

# Some Thoughts on the Measurement of Hearing Aid Performance

*James Jerger*

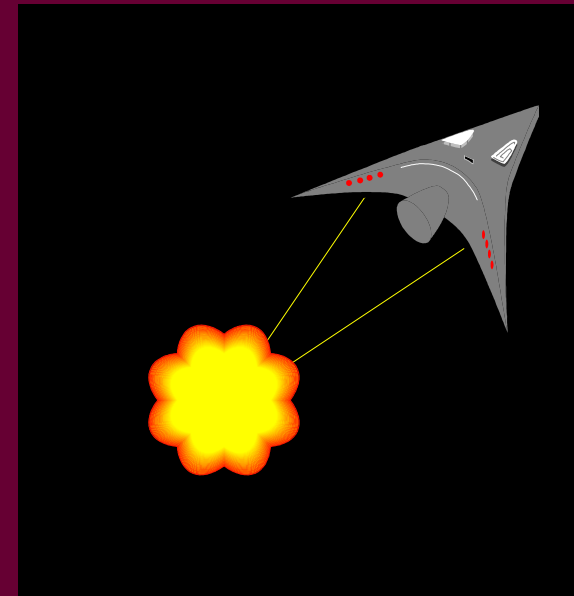
*School of Behavioral and Brain Sciences  
The University of Texas at Dallas*

*Association of VA Audiologists  
San Diego March 8, 2011*



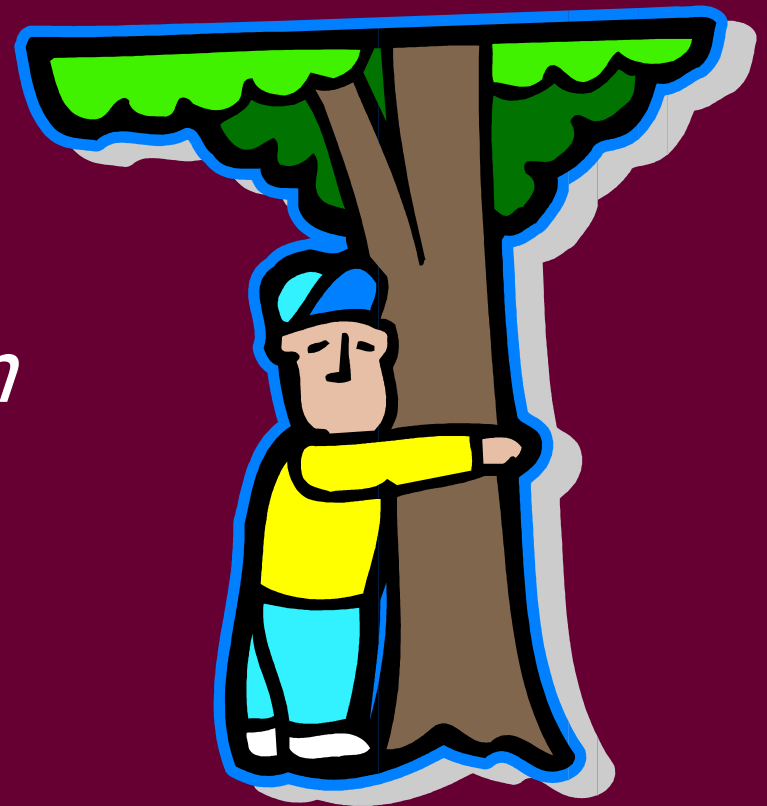
# Some Recent Technological Advances

- *Digital Signal Processing*
- *Remote Microphones*
- *Directional Microphones*
- *Adaptive Testing Strategies*
- *Bluetooth Technology*



# Highlights in the Quantification of Hearing Aid Performance

- *SRT*
- *PB Max*
- *Live Voice Presentation*
- *12-Talker Babble*



# How Do Hearing Aid Users Actually Function in Real Life?

- *They don't spend a lot of time in small, dimly lit, sound-treated chambers!*



# How Do Hearing Aid Users Actually Function in Real Life?

- *They are not always facing the source of the message!*



# How Do Hearing Aid Users Actually Function in Real Life?

- *When they do face the talker they benefit from a rich source of helpful visual cues*



# How Do Hearing Aid Users Actually Function in Real Life?

- *The source of competition is more likely to be the speech of other persons than temporally or spectrally modulated noise!*



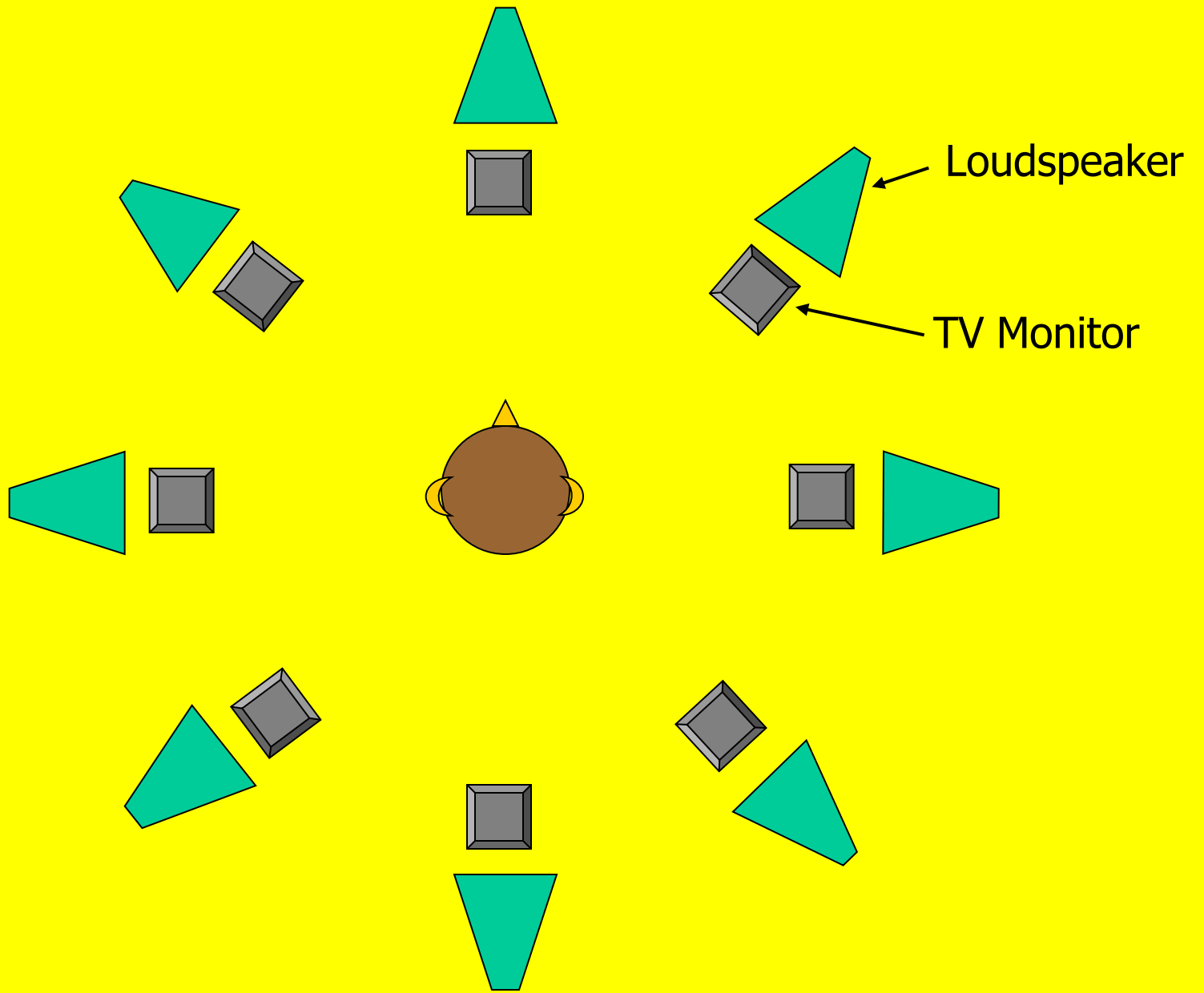
# How Do Hearing Aid Users Actually Function in Real Life?

