on how to combine information from these state-of-the-art imaging tools while reconciling differences that are commonly reported in the literature.

Neuroimaging tools and their associated analysis techniques have come a long way in the last two decades, enabling us to map the cortical dynamics involved in auditory attention. But in addition to knowing when and where the cortex is involved in auditory perception and cognition tasks, we would like to push the envelope even further. Drs. Eric Larson, Ross Maddox and I, along with our collaborators spread across the neuroimaging and signal processing communities, are now developing new analysis techniques that will eventually enable us to provide a systems neuroscience view of the auditory attentional network. We are working to describe how different brain regions coordinate top-down attention (e.g., listening to the directions provided on my smartphone) while gating salient signals in or out (e.g., noticing that my other cell phone is ringing while ignoring the baby crying in the back of my car).

Writing this article now reminds me of the feeling I had when I wrote that term paper during graduate school—there are so many neuroimaging techniques out there to learn about and so many interesting questions left to be asked, let alone answered. To paraphrase comments from one of my mentors, Nat Durlach, on the state of neuroimaging in a lab meeting, "you're all asking questions that have fascinated us in the 60's or even before, but I think now you have the right tools to answer these questions." It is exciting to be a psychoacoustician and physiologist right now!

So next time when you are attending a cocktail party, spare a moment to marvel on the complicated task that your brain is doing such that you can eavesdrop on the gossiping conversation behind you while ignoring all the clinking of the cocktail glasses around you. Then give a quiet cheer for your brain!

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*Student reception at Acoustics 2012 Hong Kong*