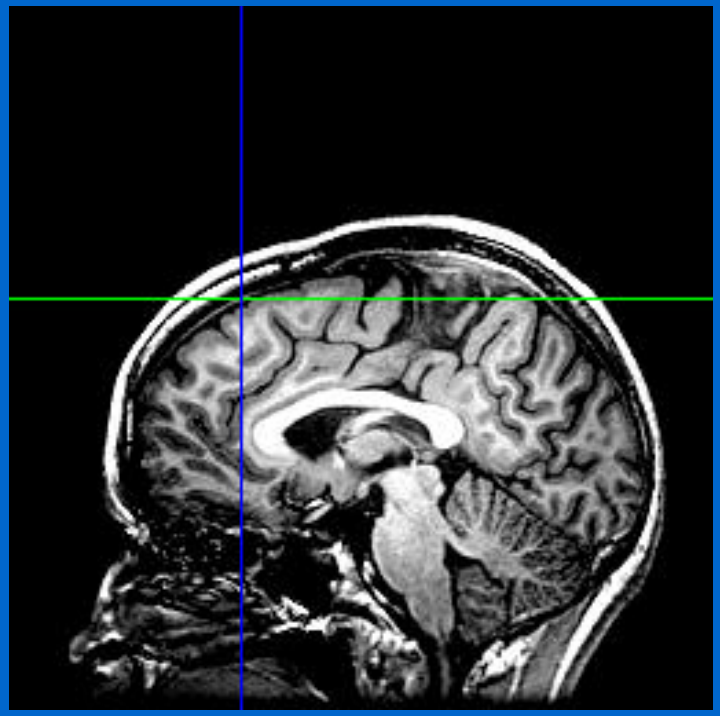
Neural Networks: Tracing Cellular Pathways



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Sunfest 2000

Neural Networks: Tracing Cellular Pathways

- Research Objective
- Background
- Methodology and Experimental Approach
- Results and Conclusions
- Summary and Discussion

Credits

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Research Objective:

Source Analysis Utilizing Two Methods

1. **Metabolic method:** fMRI data provides visualization of brain tissue for source location

2. **Electromagnetic method:** EEG provides scalp distribution pattern corresponding to source dipole

Research Objective:

Source Analysis Utilizing Two Methods

Project Goals:

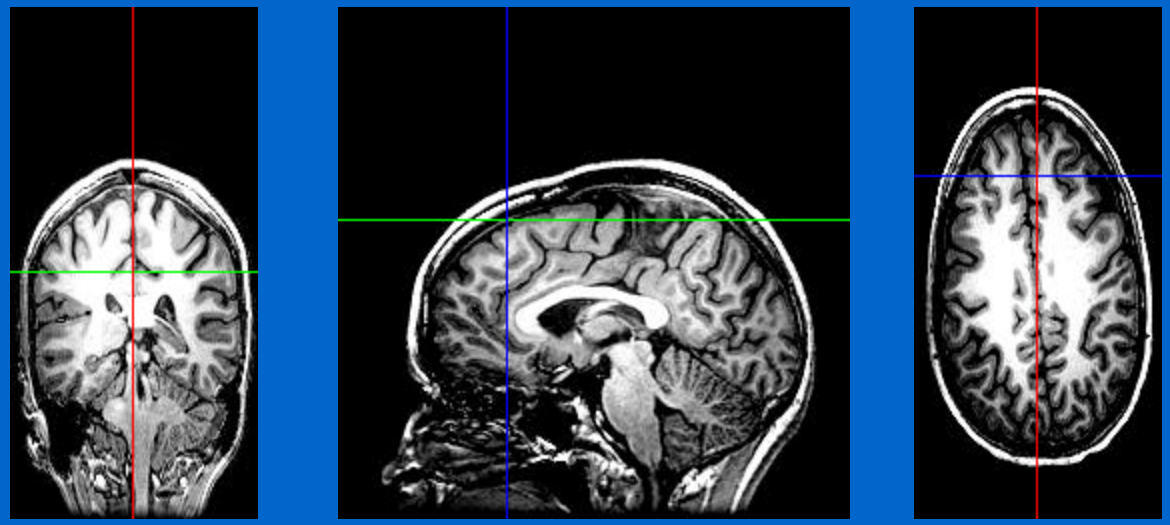
1. Test widely used three-shell conductivity model of the head used for scalp potential mapping and source analysis

2. Identify cellular pathways and cells responsible for recorded EEG activity

The Functional MRI (fMRI):

Magnetic Resonance Imaging

1



2

Images entire three-dimensional volume of the brain to identify brain areas activated by visual stimuli

