

Stimulus- and task-dependent spatial processing in the human auditory cortex

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Supported by NIDCD, NSF, and Academy of Finland

Spatial processing in auditory cortex

Functional fMRI for human auditory studies - challenges but advantages

Systematic investigation throughout the tissue of AC

BOLD hemodynamic response relates *broadly* to neural activity (synaptic mainly, not spikes)

Our interest: the role of human AC in binaural and spatial hearing

AC is necessary for accurate sound localization (e.g., Zatorre and Penhune 2001, Malhotra et al. 2004, Spierer et al. 2009)

Most AC neurons are binaural tuned (Kitzes 2008)

ITD and ILD pathways partly preserved in AC (Middlebrooks et al 1980, Schröger et al. 1996)

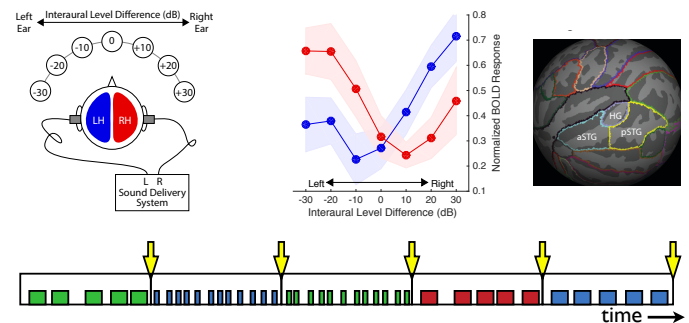
Our view of what needs to be done:

- 1) Determine how well we can resolve AC binaural tuning with BOLD fMRI
- 2) Explore how that tuning changes with interesting manipulations (i.e., the things people use binaural hearing for)

In this talk, look at:

- Dependence of BOLD on binaural stimulus features (ILD and ITD)
- Task-dependent effects

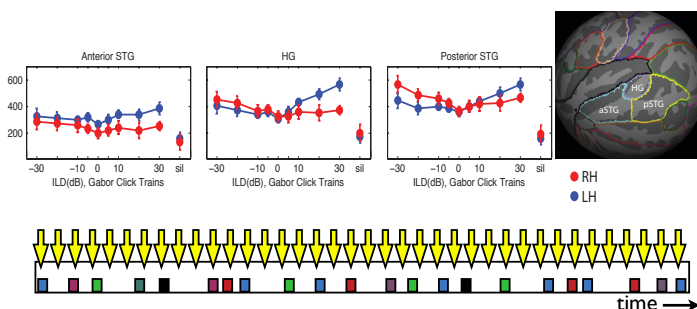
BOLD tuning to ILD



Sparse block-related imaging (arrows, TR=12s) of response to 4 kHz click trains varying in ILD from block to block (colors)

(Stecker et al., submitted)

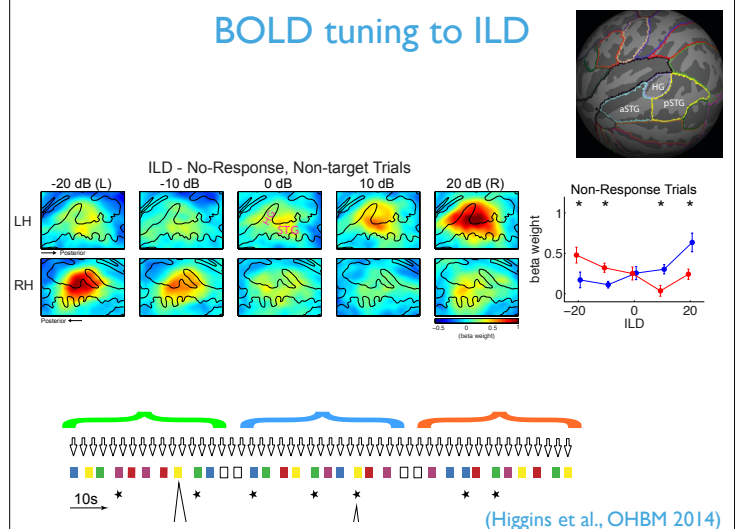
BOLD tuning to ILD



Continuous event-related imaging (arrows, TR=2s) of response to 4 kHz click trains varying in ILD from block to block (colors)

