Twenty five years of MEG -- Where do we go from here?

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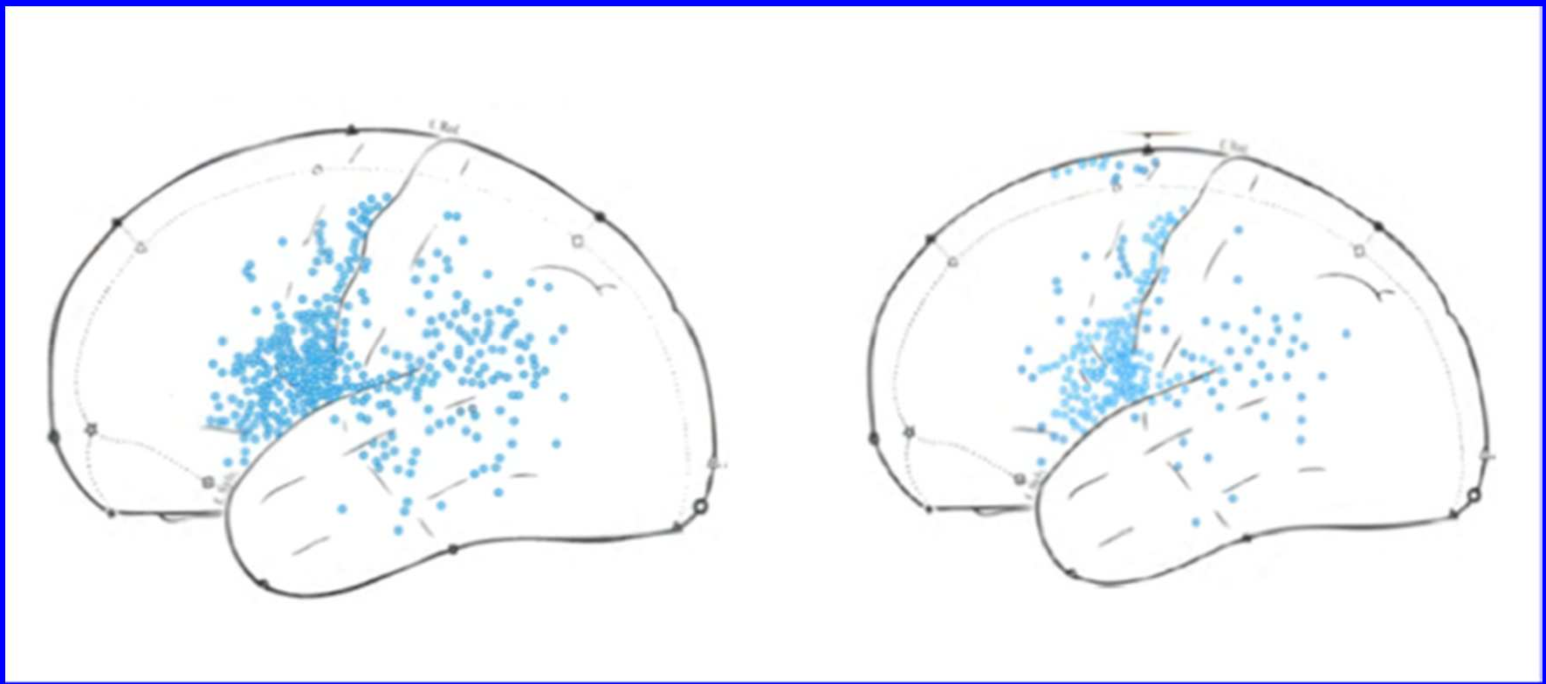
Multiple sites per patient and the complexity of even simple task
intra-patient variability and the need of presurgical mapping