- *The level of the sound to which they are attending may vary over time rather than remain constant!*



Why not simulate a real living room?







## Oticon's Virtual Sound Environment

Adapted from:

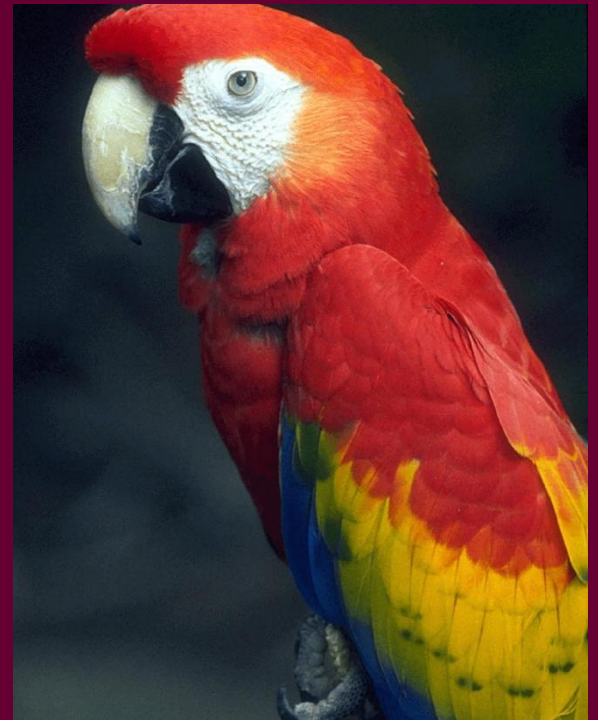
Minnaar P, Favrot J, Buchholz (2010).  
Improving hearing aids through  
listening tests in a virtual sound  
environment. *The Hearing Journal*,  
63: 40-44.

# Possible Response Modes

- 1) Repeat back what you heard.
- 2) Reply to meaningful message
- 3) Overt motor response
- 4) Open set vs closed set

# Repeat Back What You Heard

- “Say the word...”
- Parrots can do it!
- Recognition not the same as comprehension!



# Recognition vs Comprehension

*“Genuine speech comprehension requires the listener to integrate heard information with past knowledge, store it in memory for future use, or formulate a reply based on the content of the signal” (p.193)*

Schneider B, Pichora-Fuller K (2000) Implications of perceptual deterioration for cognitive aging research. In: Craik F, Salthouse T, eds. *The Handbook of Aging and Cognition*, 2<sup>nd</sup> ed. Mahwah, NJ:Lawrence Erlbaum Associates, 155-219.

# Reply to a Meaningful Message

- What is the Capital City of Minnesota? *St. Paul*
- What often happens on Rainy Lake? *It rains*
- If you keep going north from Minnesota you will cross into...? *Canada*
- How many Minnesotans go fishing? *2.3 Million*

# Overt Motor Response

- *What is the capital of Minnesota?*

St Cloud



Minneapolis



Washington



St. Paul



# Open Set vs Closed Set

- Open Set:

*Set of all possible responses unknown.*

- Closed Set:

*Set of all possible responses rigidly defined (how we test children).*

# Open Set vs Closed Set

- Open Set:

*Set of all possible responses unknown.*

- Closed Set:

*Set of all possible responses rigidly defined (how we test children).*

# Open Set vs Closed Set

- Open Set:

*Set of all possible responses unknown.*

- Closed Set:

*Set of all possible responses rigidly defined (how we test children).*

# Possible Materials

- Nonsense Syllables (e.g., /pa/, /ta/, /ga/)
  - Sequential building block theory of speech perception: *we perceive syllables as a sequence of phonemes.*
  - Focuses only on phonological processes of analysis
  - Ignores influence of co-articulation
  - Ignores influence of context
  - Ignores lexical and semantic processes of analysis

# Possible Materials

- Words (Spondee, PB etc.)
  - Sequential syllable theory of speech perception: *we perceive a word as a sequence of syllables.*
  - Ignores influence of coarticulation between successive words.
  - Ignores effect of context
  - Better than nonsense syllables

# Possible Materials

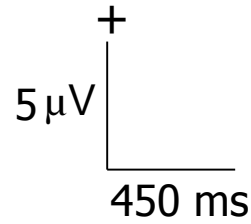
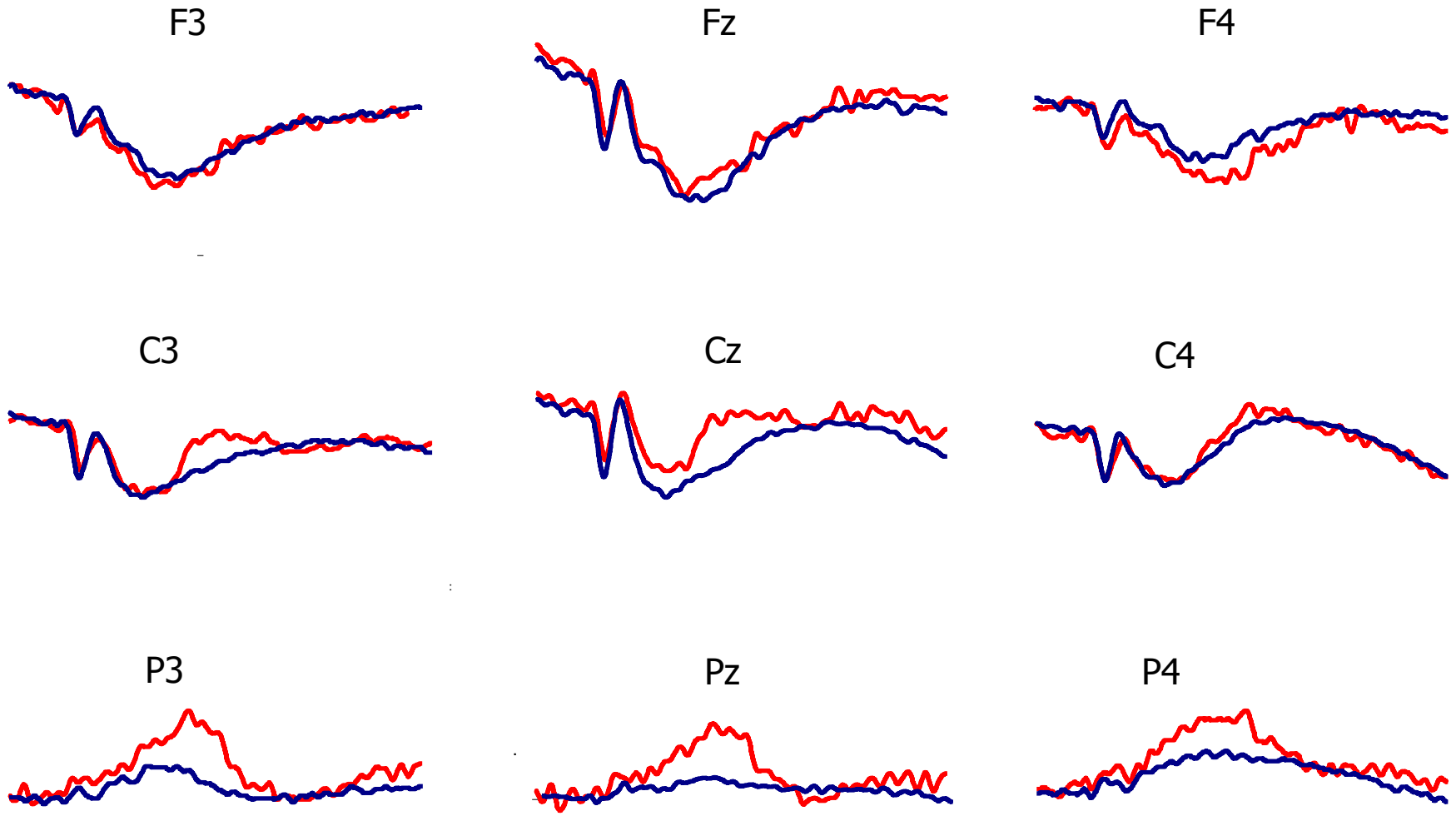
- Sentences (e.g. HINT, Quick SIN)
  - Sequential word theory of speech perception: *we perceive a sentence as a sequence of words.*
  - Ignores context of entire message.
  - Scoring a continuing issue.
  - Better than isolated words

