Orienting Towards Auditory Double Stimuli in Elevation

or

Target Selection by the Auditory System

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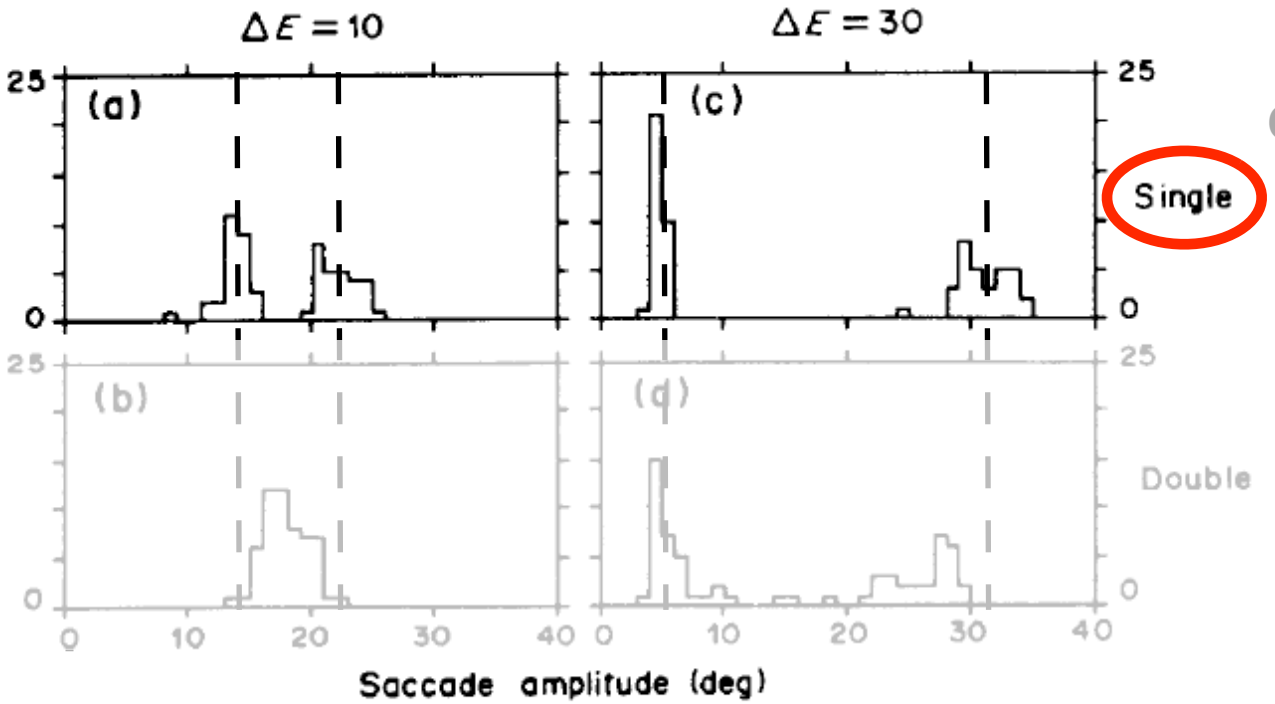
Three Basic Questions

- How do humans analyze auditory scenes?
- How are targets selected?
- Which cues are necessary for segregating sounds in a mixture?

An Example: The Visual System



Cues for Segregation:

- *Space*
- *Size*
- *Intensity*
- *Time*

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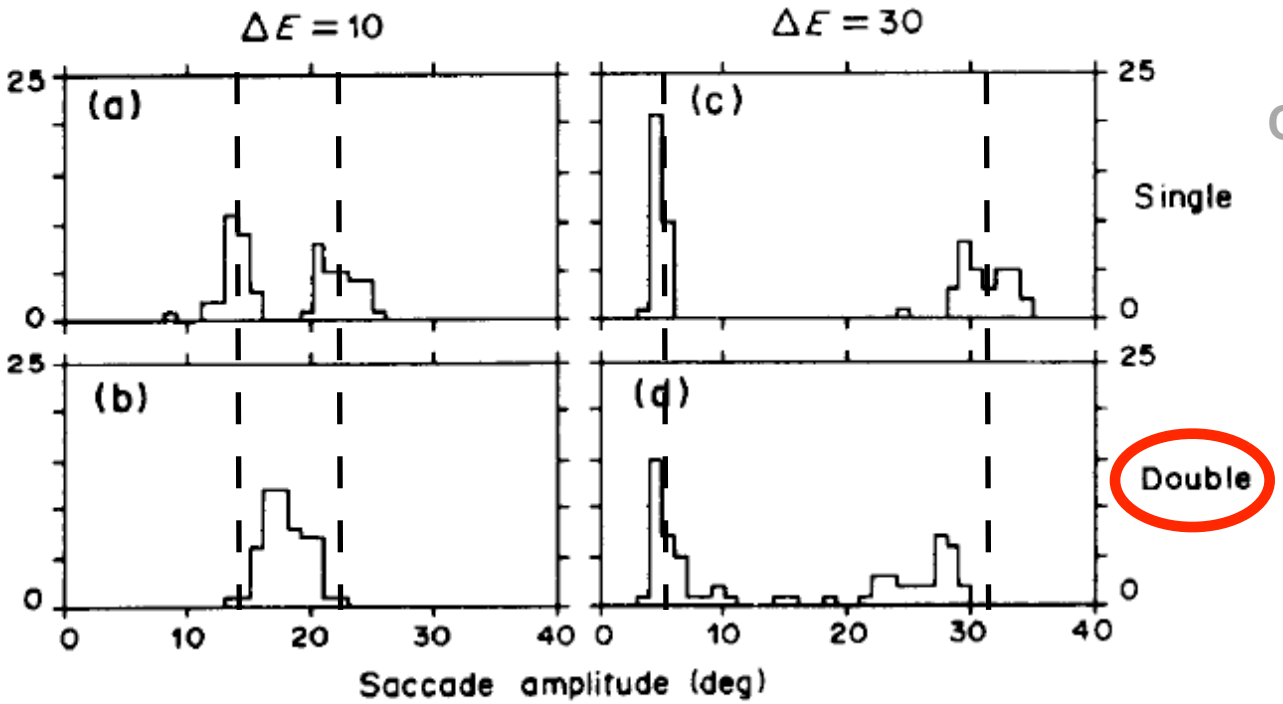