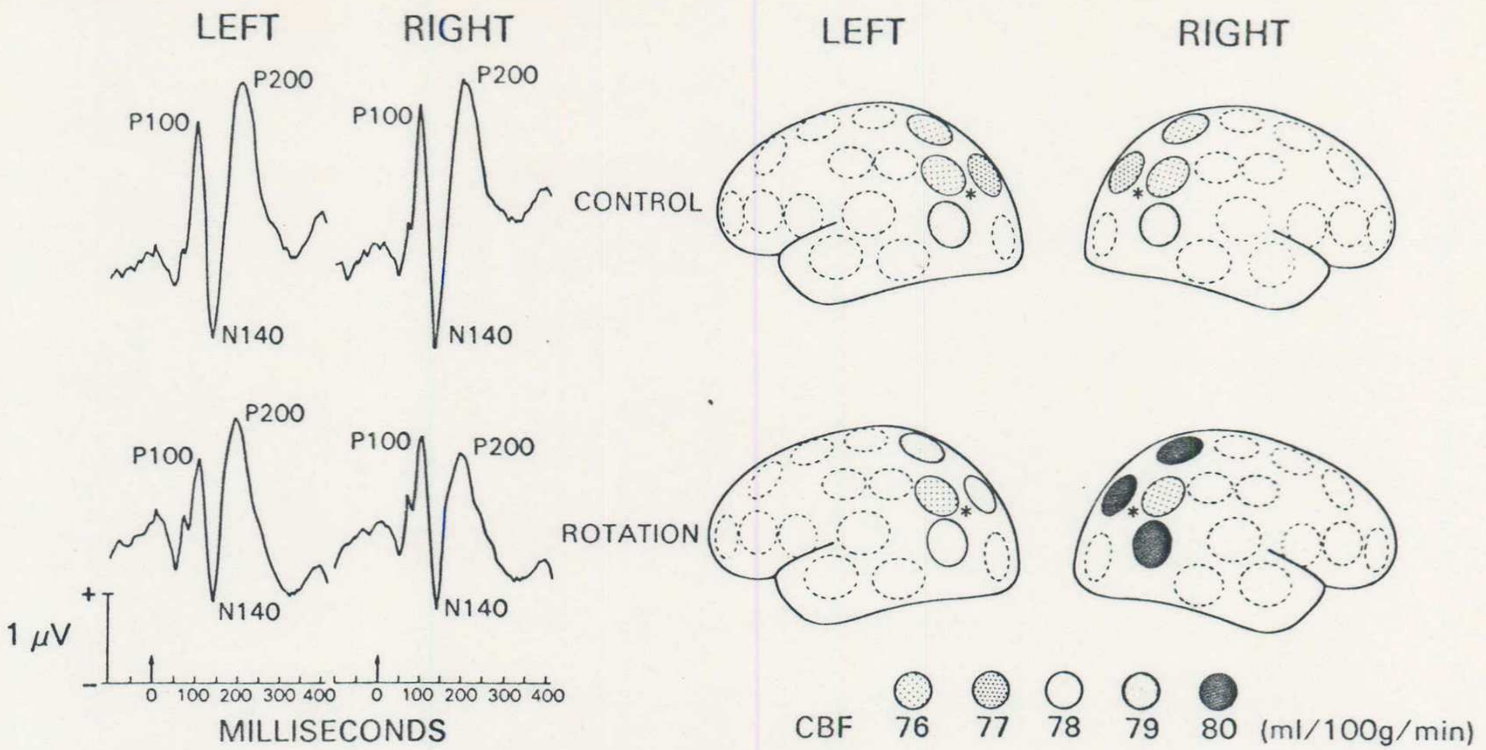


Fig. 1. Grand averages of probe EPs and rCBF values of all 19 subjects recorded over the parietal region of the left and right hemispheres during the control and rotation tasks. The approximate locations of the rCBF detectors are indicated by circles and the location of the recording electrode by asterisks.

Electroencephalography and clinical Neurophysiology, 1987, 66: 515–520
Elsevier Scientific Publishers Ireland, Ltd.

EEG 03249

Experimental Section

Convergent evoked potential and cerebral blood flow evidence of task-specific hemispheric differences [1]

Andrew C. Papanicolaou, Georg Deutsch, W. Tom Bourbon [2], Kelly W. Will, David W. Loring [3] and Howard M. Eisenberg

Division of Neurosurgery, University of Texas Medical Branch, Galveston, TX 77550-2770 (U.S.A.)