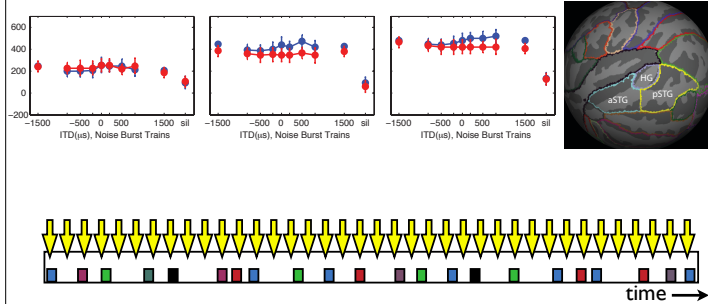
(McLaughlin 2013)

BOLD tuning to ILD



(Higgins et al., OHBM 2014)

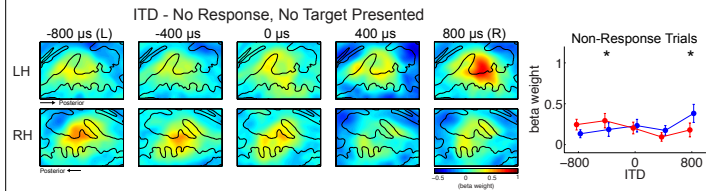
BOLD tuning to ITD



Continuous event-related imaging (arrows, TR=2s) of response to noise-burst trains varying in ITD from block to block (colors)

(McLaughlin 2013)

BOLD tuning to ITD

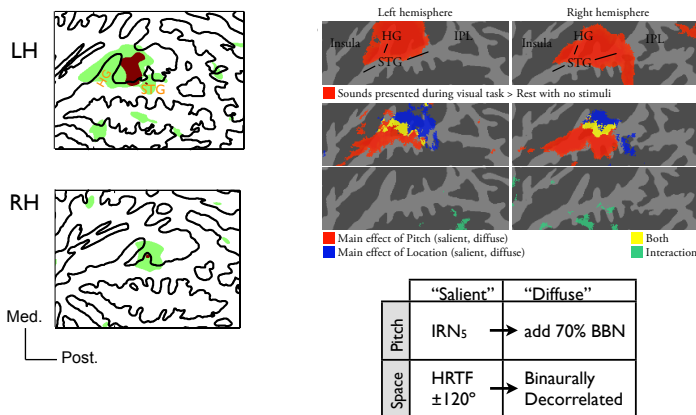


(Higgins et al., OHBM 2014)

Functional organization of spatial tuning

(Higgins et al. OHBM 2014)

(Talja et al., submitted)



So, what about task dependence?

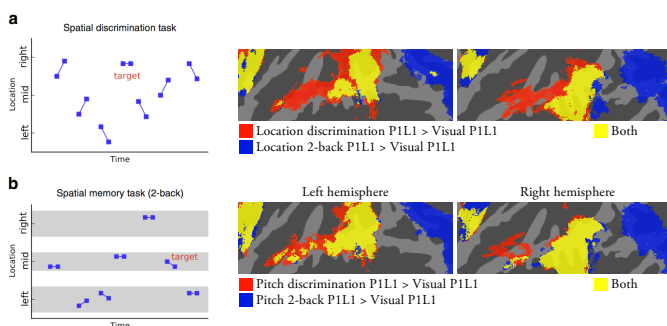
Kinds of tasks in the literature

- 1) "Passive" listening
- 2) Task on irrelevant modality (e.g. visual task)
- 3) Task on irrelevant (non-spatial) auditory feature
- 4) Task on relevant (spatial) feature
- 5) Higher-order tasks, e.g. motion, memory

Data presented earlier were collected with pitch task (the third kind)

Rinne et al (2005, 2009, 2012, ...) systematically compare task types

Task-dependent modulations



(Talja et al., submitted)

Task-modulation of ITD/ILD tuning

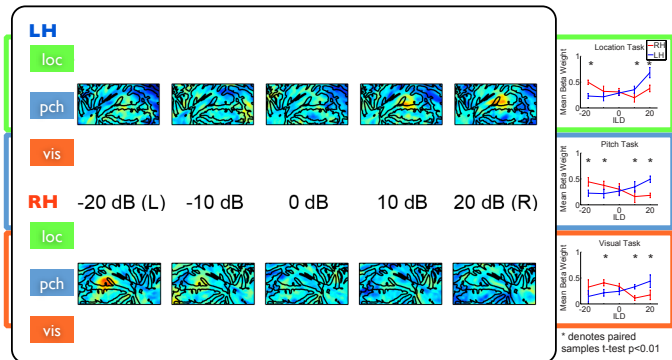
Task-block design (Rinne et al. 2009): compare task blocks (location, pitch, visual) that contain identical stimuli that vary in all these dimensions. Task effects may differ in several factors:

- Sustained attention
- Target detection
- Response selection

Nate Higgins' approach: distinguish these components using single-trial event-related analysis across location, pitch, and visual task blocks:

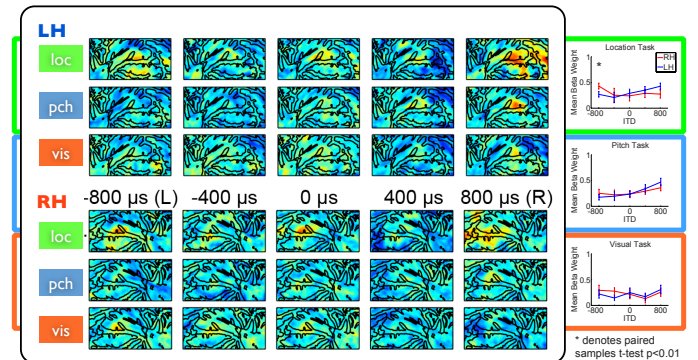
- 1) No-target, no-response trials (to focus on attentional modulation)
- 2) Correct-response trials (target detection, see poster PS-714)

Task effects on ILD tuning (no-target, no-response trials)



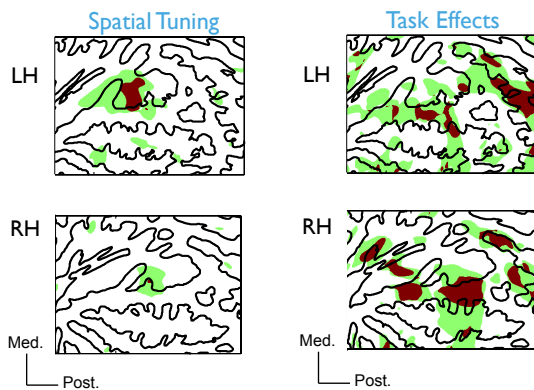
(Higgins et al., OHBM 2014)

Task effects on ITD tuning (no-target, no-response trials)



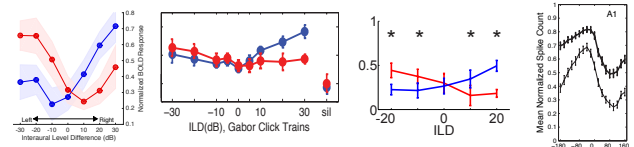
(Higgins et al., OHBM 2014)

Functional organization of spatial tuning and task effects



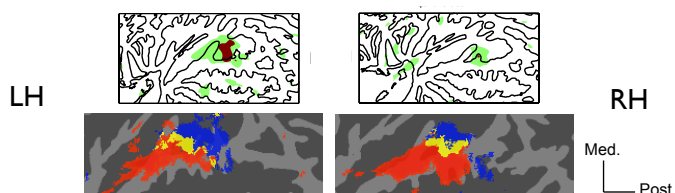
(Higgins et al., OHBM 2014)

Conclusions: A) Binaural tuning



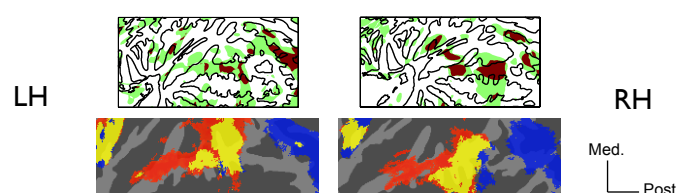
- 1) Binaural tuning is clearly evident in AC BOLD responses
- 2) ILD tuning is contralaterally biased; more so in LH than RH
- 3) ITD tuning is less clear, but also stronger in LH than RH
- 4) Hemispheric asymmetries consistent with contralateral tuning within left AC, bilateral tuning in RH (Magezi & Krumbholz 2010)

B) Organization of spatial sensitivity



- 5) A common region of posterior AC in both hemispheres exhibits:
 - Significant tuning to ILD and ITD (Higgins et al.)
 - Greater response to salient vs diffuse location (Talja et al.)
- 6) These modulations appear space-specific. Sensitivity to salient pitch and to ILD (intensity) extend anterior to HG

C) Organization of task-related modulations



- 7) A region of posterior lateral STG is strongly modulated by auditory tasks. (cf. Petkov et al. 2005, Woods et al. 2009, Rinne et al. 2009, 2012)
- 8) That modulation is not specific to space, and appears additive rather than interactive with sensitivity to stimulus features (e.g. ILD/ITD)
- 9) A separate region of inferior parietal lobule (IPL) is modulated across these tasks, particularly for categorical processing and/or high memory load (n-back tasks, Rinne et al. 2009, 2012)