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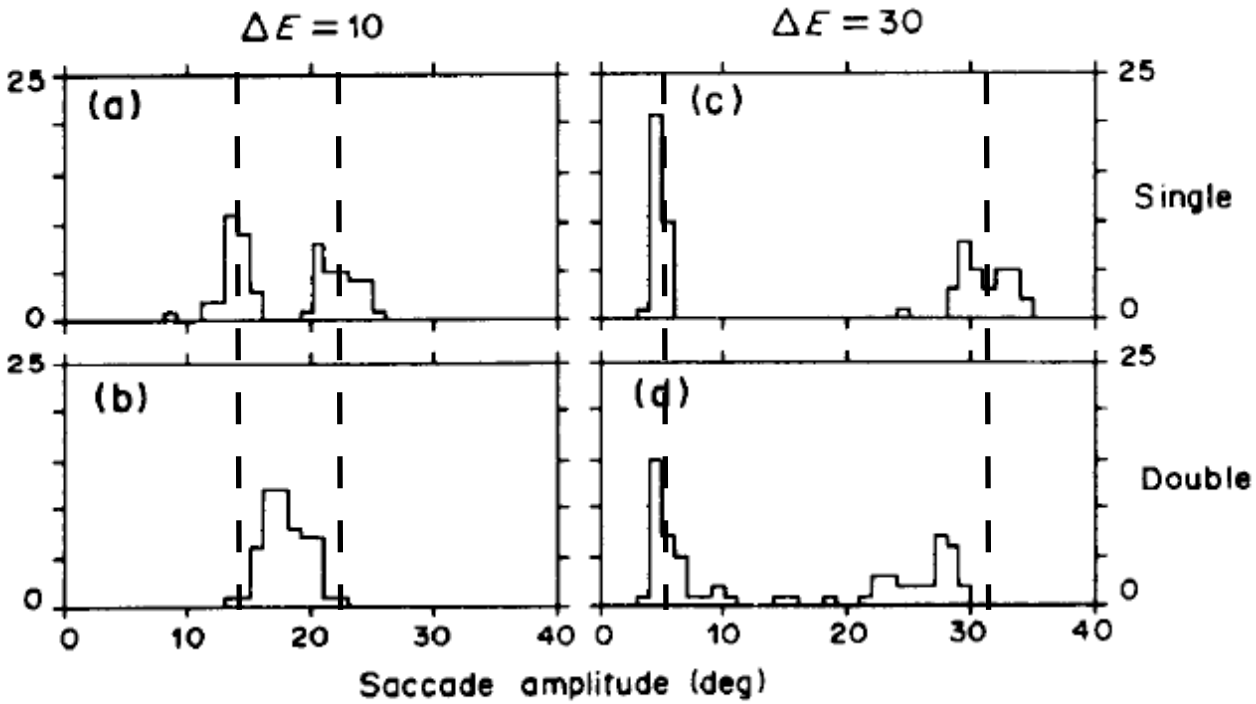

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Cues for 2D Sound Localization

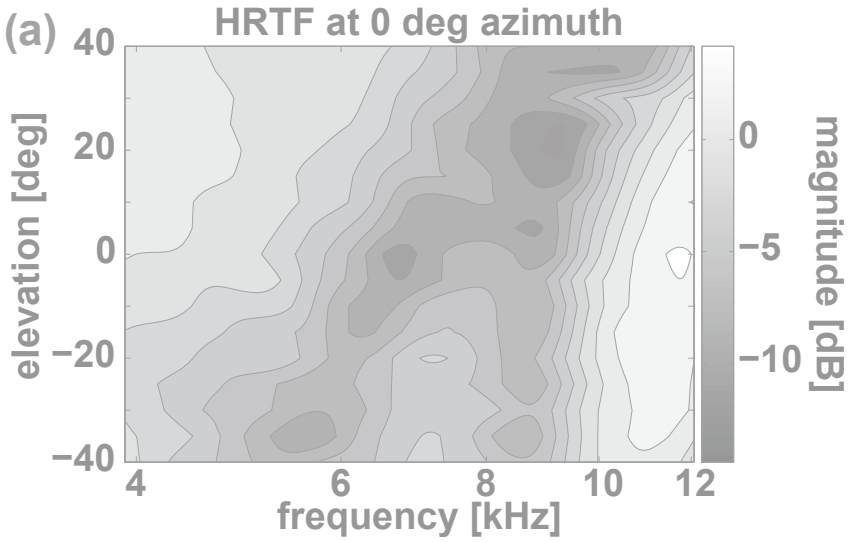
Azimuth: *Binaural Cues*

Duplex Theory of Sound Localization (Strutt 1877)

Low Frequencies (<1.6 kHz): ***I**nteraural **T**iming **D**ifferences (ITDs)*

High Frequencies (>1.6 kHz): ***I**nteraural **L**evel **D**ifferences (ILDs)*

Elevation: *Monaural Spectral Cues (**H**ead **R**elated **T**ransfer **F**unction)*