# Possible Materials

- Paragraphs (PAL Auditory Test #8)
  - Best face validity
  - Probably beset by too many extra-auditory factors

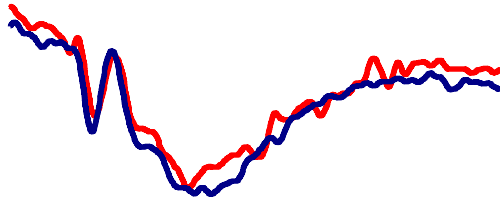
# A Small Experiment

- Pairs of stimuli presented to both ears simultaneously (dichotic).
- Two types of stimulus:
  - Non targets (80%)...Two different CVC words (male talker).
  - Targets (20%)...Four task conditions.
    - *Acoustic dimension*...Burst of noise in one ear.
    - *Spectral dimension*...female talker in one ear.
    - *Phonemic dimension*...word that rhymes with “jet” in one ear.
    - *Semantic dimension*...word belonging to a pre-cued semantic category in one ear.



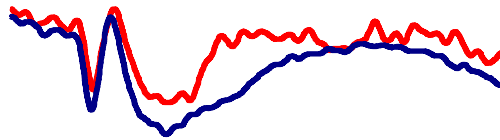
Phonemic Task

Fz



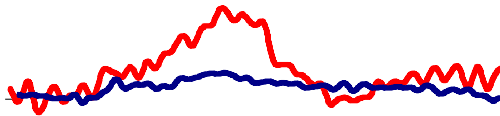
Frontal

Cz

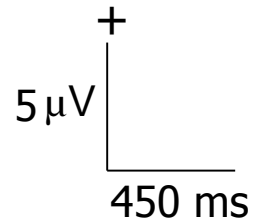
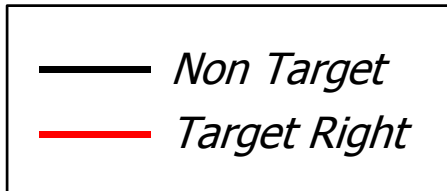


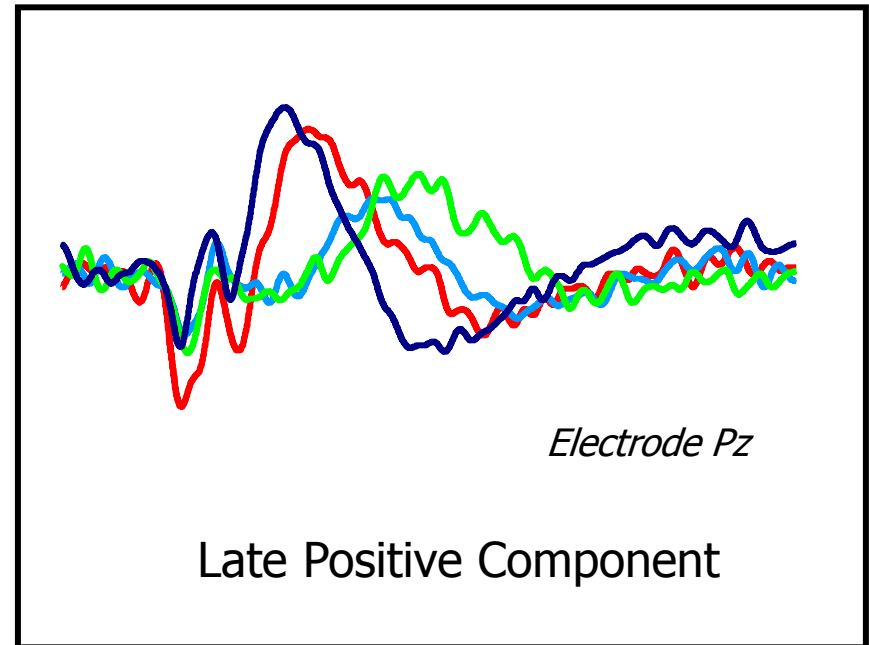
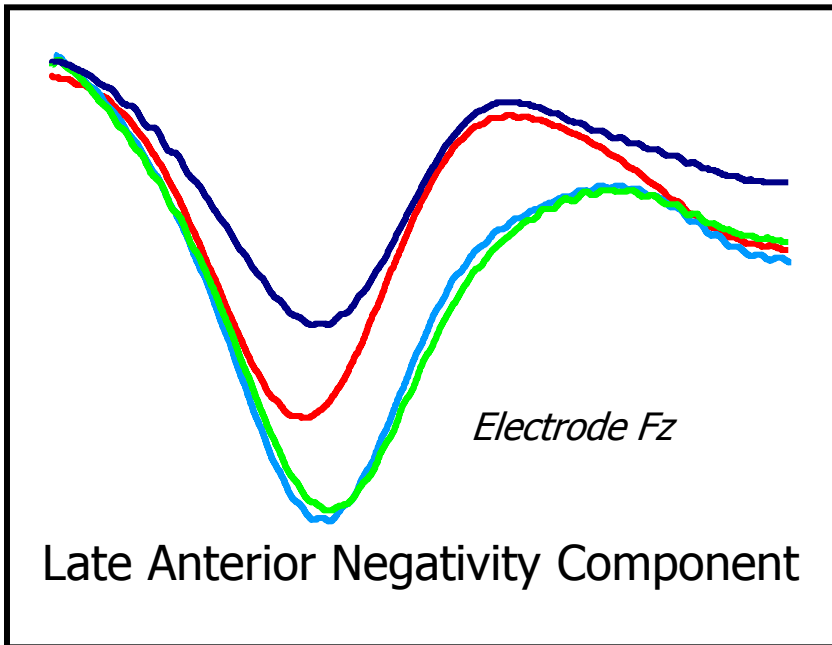
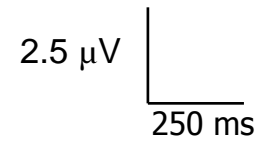
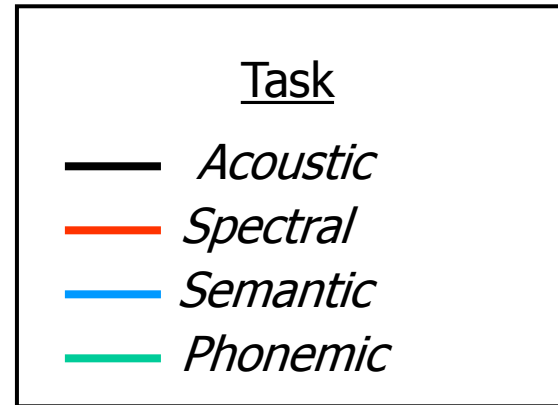
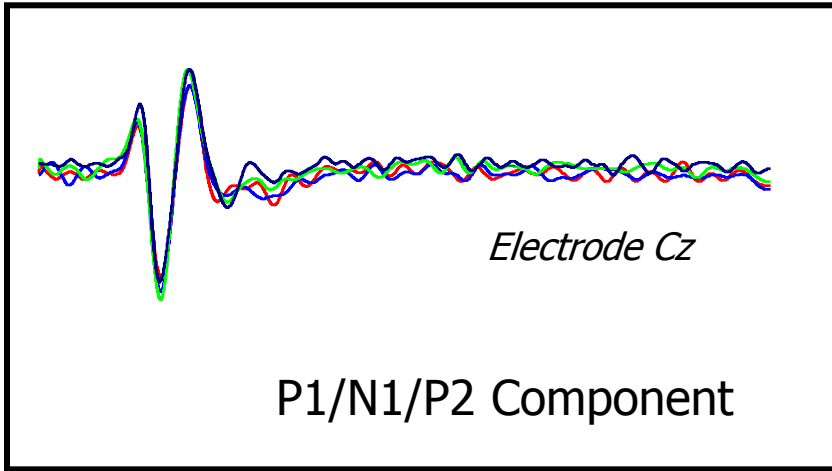
Central

