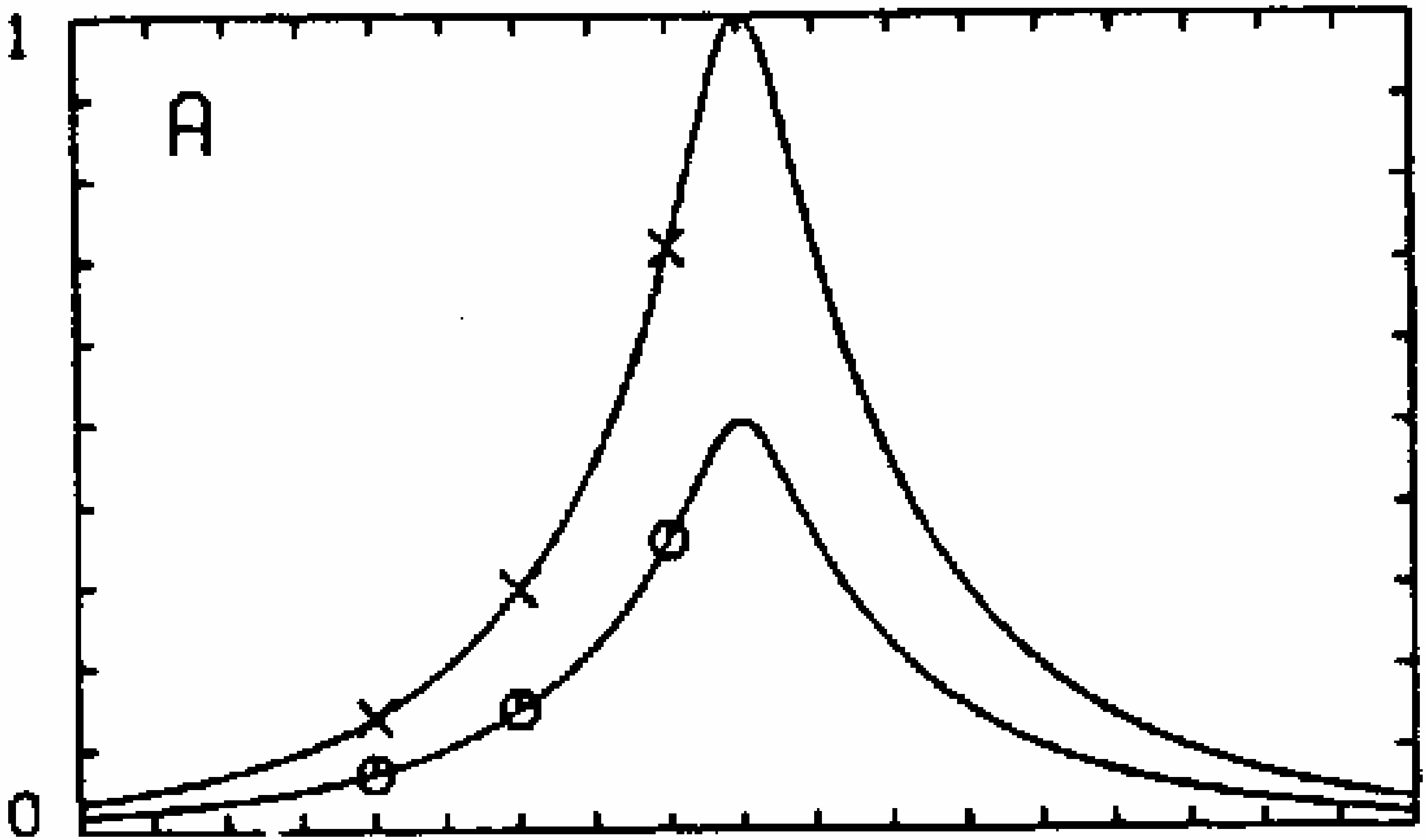
- ❑ Course Evals
- ❑ 3x5s

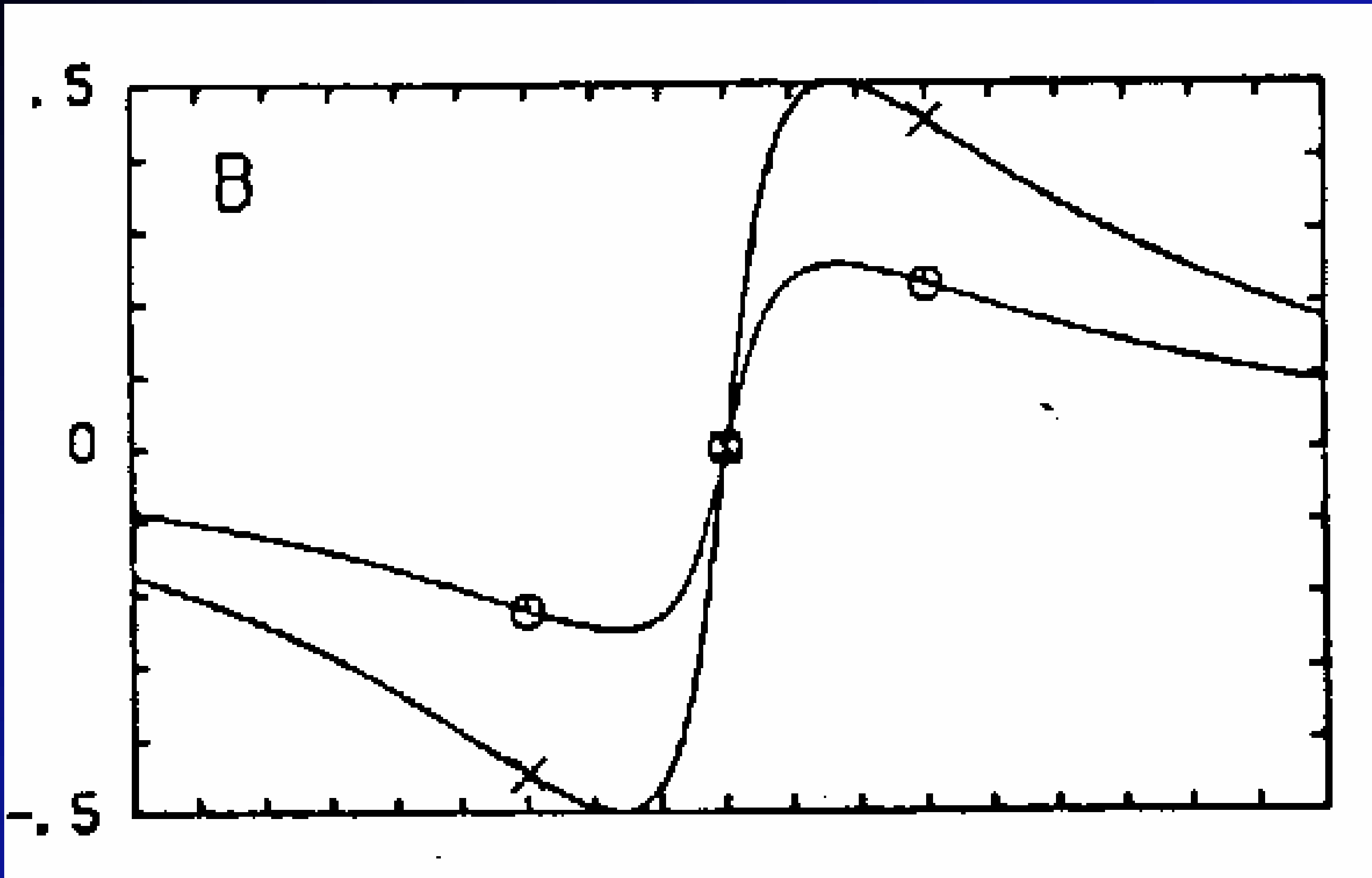
On to Lecture

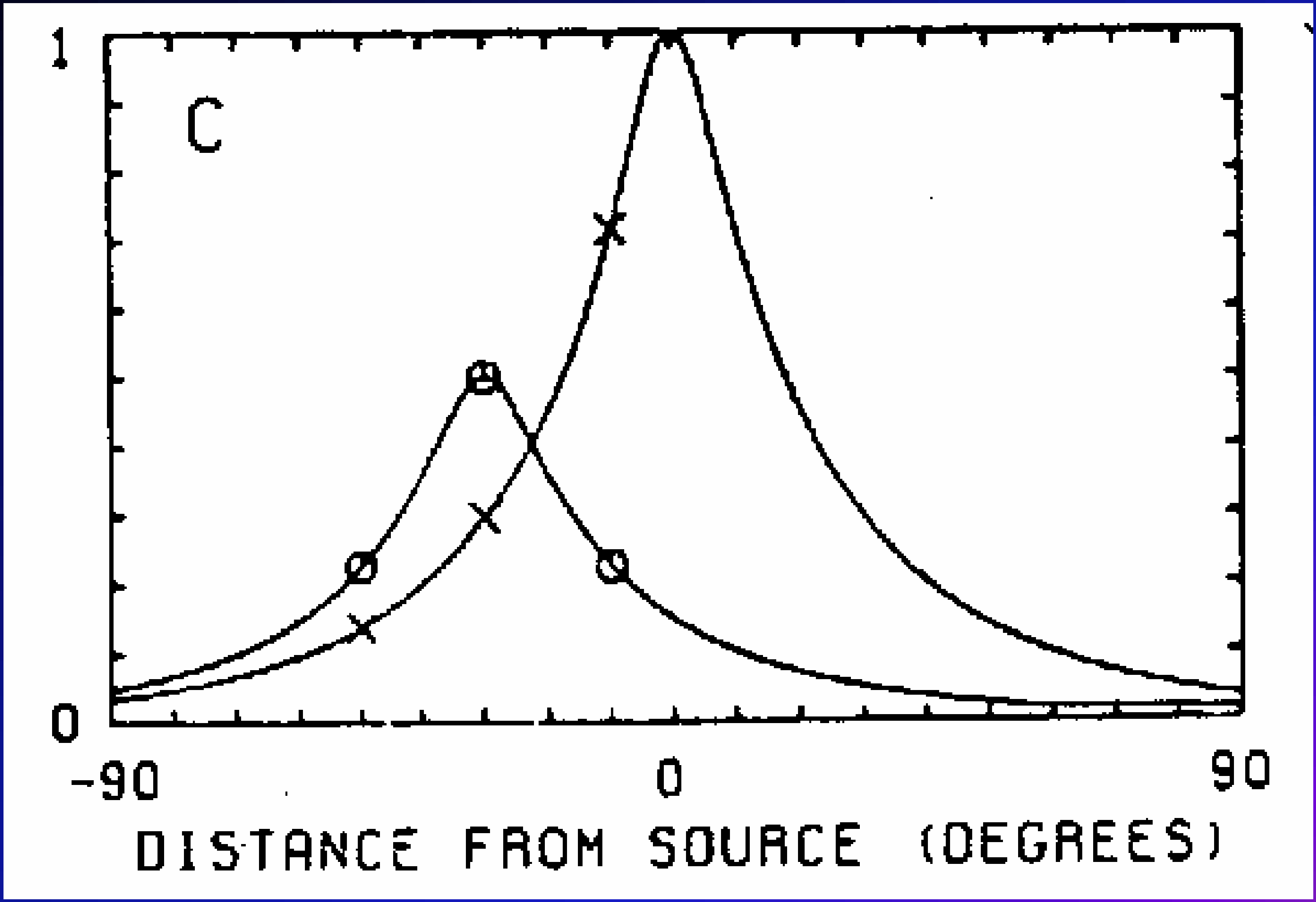
Using Scalp Topography to Infer Different Generators

- Assumption is that if there are different source generators between, there will be different resultant scalp distributions
- Therefore would expect to find a Scalp site by Condition interaction in ANOVA
- The Problem (Wood & McCarthy, 1985)
  - Potentials do not propagate to scalp in strictly additive manner
  - Same source at different strengths can produce a Scalp site by Condition interaction