The Functional MRI (fMRI):

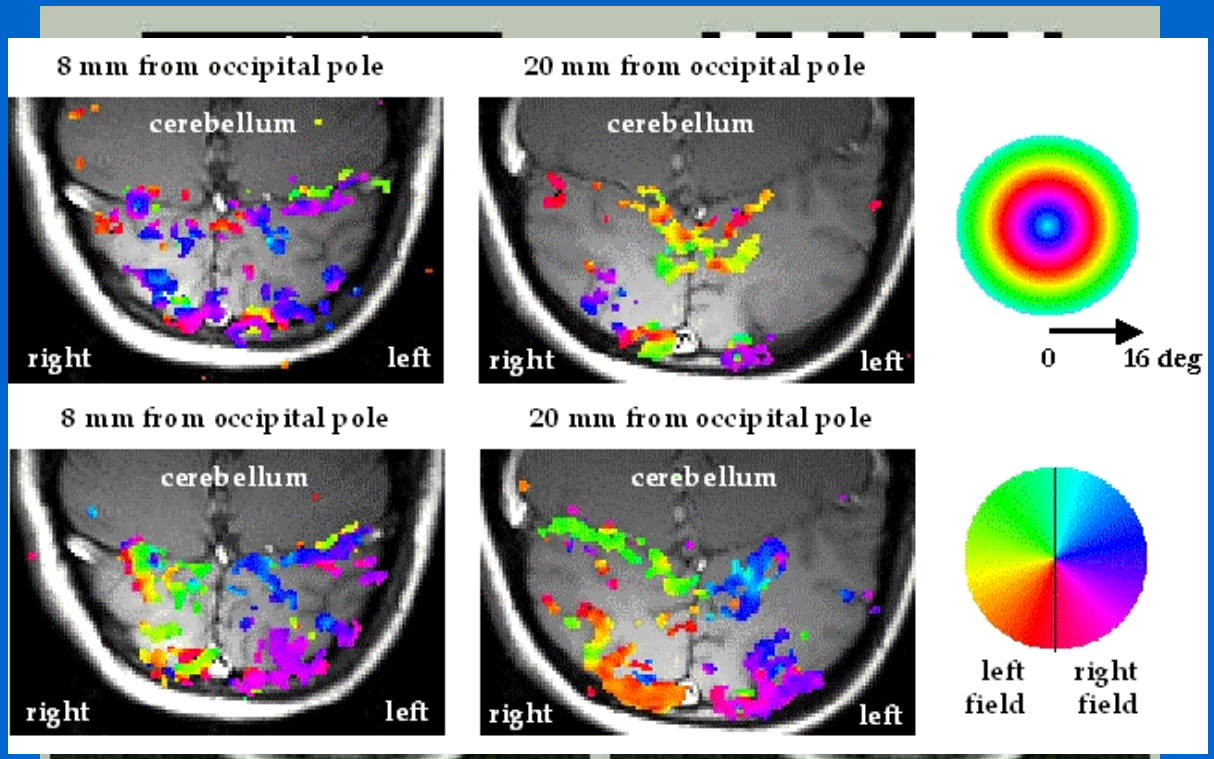
Stanford Vision and Imaging Science and Technology Group

1. Main components of imager are the magnet, RF coils, and control computer
2. Expanding rings and rotating wedge stimuli used to image, generating a wave of activity across cortex
3. Visualize neural activity by superimposing fMRI responses to stimuli on unfolded brain

http://www.cis.rit.edu/htbooks/mri/inside.htm

The Functional MRI (fMRI):