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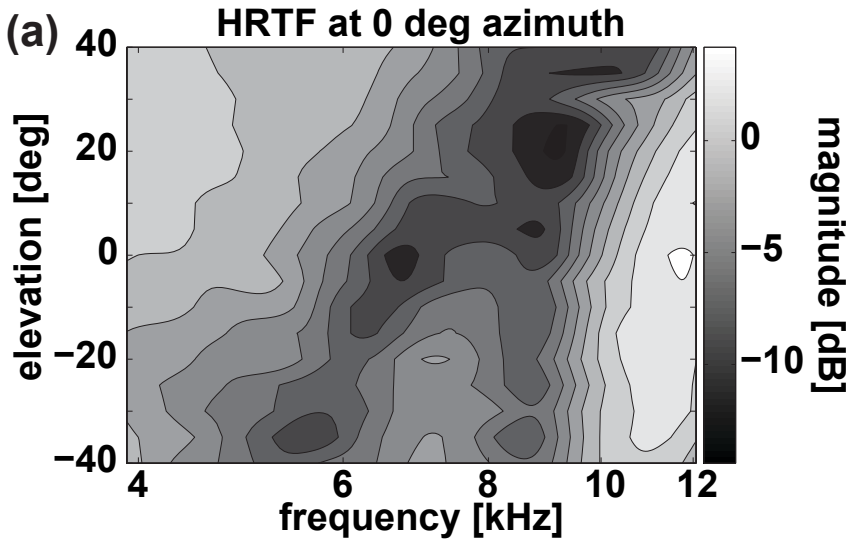

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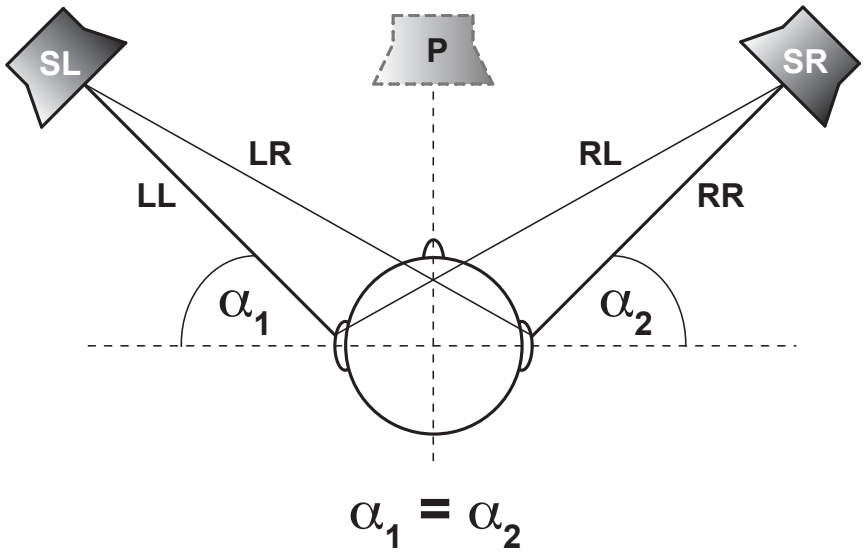
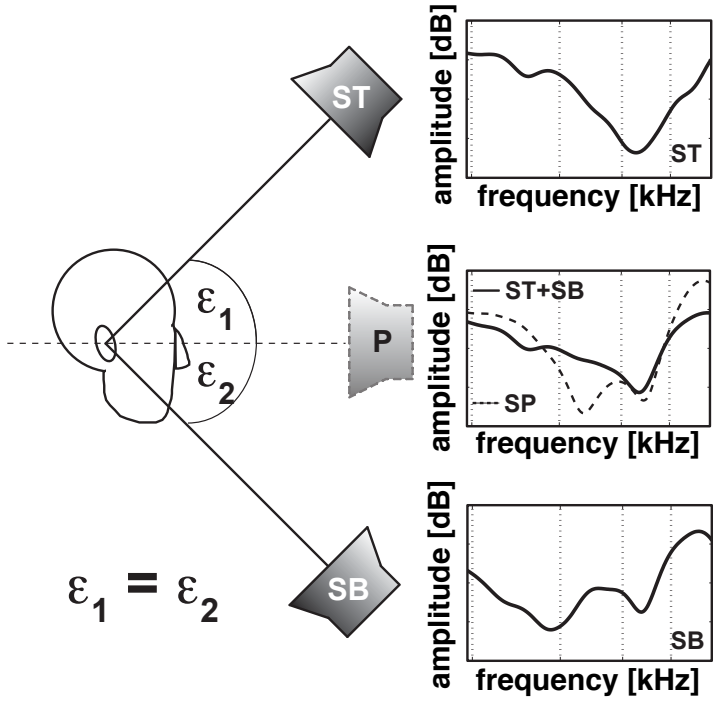
Acoustic Models

Can existing models based on single stimuli predict double stimuli responses?





*Current models can only **predict averaging**!*

Methods

Measure:

Head orienting response with search coil technique

Sounds:

- **GWN** 50 ms, 5 ms $\cos^2$ on- & offset ramp (frozen)
- Quasi-noise 50 ms with period of 10 ms (aka **Buzzer**)

Task:

Align head-fixed laser pointer with sound percept as quickly and as accurately as possible

Parameters:

Δ level -10:5:10 dBA

Δ elevation 15:15:120 deg

Subjects:

4 subjects (3 male, 1 female) with normal hearing

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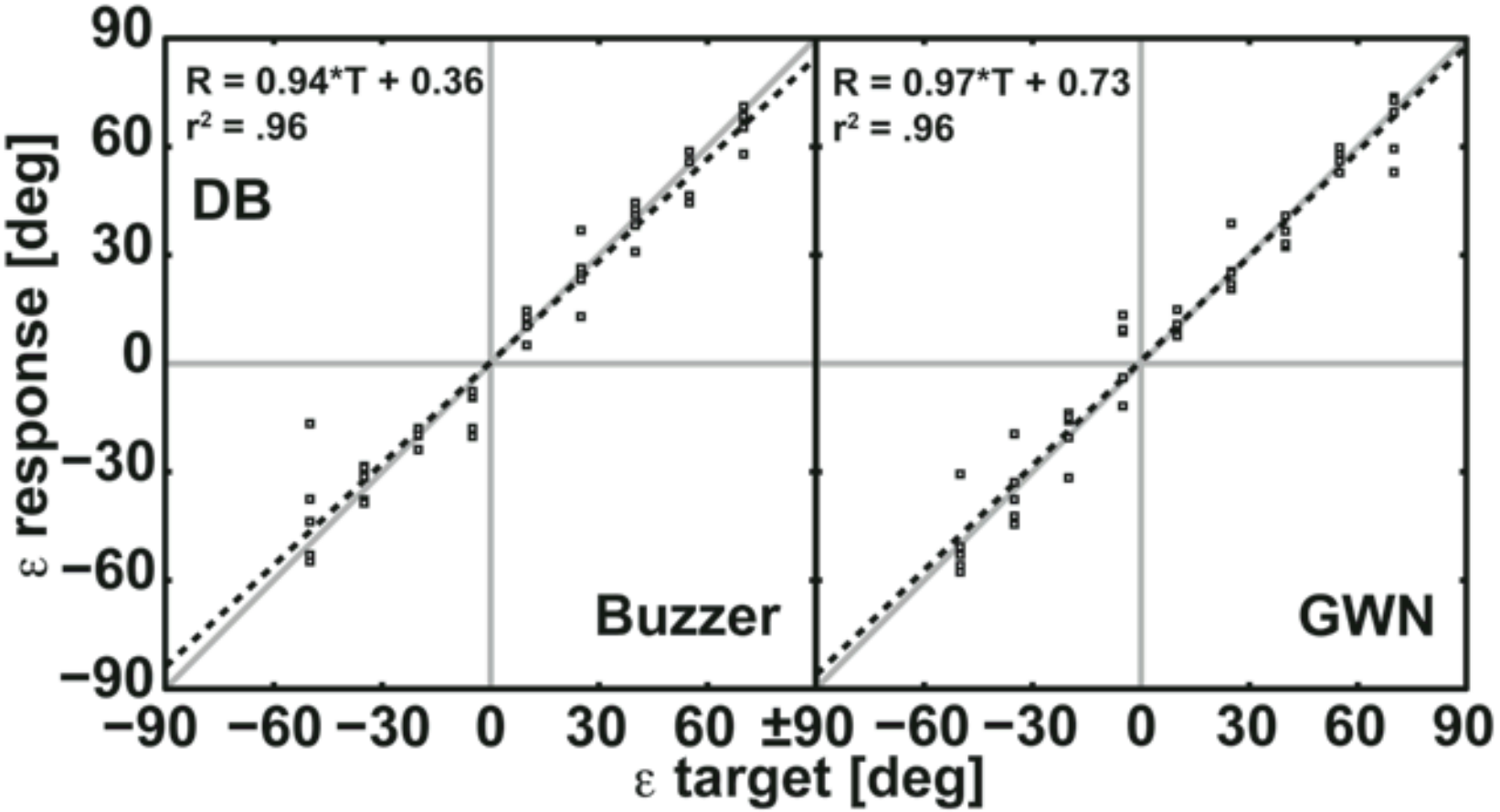
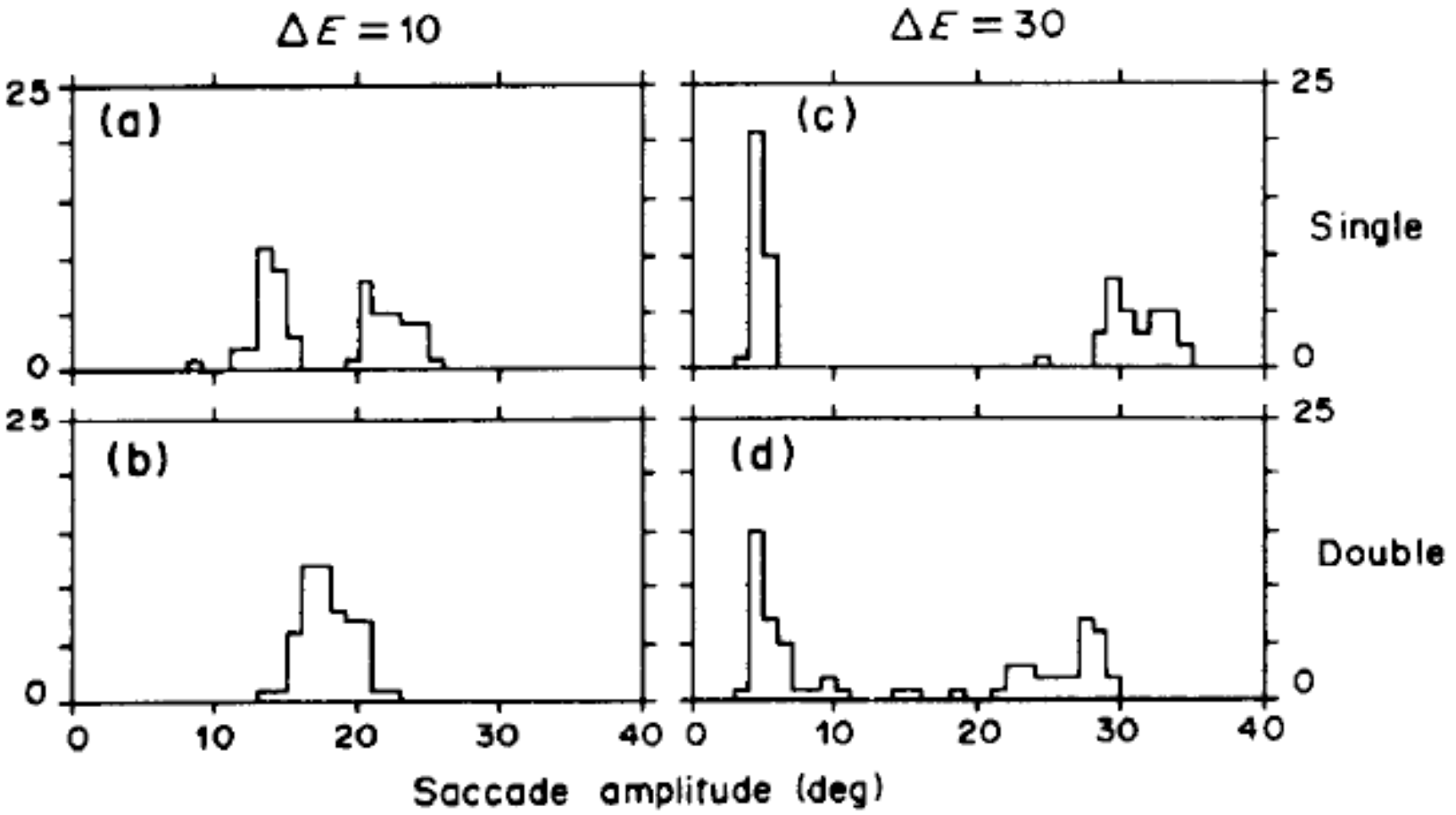
Localization Behavior: *Single Stimuli*