1
A
0


.5
B
0
-.5



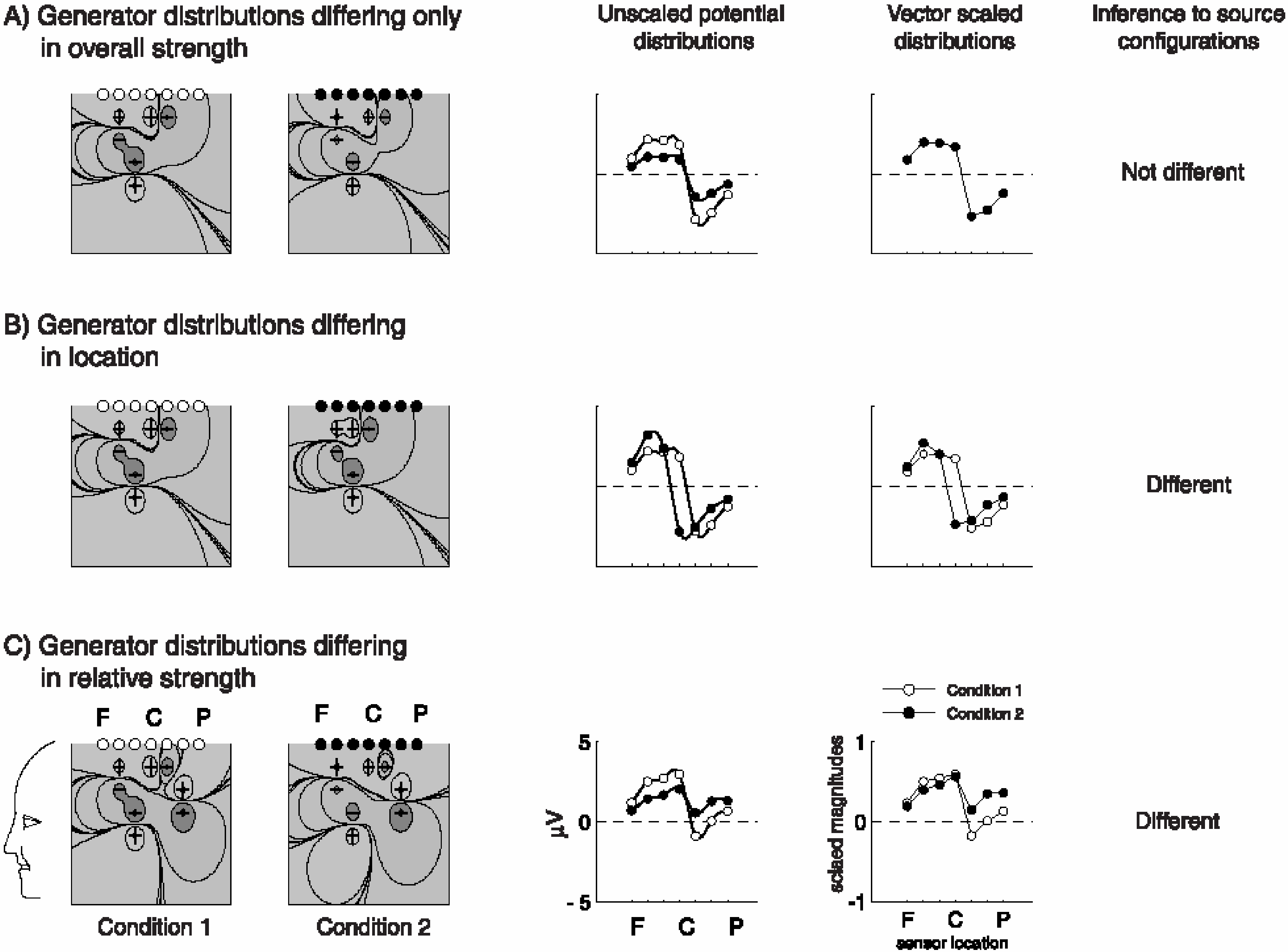
1
C
0
-90
0
90
DISTANCE FROM SOURCE (DEGREES)

The Solution

- Normalization
  - For each condition, scale data (e.g. by dividing by site of maximum amplitude)
- Eliminates any overall condition main effect
  - Condition main effect must be assessed in standard (non-scaled) ANOVA
  - Scaled data now lead to an interpretable interaction
  - If interaction survives scaling, then one can reasonably infer different intra-cranial generators

A New Problem

- Urbach & Kutas point out that the solution is not a solution! It's intractable
  - For single point source that is invariant in rotation, perhaps Wood & McCarthy were right
  - But when dipole rotates (e.g. on a gyrus), changes polarity, the W&M strategy will not work
  - When there are multiple generators, with changes in *relative* strength, W&M strategy will not work



A) Generator distributions differing only in overall strength
B) Generator distributions differing in location
C) Generator distributions differing in relative strength
Unscaled potential distributions
Vector scaled distributions
Inference to source configurations
Not different
Different
Different
F C P
F C P
Condition 1
Condition 2
5
0
- 5
µV
1
0
-1
scaled magnitudes
F C P
F C P
sensor location

If, and only if…

- W&M procedure produces valid inferences if and only if two generator distributions *G*1, *G*2, are multiplicatively related
- Two generator distributions are multiplicatively related iff:
  - 1. The locations of the generators are all the same AND
  - 2. The polarities of the generators are all the same AND
  - 3. The intensities of the generators differ in overall strength, not *relative* strength
- But how would you ever know, unless you *knew* where the generators were
  - … in which case you would not be using the W&M procedure!

So, where's that leave us?