Pz

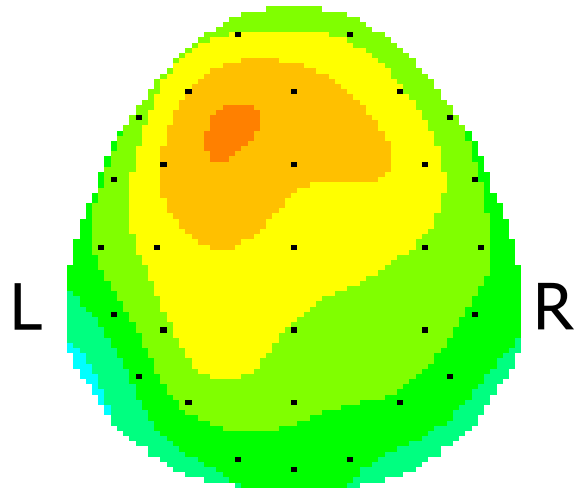


Parietal

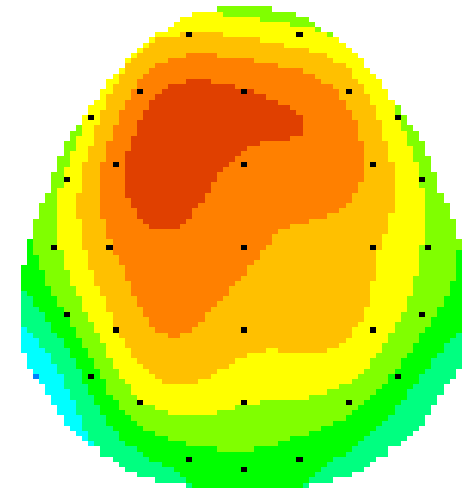




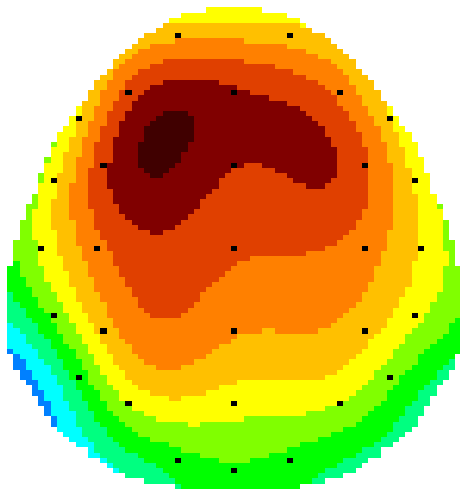
# Late Anterior Negativity (LAN)



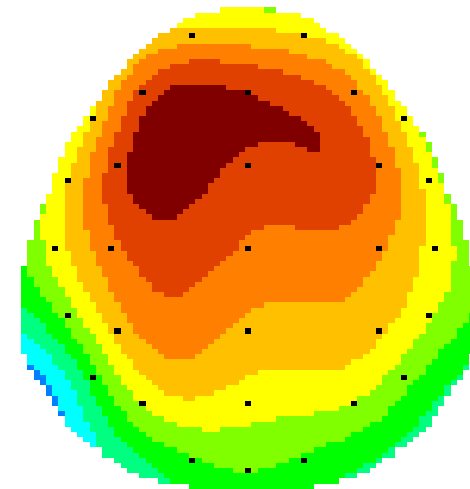
*Acoustic Task – 522 ms*



*Spectral Task – 448 ms*



*Semantic Task – 482 ms*



*Phonemic Task – 532 ms*



# The Importance of Complementary Visual Information

- *Ask any teacher*
  - *of the deaf...*
- *Experience with*
  - *Cochlear Implants*