Just to remind you: *Visual Double Stimuli*



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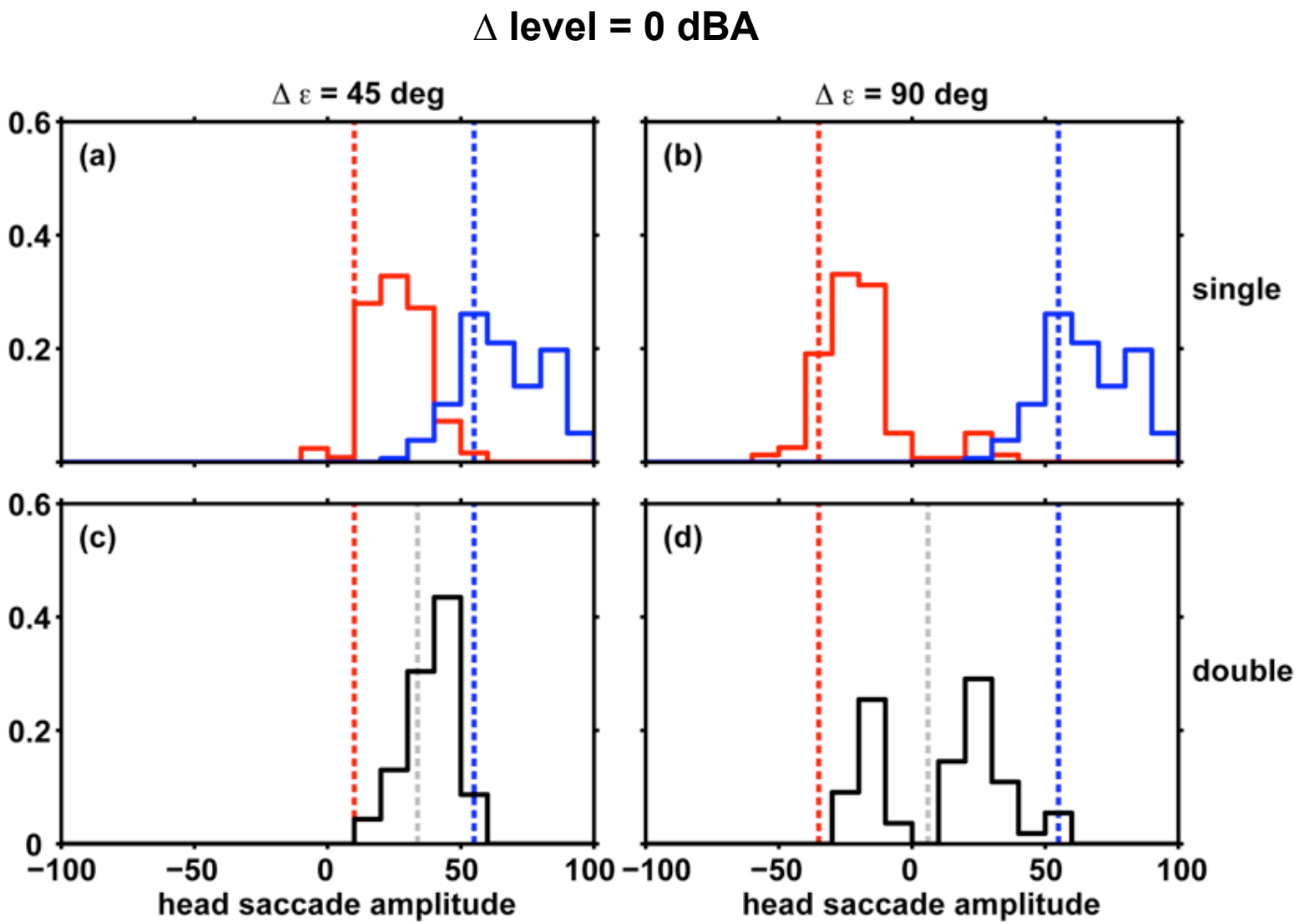
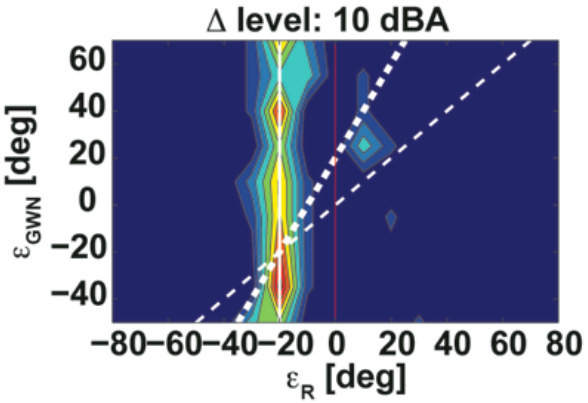
Localization Behavior: *Double Stimuli*