- If you scale the amplitudes and there is no interaction between condition and site, then the generators are not different
- But if there is such an interaction, you don't know whether:
  - generators differ in location OR
  - generators differ in polarity OR
  - generators differ in *relative* strength
- So a nonsignificant effect is informative

Principle Components Analysis

- A method for reducing massive data sets
- See Handout for gory details

Source Analysis

- BESA -- Brain Electrical Source Analysis
- This is a model-fitting procedure for estimating intracranial sources underlying ERPs
    - Estimate -- if model fits, then data are consistent with these sources; yet there is no unique solution
    - Not for ongoing EEG -- too many sources

BESA

- Imagine a data matrix of ERPs:

$\mathbf{V}_{\mathbf{Cxn}}$ (# Channels by # timepoints)

- Note that this is really the result of the subtraction of the activity at the reference from the activity at the these sites; i.e.,

$\mathbf{V}_{\mathbf{Cxn}} = \mathbf{U}_{\mathbf{Cxn}} - \mathbf{R}_{\mathbf{Cxn}}$

- Note: the reference matrix has identical rows! Thus BESA Presumes that all channels referenced to the same reference!

BESA

- Reconstruct a data matrix that includes not only the original channels, but the implicit channel (reference) as well:

$\mathbf{U}_{\mathbf{Exn}}$ (# electrodes = # channels+1),

which represents the activity at each electrode with respect to an average reference (i.e., the average of all channels)

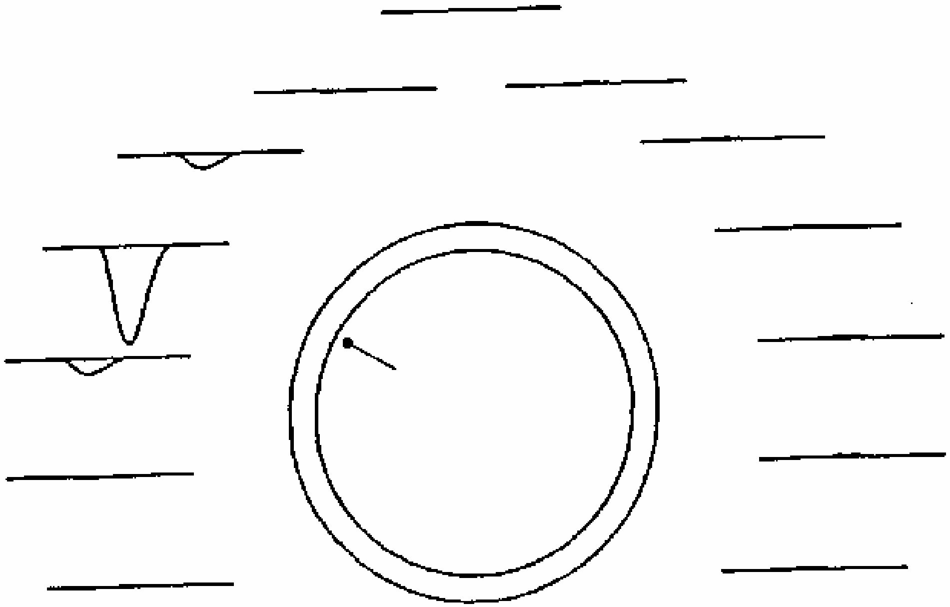
BESA

- Now this matrix $\mathbf{U}_{\mathbf{Exn}}$ can be decomposed into
  - a set of sources: $\mathbf{S}_{\mathbf{Sxn}}$ (# Sources by # timepoints)
  - a set of attenuation coefficients $\mathbf{C}_{\mathbf{ExS}}$
  - so that $\mathbf{U}_{\mathbf{Exn}} = \mathbf{C}_{\mathbf{ExS}}\ \mathbf{S}_{\mathbf{Sxn}}$

BESA

- The attenuation matrix is determined by:
  - the geometry between the source and the electrodes
  - the nature of the conductance of the three-layer head model (Brain, Skull, Scalp);
    - the skull is less conductive than the layers on either side
    - this results in a spatial smearing of potentials as they cross the skull
    - the skull produces the equivalent of a brain that is 60% of the radius of the outer scalp (rather than the "true" figure of ~84%)