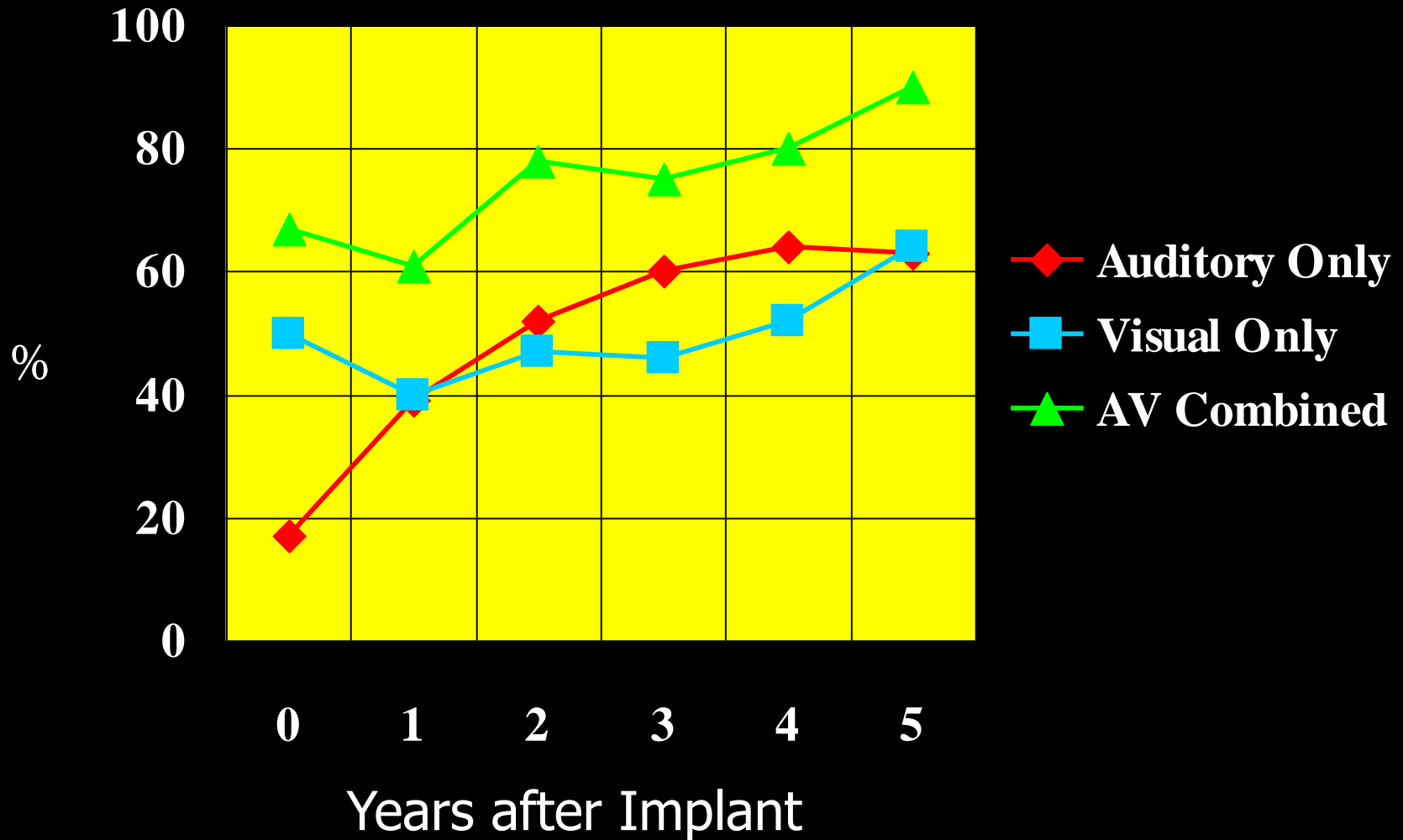


# Speech Reading

- Speech reading is speech recognition using both auditory and visual cues.
- Even if you have normal hearing you rely on visual speech information to recognize and comprehend a message.
- The greater the hearing impairment, the more an individual will rely on visual information for communication.

*....Nancy Tye-Murray*

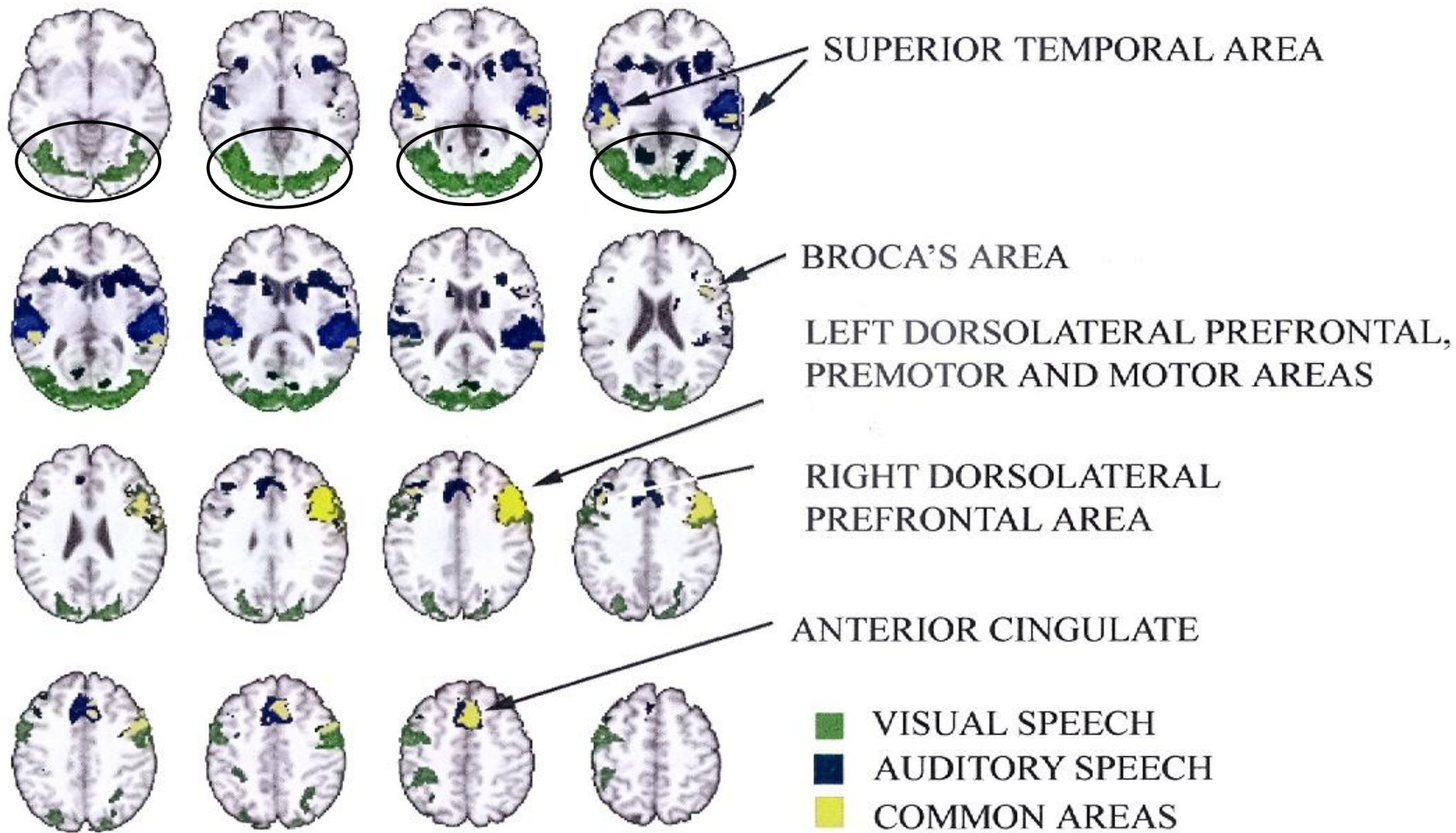
# Common Phrases



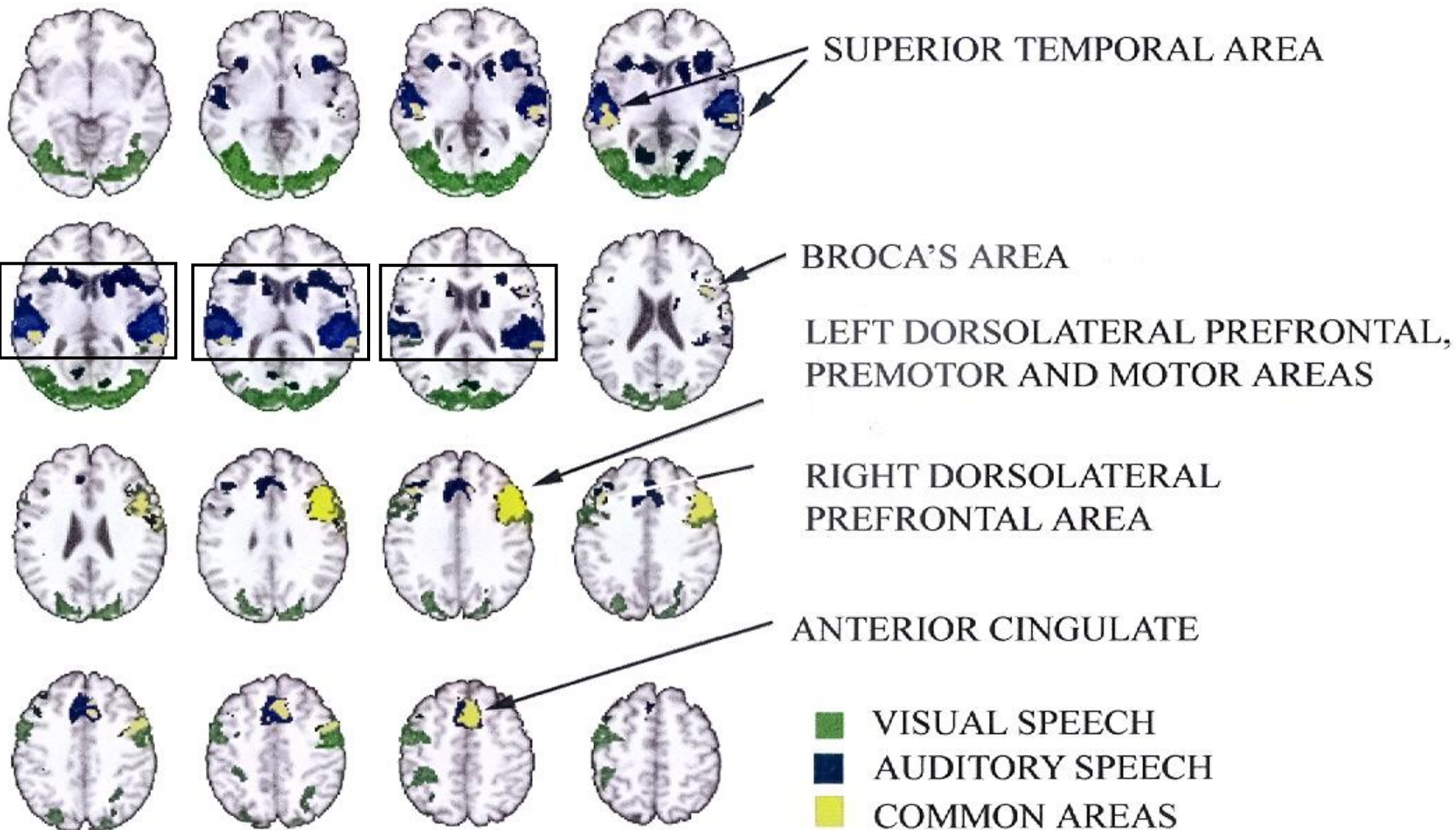
After Bergeson, Pisoni & Davis (2005) Development of audiovisual comprehension skills in prelingually deaf children with cochlear implants *Ear & Hearing*, 26: 149-164.