The fMRI Stimulus



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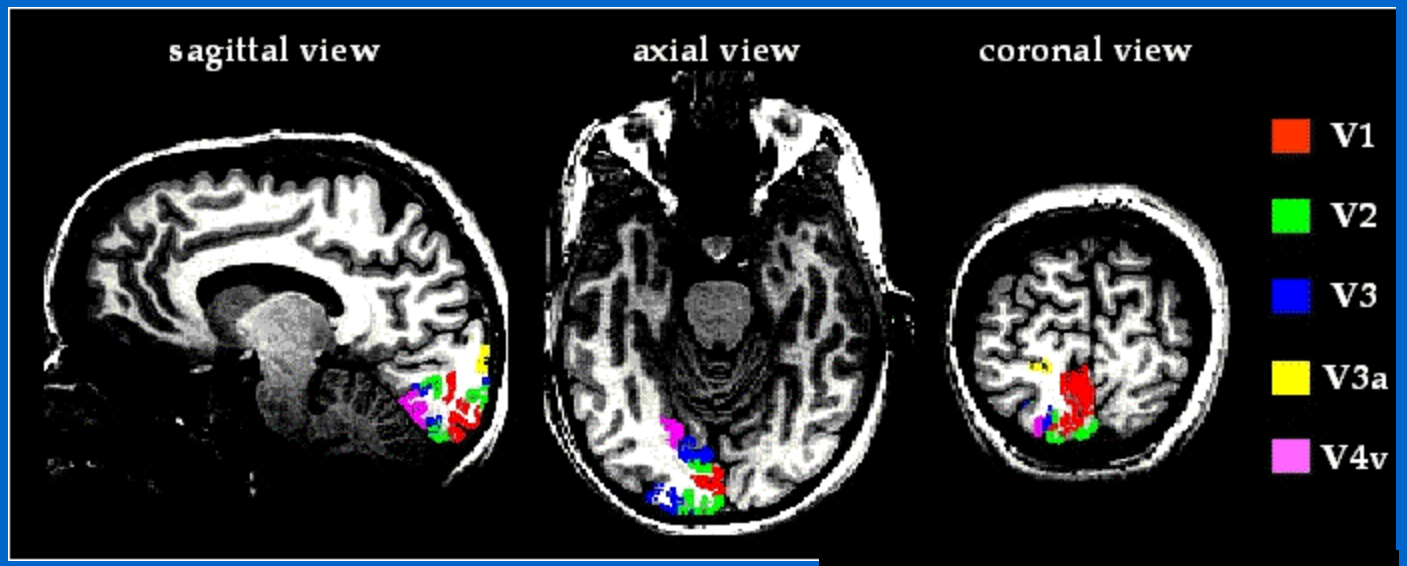
3

Superimpose functional phase data from both stimuli to locate active cortical visual areas

The Functional MRI (fMRI):

Organization of the Visual Cortex



http://white.stanford.edu

2

Exact locations of visual areas can be identified through fMRI analysis, allowing for the precise design of stimuli

The Volume Conductor Model:

Three-Shell Conductivity Model Description

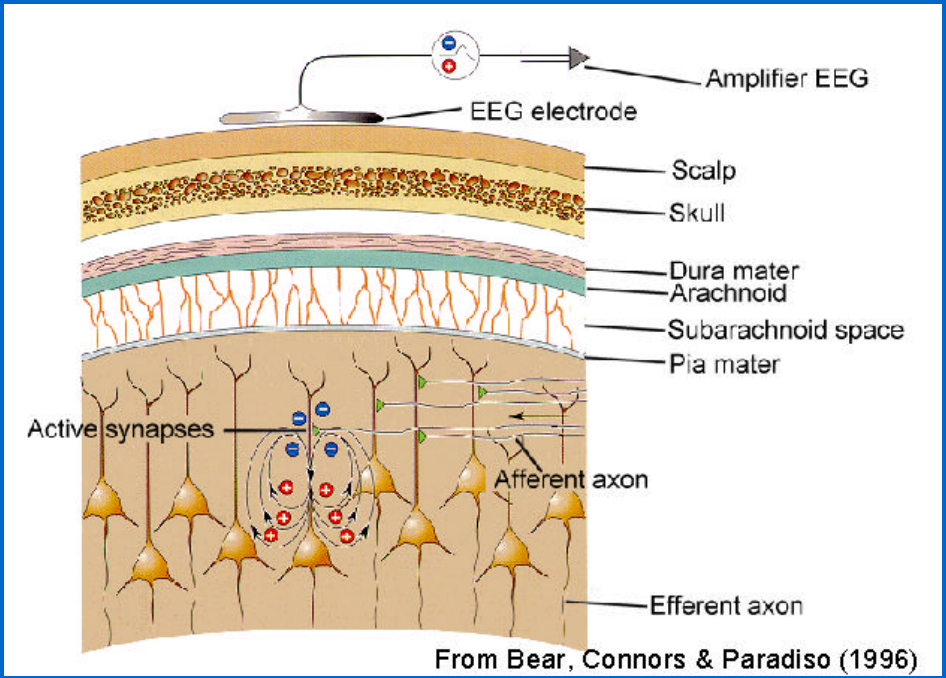
1. Human head modeled as volume conductor having three concentric shells of uniform conductivity