Next



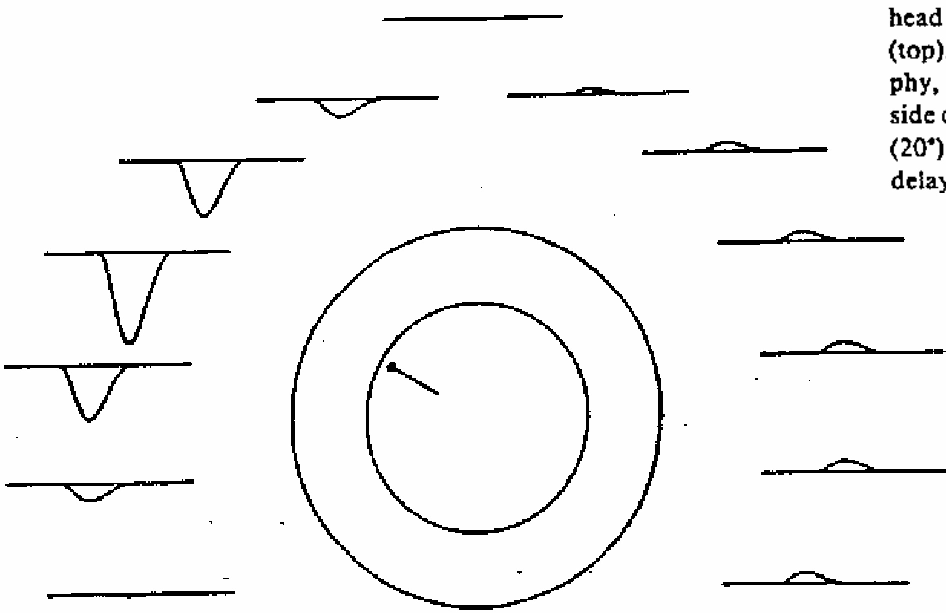


Fig. 4. Coronal scalp potential distribution of a radial equivalent dipole modeling activity of superficial cortex. The dipole is oriented inward to mimic, for example, excitatory pyramidal cell activation at the apical dendrites, producing surface negativity. neglecting the shielding effect, i.e. taking an eccentricity of about 80% in a homogeneous head model, results in a narrow focus, similar to the epicortically recorded topography (top). Adequate reduction of equivalent eccentricity results in a realistic scalp topography, which is much more widespread and exhibits a positive maximum on the opposite side of the sphere (bottom). The simulated waveforms at the vertex (C_z) and at equidistant (20°) electrodes over both hemispheres depict a monophasic activity arising with some delay after stimulus delivery.