# Audiovisual Integration

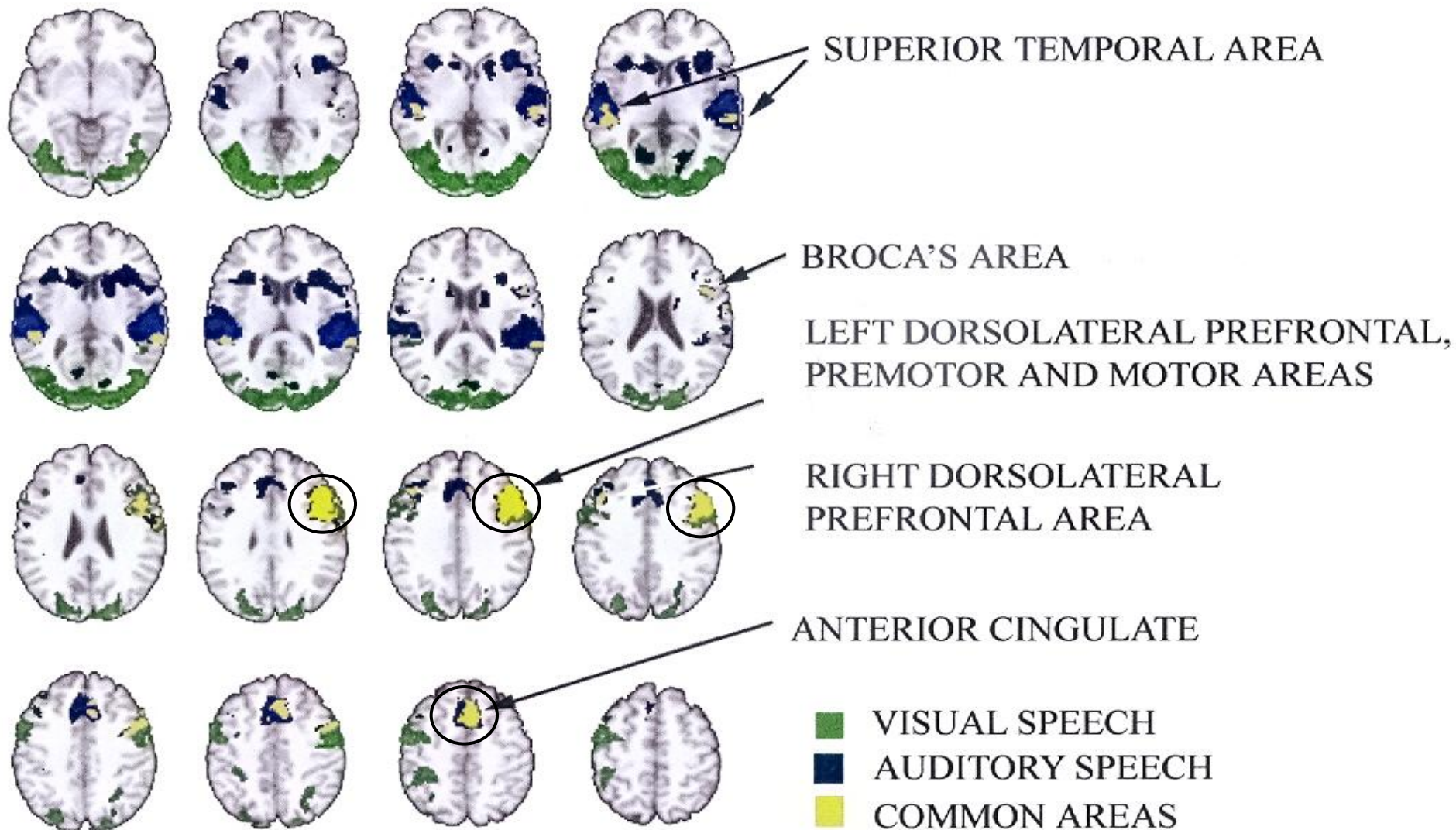
- Auditory and visual speech inputs interact in the motor cortical areas involved in speech production .



Ojanen, V. (2005) *Neurocognitive Mechanisms of Audiovisual Speech Perception*, Ph.D. Dissertation, Helsinki University of Technology, Finland.



Ojanen, V. (2005) *Neurocognitive Mechanisms of Audiovisual Speech Perception*, Ph.D. Dissertation, Helsinki University of Technology, Finland.



Ojanen, V. (2005) *Neurocognitive Mechanisms of Audiovisual Speech Perception*, Ph.D. Dissertation, Helsinki University of Technology, Finland.

So, what is  
the take home message?