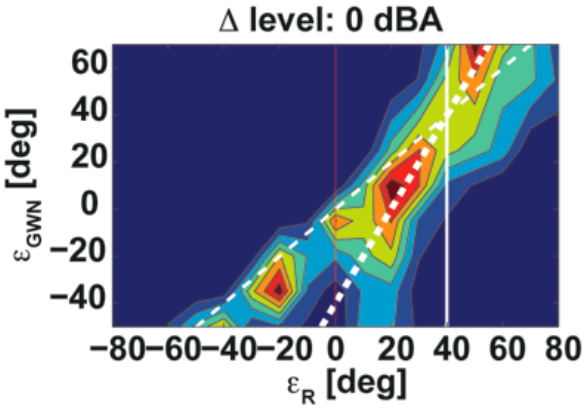


Localization Behavior: *Double Stimuli*



Buzzer @ -25 deg

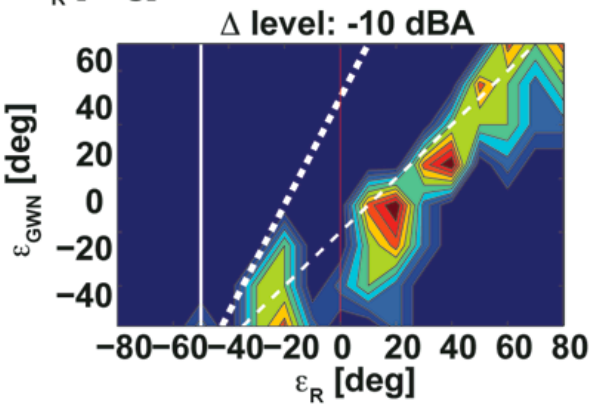
Buzzer Dominance



Averaging

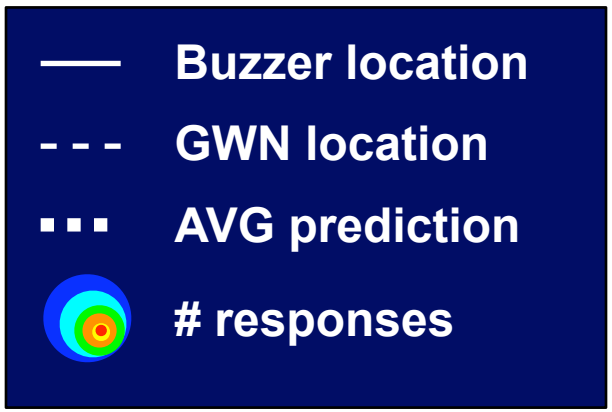
Buzzer @ 40 deg

Bi-stability



Buzzer @ -50 deg

GWN Dominance



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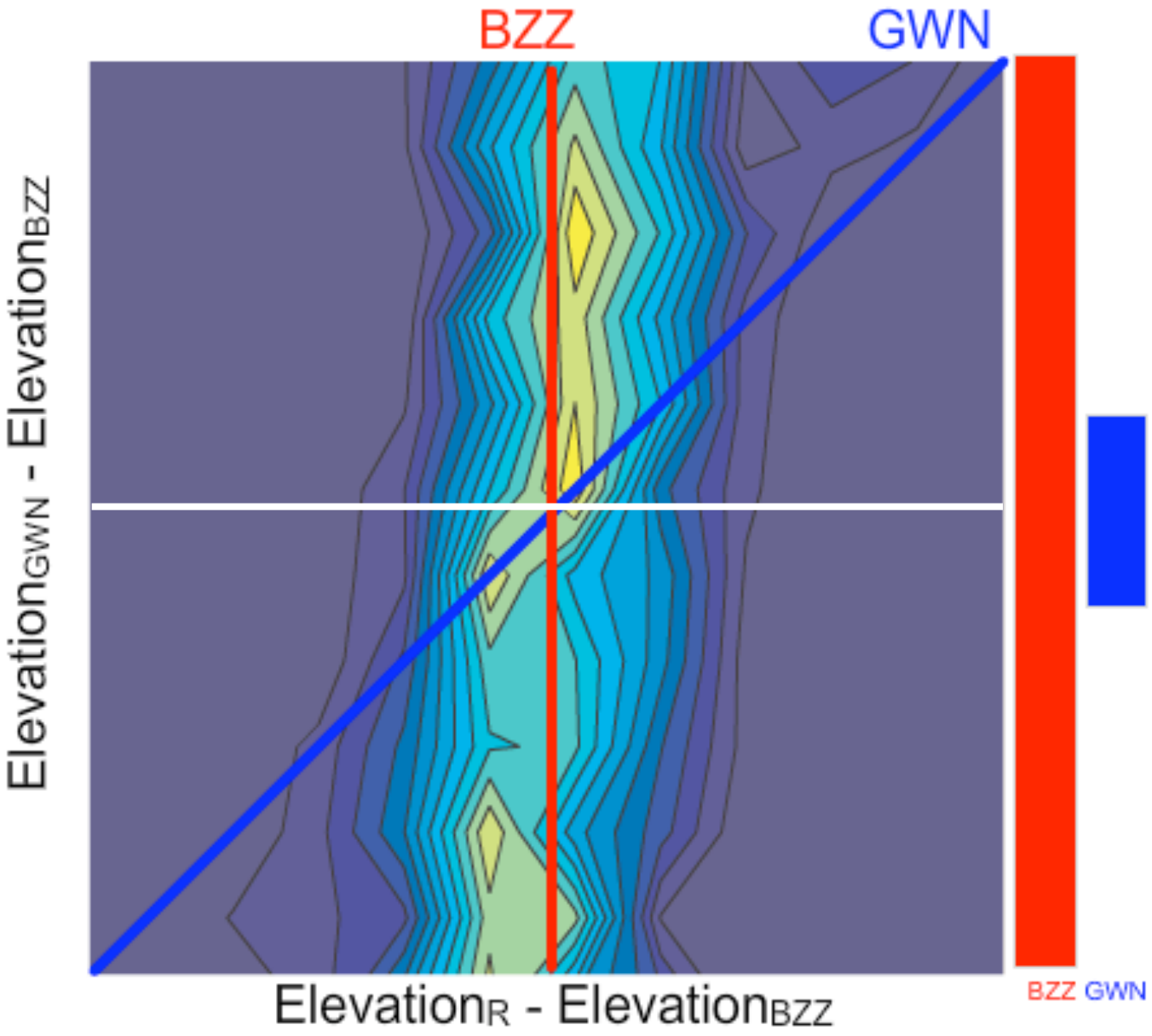
Localization Behavior: *Double Stimuli*



Summary

We see:

- *small distance & Δ level = small* = Averaging
- *Δ level = large* = Dominance
- *large distance & Δ level = small* = Bi-stability

Also in: Visual-Visual; Audio-Audio; Audio-Visual & Visual Depth Cues

Acoustic Models can not explain this!