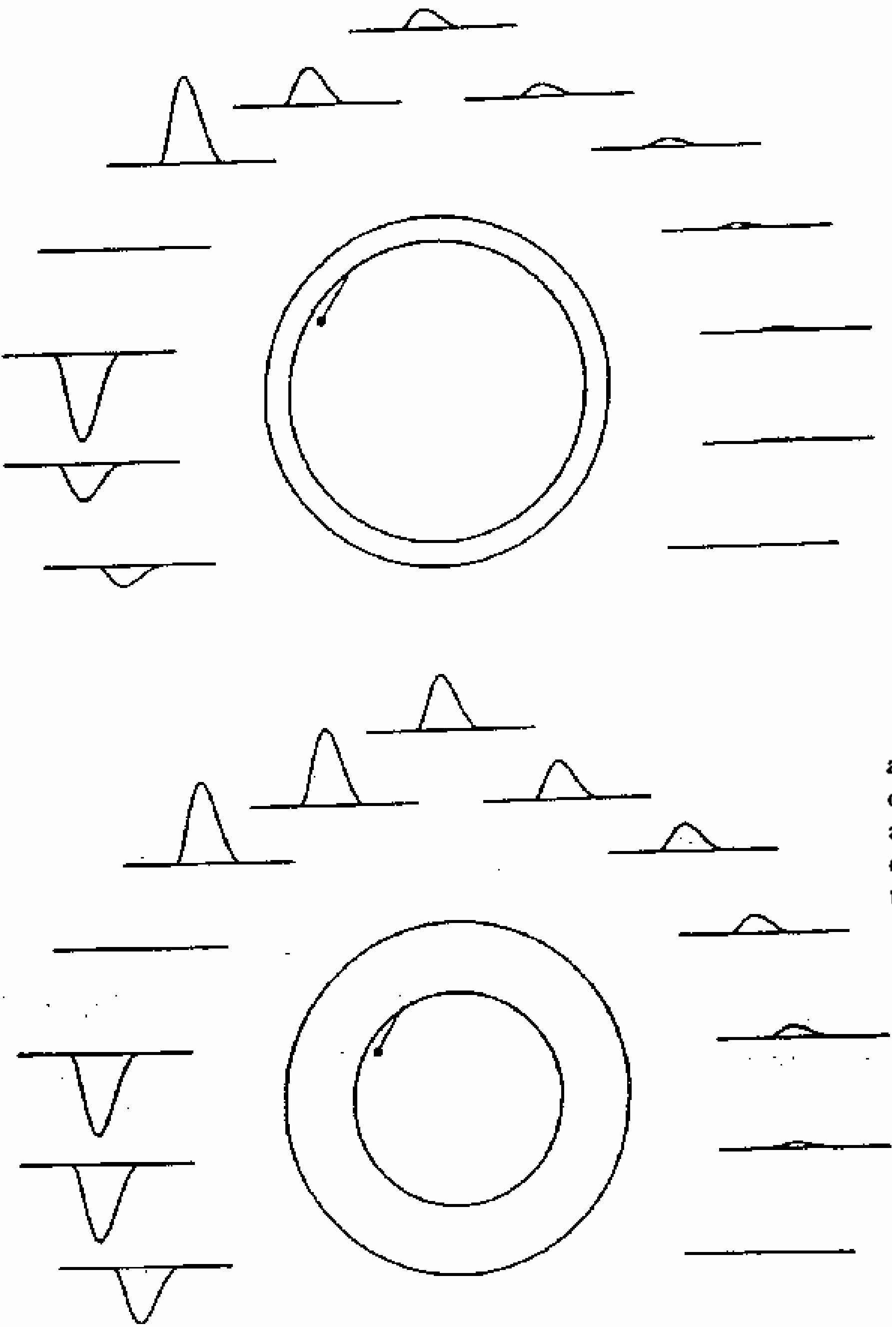
