"Competing Streams at the Cocktail Party"

A Neural and Behavioral Study of Auditory Attention

Jonathan Z. Simon

Neuroscience and Cognitive Sciences / Biology / Electrical & Computer Engineering University of Maryland, College Park

Topics In Neuroscience Seminar December 5, 2008

Computational Sensorimotor Systems Laboratory



Current & Former StudentsCuJuanjuan XiangJiachen ZhuoNai DingHarsha AgasheHuan LuoMaria ChaitNayef AhmarLing MaMinsuk Park

Faculty Collaborators David Poeppel *Shihab Shamma* Alain de Cheveigné *Current & Former Postdocs* Dan Hertz Yadong Wang *Mounya Elhilali*

> *Lab Staff* Jeff Walker Ray Shantanu

Supported by NIH: NIDCD, NIBIB, NIA

Outline

• Magnetoencephalography (MEG) as a tool of Non-Invasive Auditory Physiology

• MEG in the Frequency Domain

 Neural & Behavioral Correlates of Auditory Attention

Magnetoencephalography (MEG)

- Non-invasive, Passive, Silent Neural Recordings
- Simultaneous Whole-Head Recording (~200 sensors)
- Sensitivity

high: ~100 fT (10^{-13} Tesla)

low: $\sim 10^4 - \sim 10^6$ neurons

- Temporal Resolution: ~1 ms
- Spatial Resolution coarse: ~1 cm ambiguous



Functional Imaging



Primary Neural Current



Photo by Fritz Goro

Primary Neural Current



Photo by Fritz Goro

MEG Measures Neural Currents



MEG Response 3–D Isofield Contour Map

Sagittal View

Axial View





Chait et al., Cerebral Cortex 2006

Time Course of MEG Responses



Spatial Auditory MEG Responses



MEG as Auditory Physiology Tool

- Advantages of humans over animals Subjects can be rented (by the hour) Subjects can be trained in minutes Better grasp of subjects' perceptual space (?) Access to Speech & Language processing (?)
- Advantage of Whole Head Recording
- Disadvantage of Neural Source Localization Coarseness/Ambiguity in Source Location Blindness to Many Kinds of Coding
- Neutral Aspects

Neural Source is Dendritic Current (not Spikes) Humans not typical mammals (?) New Technique/Immature Analysis Tools

Outline

• Magnetoencephalography (MEG) as a tool of Non-Invasive Auditory Physiology

• MEG in the Frequency Domain

• Neural & Behavioral Correlates of Auditory Attention

An Alternative to Time: Frequency

• Use Stimuli localized in Frequency, not time



- Examine Response at Same Frequency
- Steady State Response (SSR)
- Frequency Response/Transfer Function



Whole Head Steady State Response Simon & Wang J. Neuroscience Methods 2005 32 Hz Computational Sensorimotor Systems Laboratory

Complex Equivalent–Current Dipoles



Outline

• Magnetoencephalography (MEG) as a tool of Non-Invasive Auditory Physiology

• MEG in the Frequency Domain

 Neural & Behavioral Correlates of Auditory Attention

Competing Auditory Streams





Foreground & Background



Foreground & Background





Experimental Paradigm



Experimental Paradigm



Foreground & Background Paradigm



Psychophysical Performance





Psychophysical Performance





Tracking 4 Hz task









Attention Modulates Response to Target





Neural Enhancement by Frequency

Neural Response Enhancement



Neural Enhancement of Target



Attention Modulates Phase Coherence



Coherence Enhancement by Frequency



Coherence Enhancment of Target

Long-distance Coherence Enhancement



Right Hemisperic Advantage



Target Hemispheric Asymmetry Flips



Behavioral & Neural Build-ups

Build up of 4 Hz Stream



Behavioral & Neural Build-ups

Build up of 4 Hz Stream



Target Behavioral & Neural Build-ups



Target Behavioral & Neural Build-ups



Behavioral & Neural Build-ups

Build up of 7Hz Stream



Time after Sequence Onset (seconds)

Summary

- Strong Neural Response to Both Streams
 - + Acquired non-invasively, with high temporal resolution
- Attention strongly modulates Neural Response & Coherence
- Change in Behavior correlates with Change in Neural Response
 - + Buildup of Neural Response correlates *within subjects* with Behavioral Buildup for Slow Stream Only
- Right Hemispheric Advantage
 - + Modulated by Attention

(more complicated in Foreground/Background experiment)

Thank You