(Accepted for publication: 11 September, 1986)

Lateralization of phonetic and semantic operations

BRAIN AND LANGUAGE **9**, 269–280 (1980)

Cerebral Excitation Profiles in Language Processing: The Photic Probe Paradigm

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University of Cincinnati College of Medicine

reliability and generality of the paradigm:
normative studies

14. Papanicolaou AC: Cerebral excitation profiles in language processing: The photic probe paradigm. *Brain Lang* 1980;9:269-280.

15. Papanicolaou AC, Johnstone J: Probe evoked potentials: Theory, method and applications. *Int J Neurosci* 1984;24:107-131.

16. Papanicolaou AC, Levin HS, Eisenberg HM, et al: Evoked potential indices of selective hemispheric engagement in affective and phonetic tasks. *Neuropsychologia* 1983;21:401-405.

17. Papanicolaou AC, Schmidt AL, Moore BD, et al: Cerebral activation patterns in an arithmetic and a visuospatial processing task. *Int J Neurosci* 1983;20:283-288.

18. Papanicolaou AC, Deutsch G, Bourbon WT, et al: Convergent evoked potential and cerebral blood flow evidence of task-specific hemispheric differences. *Electroencephalogr Clin Neurophysiol* 1987;66:515-520.

clinical applications to the study of the restitution of language post left hemisphere stroke

and

cross-validation of results

against behavioral and rCBF data

19. Papanicolaou AC, Levin HS, Eisenberg HM: Evoked potential correlates of recovery from aphasia after focal left hemisphere injury in adults. *Neurosurgery* 1984;14:412-415.

20. Papanicolaou AC, Moore BD, Levin HS, et al: Evoked potential correlates of right hemisphere involvement in language recovery following stroke. *Arch Neurol* 1987;44:521-524.

21. Moore B, Papanicolaou AC: Dichotic listening evidence of right hemisphere involvement in recovery from aphasia following stroke. *J Clin Exp Neuropsychol*, in press.

22. Deutsch G, Papanicolaou AC, Eisenberg HM: CBF during tasks intended to differentially activate the cerebral hemispheres: New normative data and preliminary applications in recovering stroke patients. *J Cereb Blood Flow Metab*