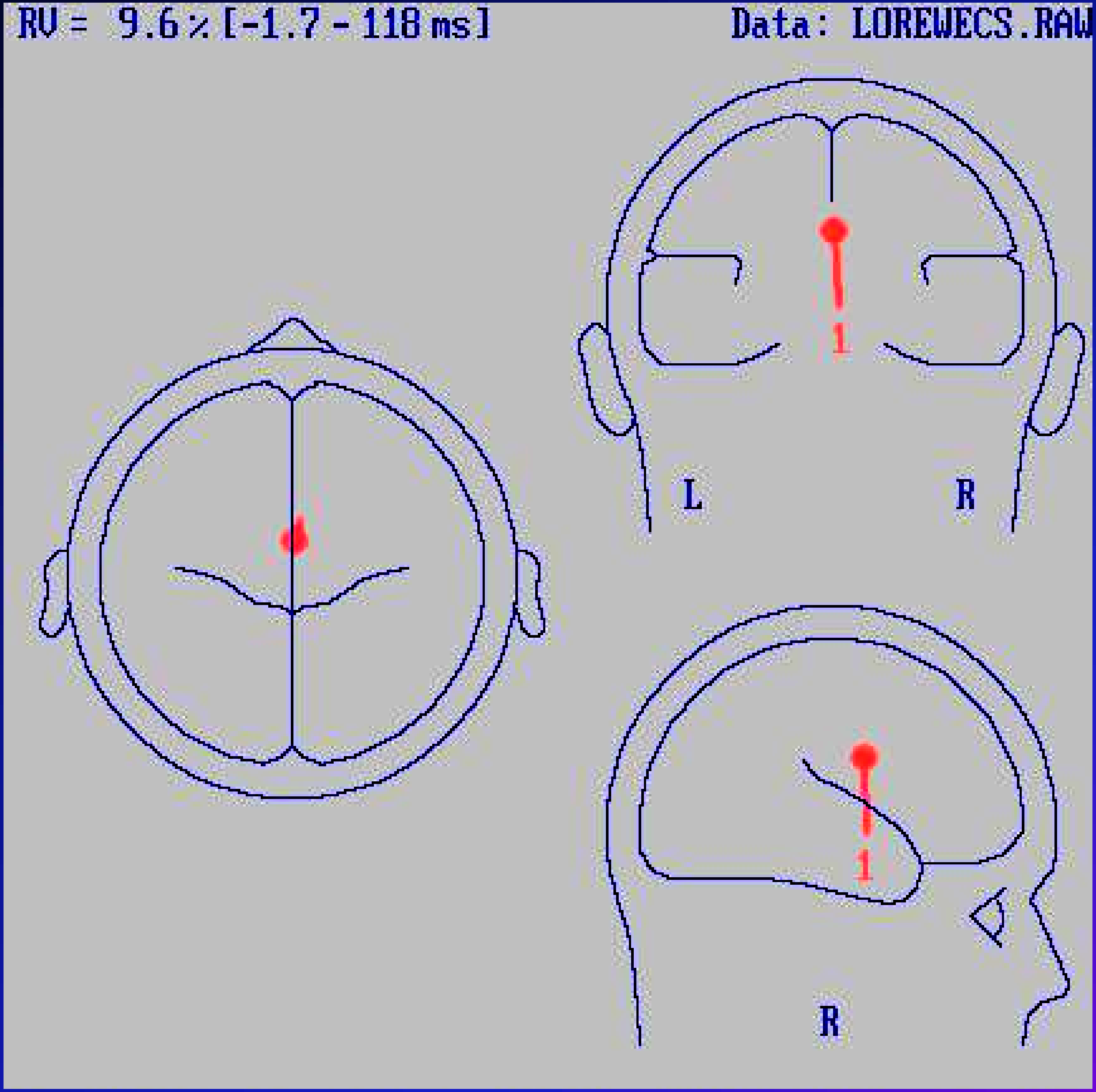