# For Ecologically Valid Measurement

- *Get out of the sound booth.*
- *Let the test stimuli come from different directions.*
- *Add vision to the test paradigm.*
- *Use real speech as competition.*
- *Let the test stimuli vary in level.*

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# For Ecologically Valid Measurement

- *Get out of the sound booth.*
- *Let the test stimuli come from different directions.*
- *Add vision to the test paradigm.*
- *Use real speech as competition.*
- *Compare performance across different tasks.*

# Possible Objections

*Once you leave the sound-treated booth the acoustic environment is uncontrolled. It is now subject to reverberation, reflected waves, variation in absorption, etc.*

# Possible Objections

*Current test instruments have been carefully normed under a number of specified conditions. This approach would void such norms.*

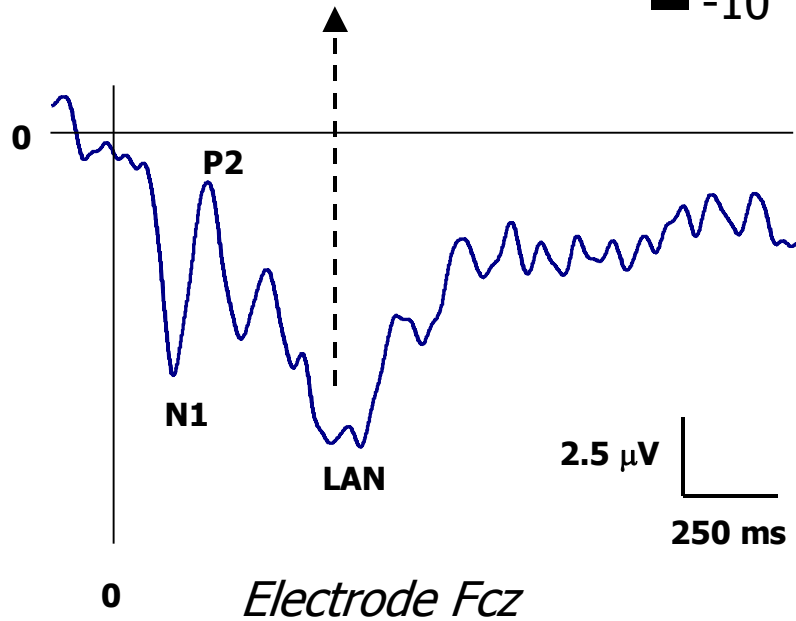
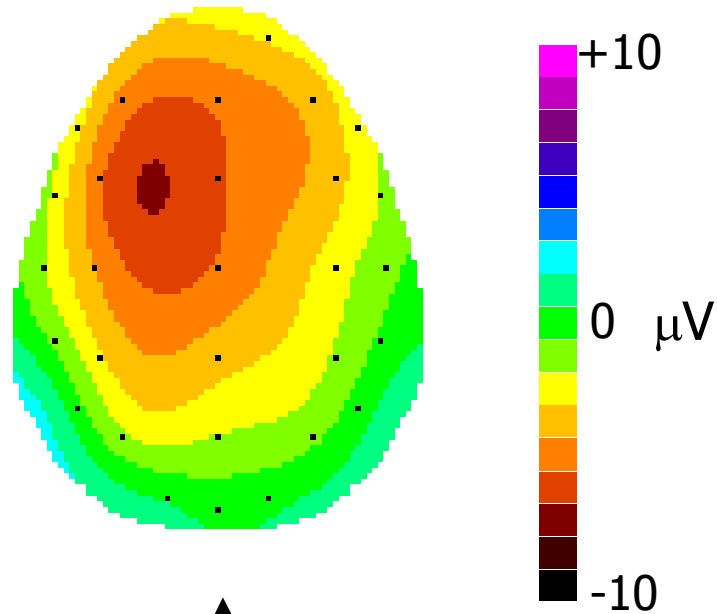
# Possible Objections

*All this would take too much time, time one can ill afford in today's busy practices.*

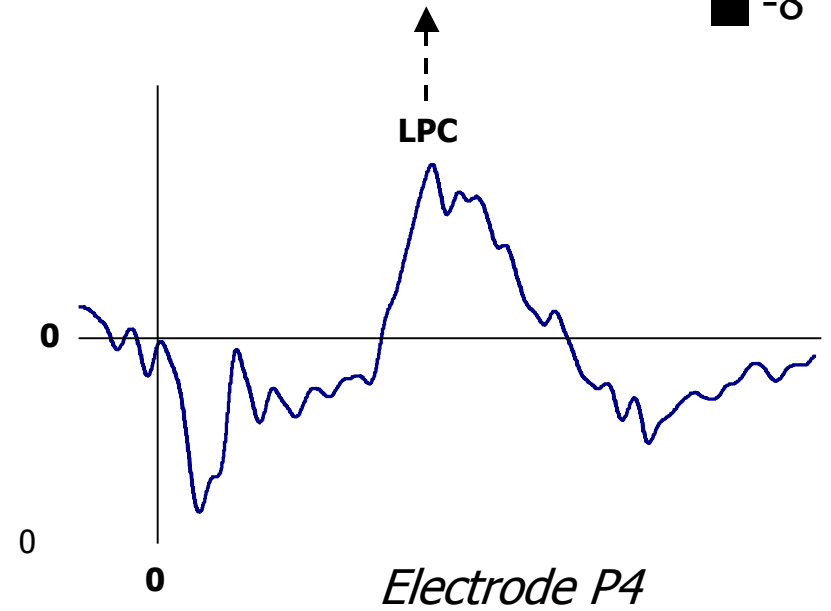
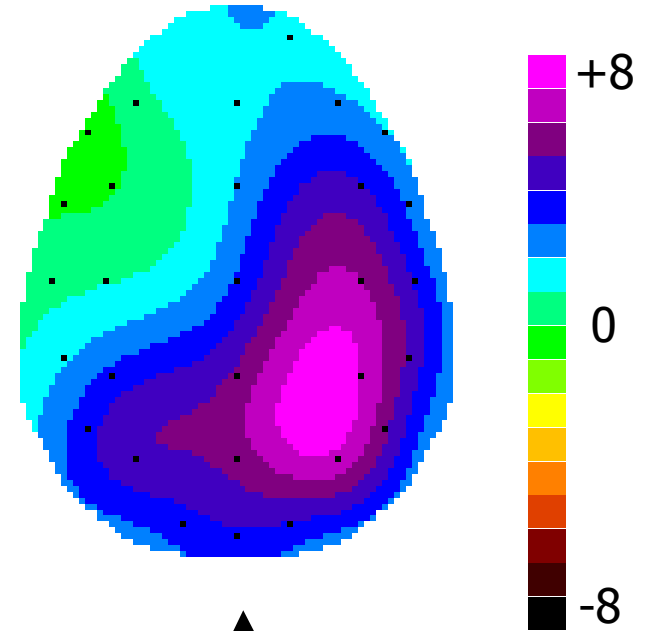
**the end**

The text "the end" is rendered in a bold, 3D block font. Each letter is composed of a bright yellow top surface and brown, vertically-lined sides, giving it a thick, blocky appearance. The letters are set against a plain, light gray background.