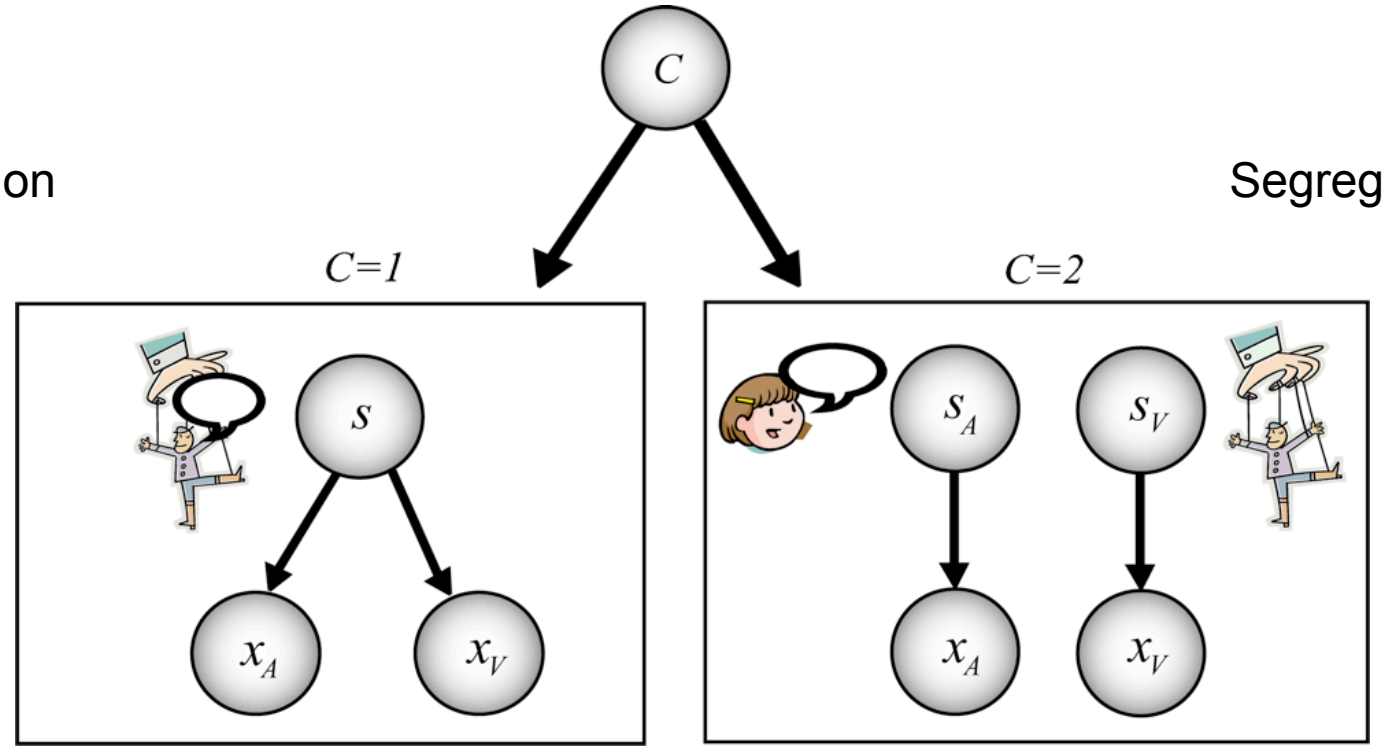
→ Forced-Fusion = There is always only one stimulus/cause

Future Perspective: Mixture Model

Brain has to *infer* if a sensory event is *caused* by *one* or *two* sources

Integration

Segregation



This model has been successfully applied to audio-visual stimuli and visual depth cues