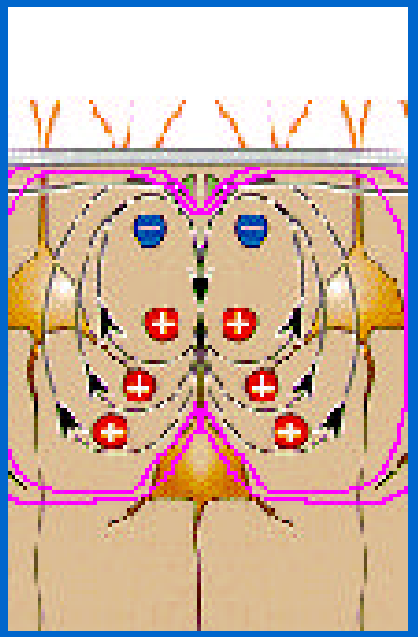
2. Scalp potential distribution depends on locations and orientations of dipoles and thicknesses and conductivites of shells

3. Outermost shell is scalp; middle shell is skull; innermost shell is entire brain and surrounding fluid

The Volume Conductor Model:

Three-Shell Conductivity Model Flaws





2

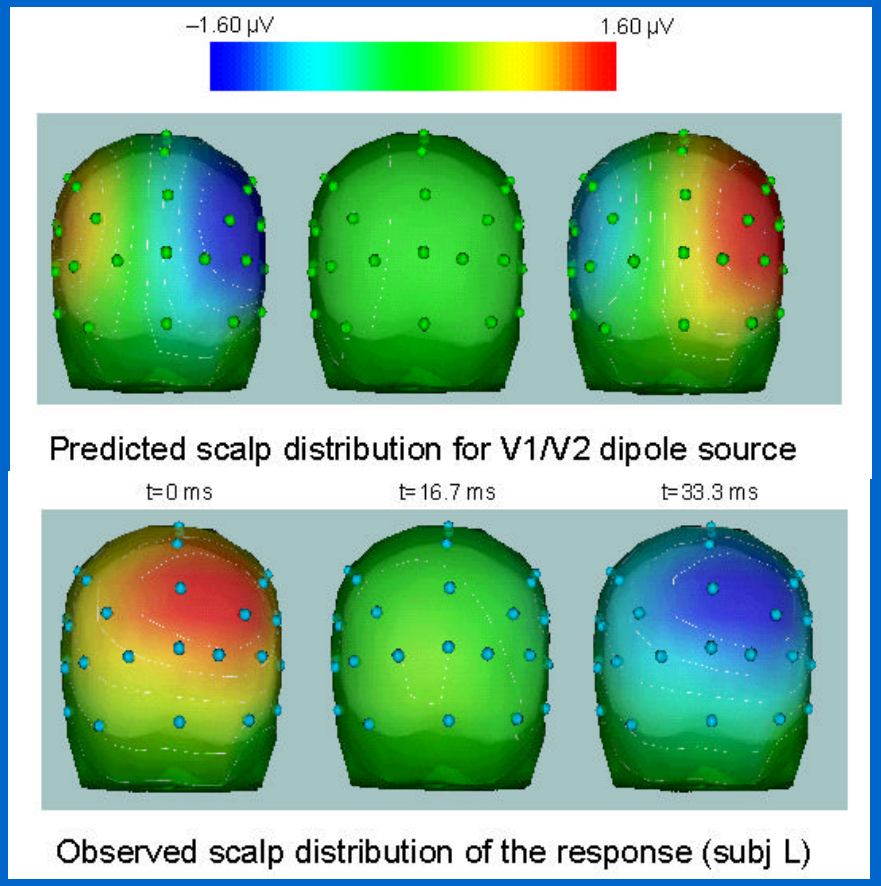
Boundaries affect return path of cellular dipoles, spreading out current so that greatest amplitude is not necessarily recorded directly above dipole

The Volume Conductor Model:

Three-Shell Conductivity Model Predictions

Predicted

Observed



The Electroencephalogram:

Experimental Design Using fMRI Data

1. Design EEG stimulus to activate V1 and V2 using brain visualization from fMRI data
2. Fourier analysis of collected EEG data and Matlab plotting yields amplitude spectra and polar plots
3. Plot contrast responses at twice the fundamental frequency to obtain a contrast response function