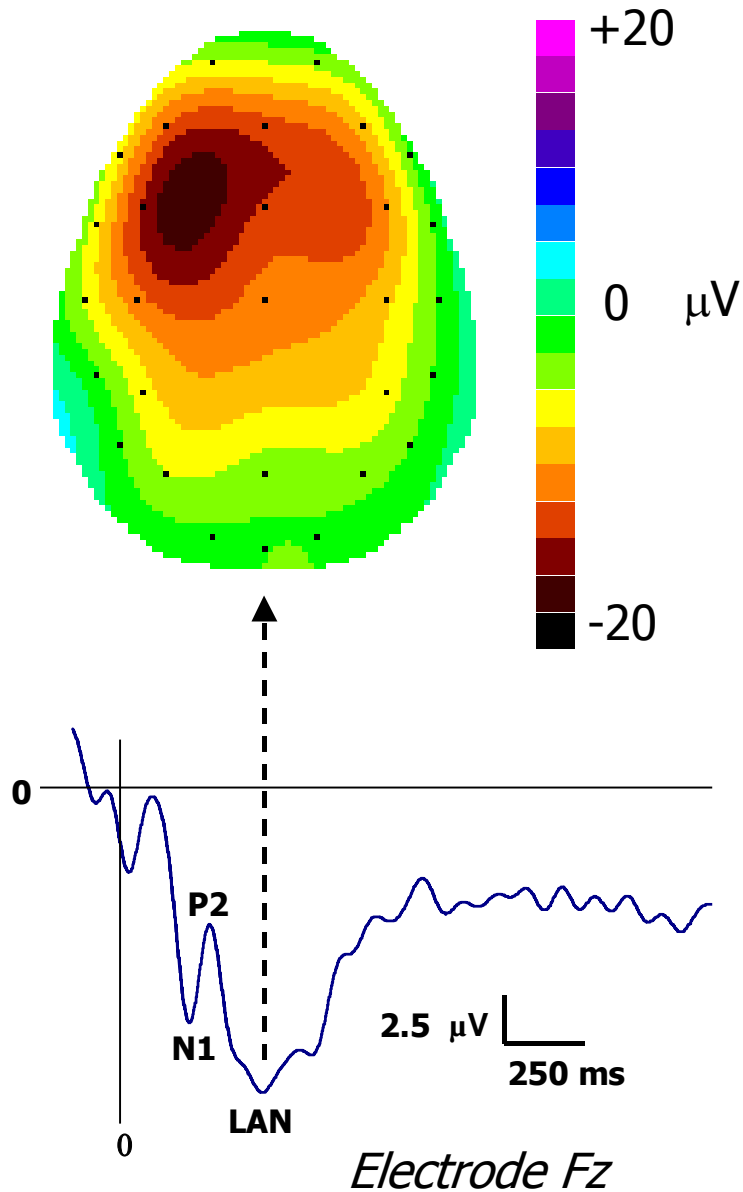
S: C1 Phonemic Nontarget



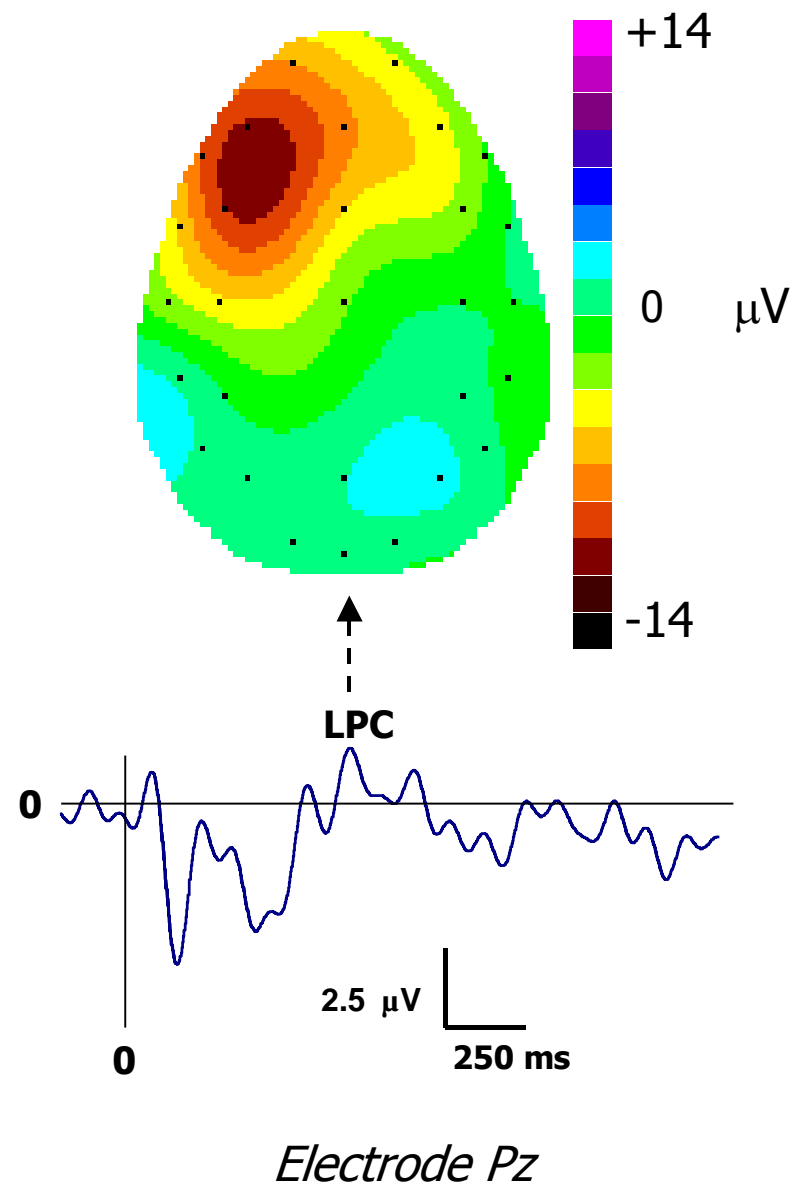
S: C1 Phonemic Target



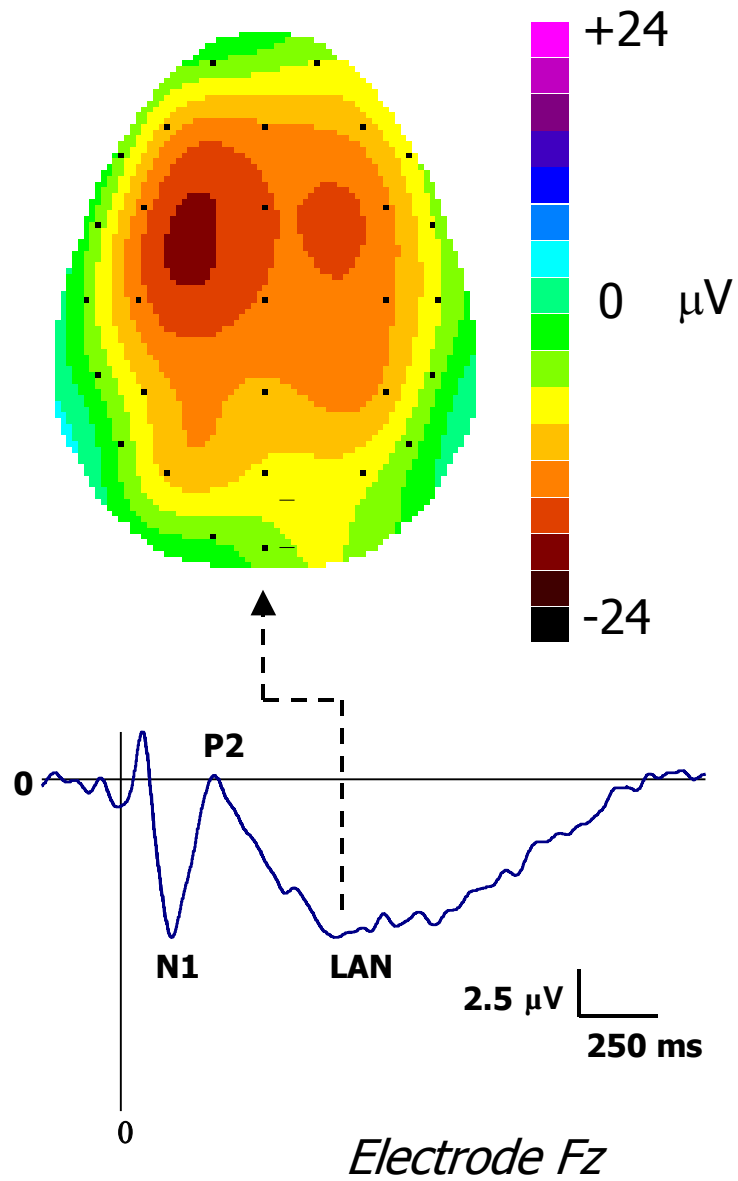
S: MS 1 – Phonemic Nontarget



S: MS 1 – Phonemic Target



S: MS 2 – Phonemic Nontarget



S: MS 2 – Phonemic Target