Fig. 5. Coronal scalp distribution of a tangential dipole modeling fissural cortical activity. As explained for figure 4, the correctly transformed ecentricity in the homogeneous head model (bottom) results in a realistic scalp topography with widespread positive and negative maxima to either side of the actual location of the source. Note that in the quasistatic approach a single dipole source contributes the same waveform at all electrodes. Only the attenuation factor and the sign vary with electrode site.

BESA

- Note that the decomposition of **U** into **C** and **S** results in
  - an electroanatomical time-independent matrix (**C**) that reflects that anatomical substrates do not move around in the head
  - a time-variant dipole source potential matrix that represents the change in activity of each source over time


RV = 9.6 % [-1.7 - 118 ms]
Data: LOREWECS.RAW
1
L
R
1
R

BESA Vs PCA (a battle of acronyms)

- This decomposition is akin to PCA
  - PCA has sources (the loading matrix **L** in the R-PCA method) and propagation coefficients (the Factor Score matrix **S**)
  - PCA solutions are constrained by orthogonality of components, and by those that account for greatest common variance
  - BESA solutions are constrained by the geometry of the head, the volume conduction of the dipoles, and the anatomical constraints dictated by the user (e.g., inside the head, symmetrical, not in the ventricles, must not be in the brainstem after a certain point in time, etc...)

BESA Vs PCA continued

- Like PCA, the reconstruction of the original data set will be imperfect
  - Better chance of reconstructing the original matrix if data are reliable
    - as with PCA, only reliable variance may accounted for (note you may account for a reliable artifact as well!)
  - If you capture the important sources, the reconstruction should be very good (i.e., small residual variance)
  - It is useful to attempt to upset a solution by inserting another source and seeing if:
    - the original solution is stable
    - the new source accounts for any substantial variance

Implementations

- BESA can be used:
  - in a strict hypothesis-testing manner by designating sources a priori and testing the fit
  - in an exploratory/optimizing manner by allowing the program to iteratively minimize the residual variance (between observed and reconstructed waveforms) by:
    - moving dipoles
    - changing the orientation of dipoles
    - altering the time-by-activity function of the dipoles

BESA – Did it work?

- In the end, the adequacy of your solution will be judged by
  - stability of your solution:
    - against insertion of additional dipoles
    - across multiple subjects
  - anatomical feasibility
  - follow-up tests with patients with lesions
  - your reviewers!

Psychophysiology -- Synopsis

- Psychophysiology is inherently interdisciplinary, and systemic
- Psychophysiology based on dual assumptions (Cacioppo, Tassinary, & Berntson, 2000)
  - Human behavior and experience are embodied and embedded phenomena
  - Physiological responses of brain and body – when studied within the context of an appropriate experimental design – can illuminate aspects of behavior and experience.

Psychophysiology -- Synopsis

- Ultimately we obtain correlates of behavior and experience
  - Psychophysiological Correlates are not priviledged; they are no better, no worse, than any other correlate of behavior and experience
- The utility of these correlates – like any correlates in science – hinges upon:
  - good experimental design
  - strong theoretically driven hypothesis testing
  - the development of a nomological net, a set of inter-relationships among tangible measures and constructs that place the findings in a larger theoretical context, and lend construct validity to the measures and findings

Mundane Details

- Exams due Monday May 10 by 5:00 p.m. in my mailbox, room 312 Psychology.

- Papers will be returned to your mailboxes if you have one, or retained until fall semester for you to retrieve from me if you are without departmental mailbox.