DC. Knill
vision research • volume 43 • 831-854 • 2003

KP. Koerding *et al.*
PLOS One • volume 2(9) • 2007

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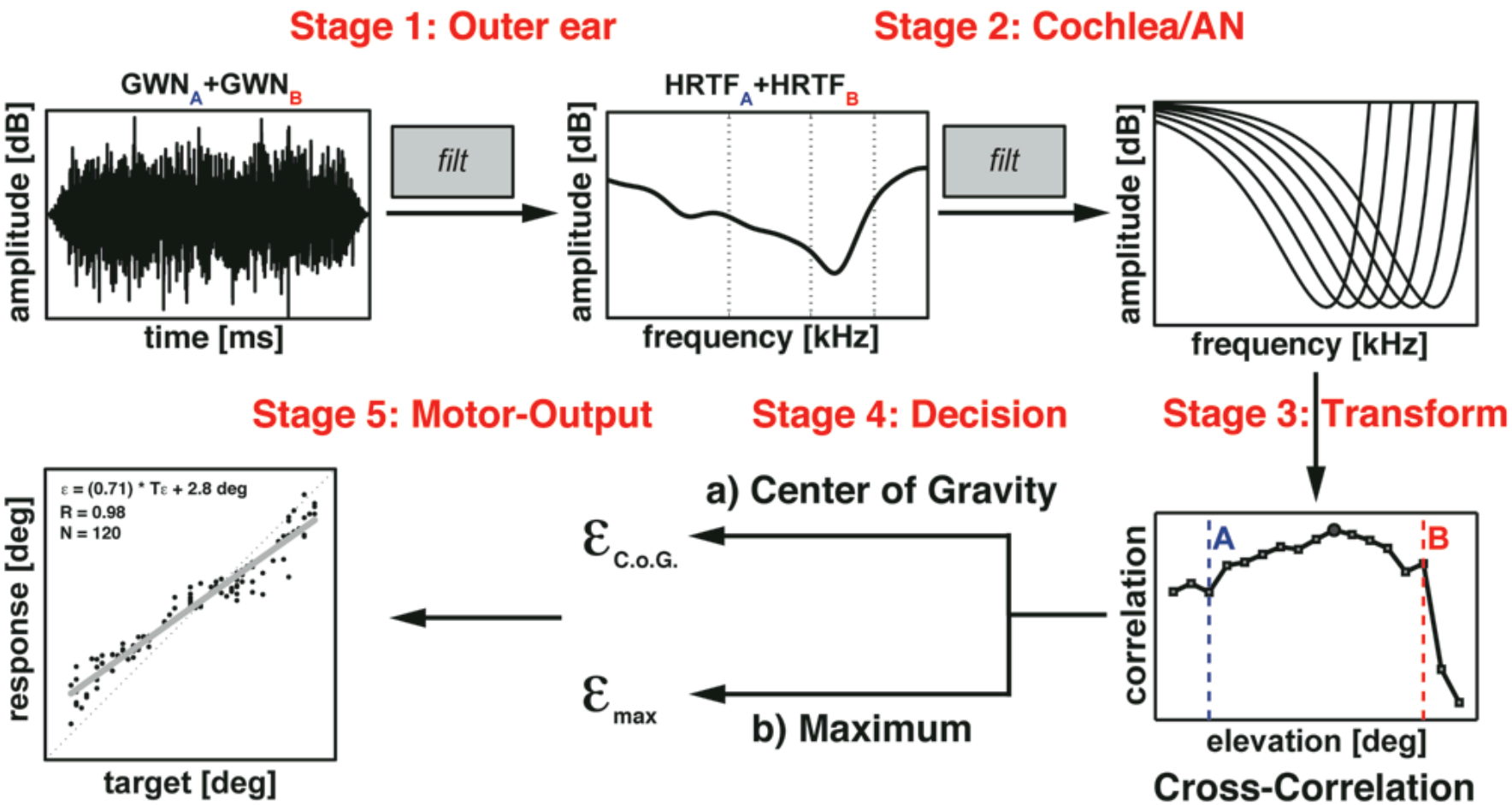
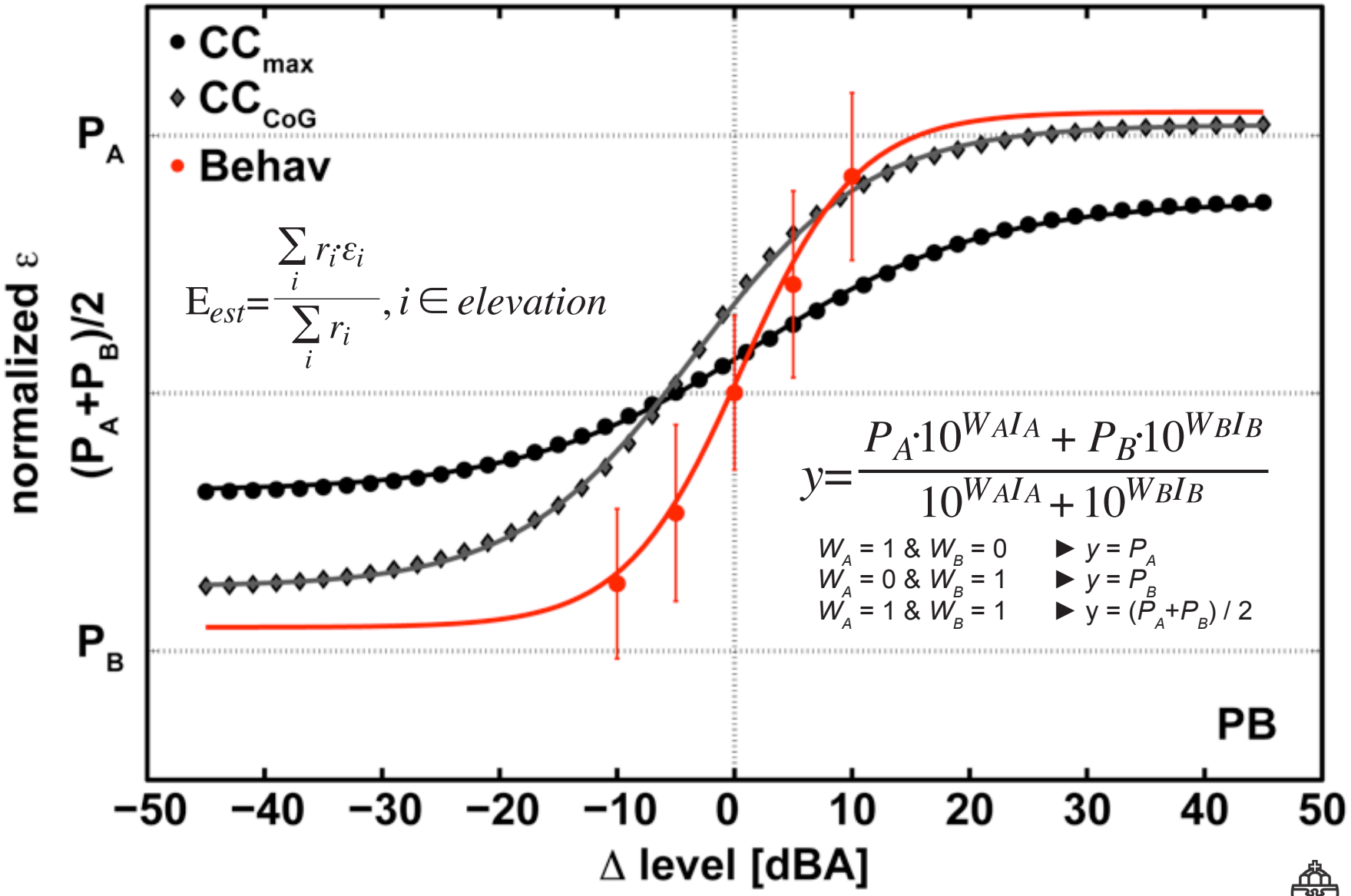
stay tuned...

A Model for Localization of Two Sound Sources in Elevation



Preliminary Results



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