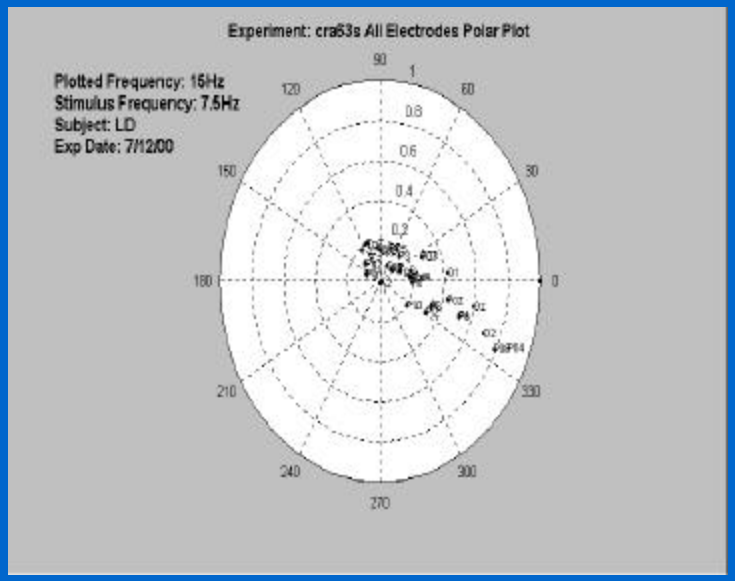
Sunfest 2000 Research:

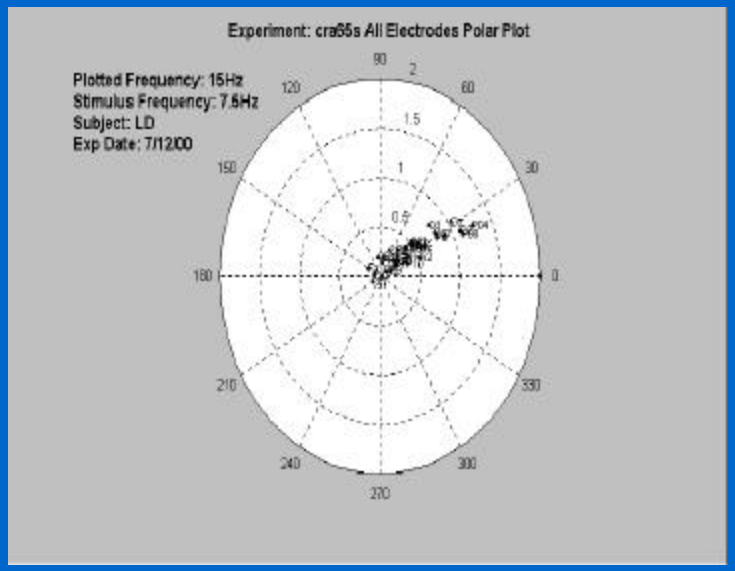
Methodology and experimental approach

Sunfest 2000 Research:

Results and Conclusions

1





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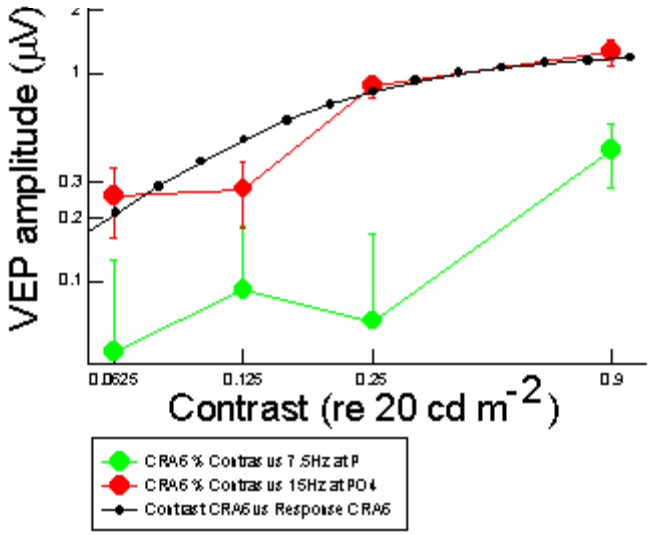
Polar plots of individual electrode recordings show phase-locked response and maximum amplitude at PO4

Sunfest 2000 Research:

Results and Conclusions

1

Contrast Response Graph



Contrast Response Function

$$R = R_{max} * \frac{C^n}{C^n + C_{1/2}^n}$$

2

Best-fit curve solves for contrast response function variables R_{max} and n, implicating magnocellular pathway for flow of visual information

Sunfest 2000 Research:

Summary and Discussion

1. **Metabolic results:** fMRI data provided location of activated visual areas V1 and V2

2. **Electromagnetic results:** EEG provided accurate picture of cellular activity in response to stimuli, allowing us to invalidate the three-shell model and suggest activation of magnocellular pathway

3. **Further research:** Propose new head model to continue investigation into source analysis