THE ADVENT OF MEG AND ITS ADVANTAGES OVER ERPs

Obviating the need of making assumptions of limited resources

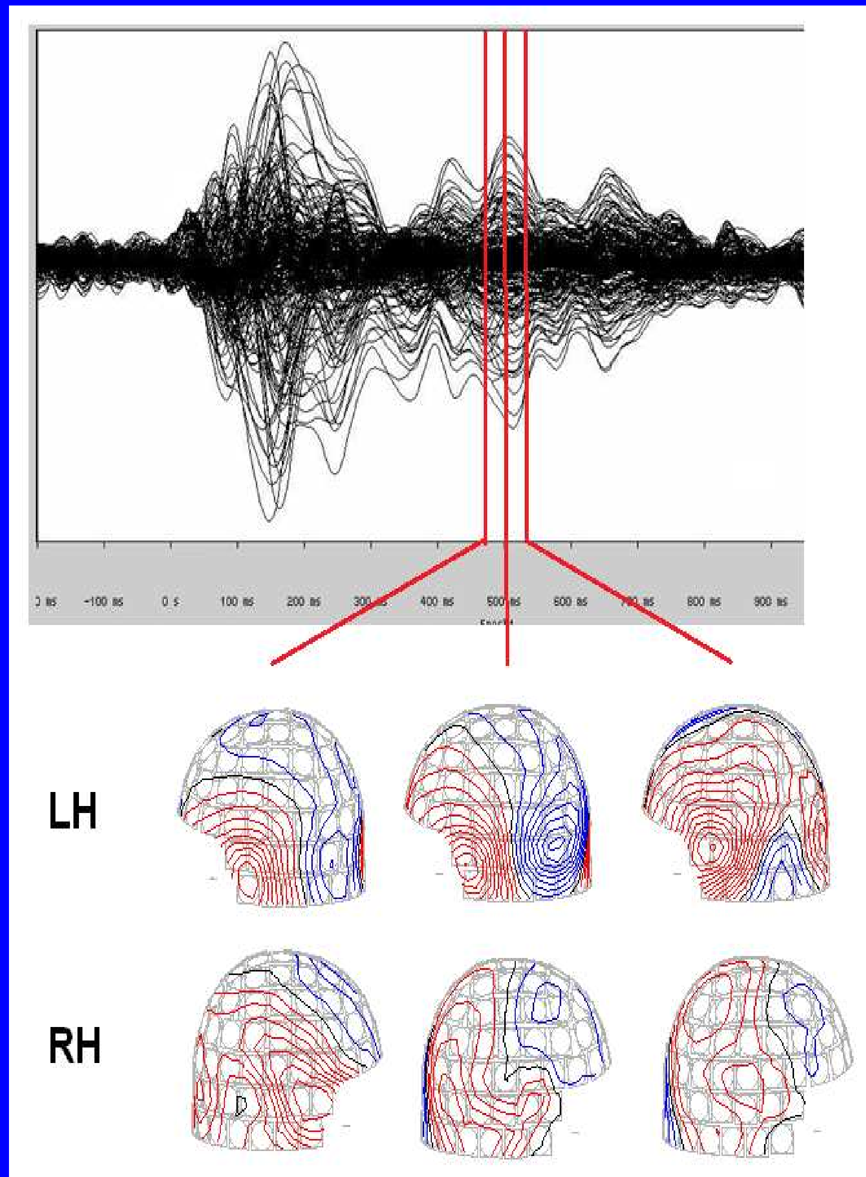
The possibility of Direct localization of acoustic phonetic and semantic circuitry

Houston
1993-2014

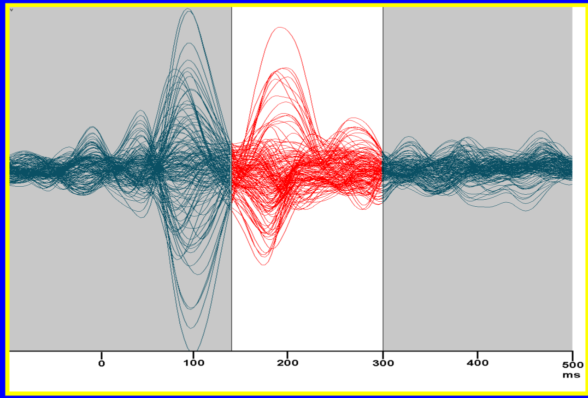
The persistence of isofield maps

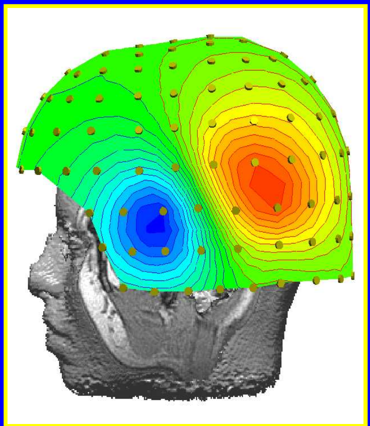
EEG journal 1990 May-Jun;77(3):237-40.

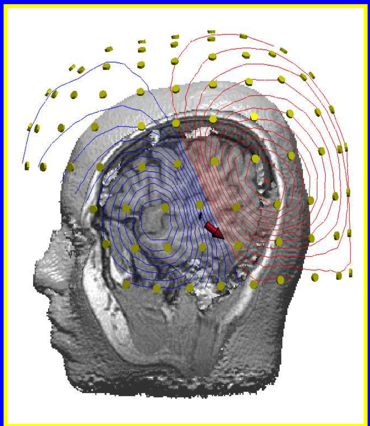
Neuromagnetic evidence of a dynamic excitation pattern generating the N100 auditory response.

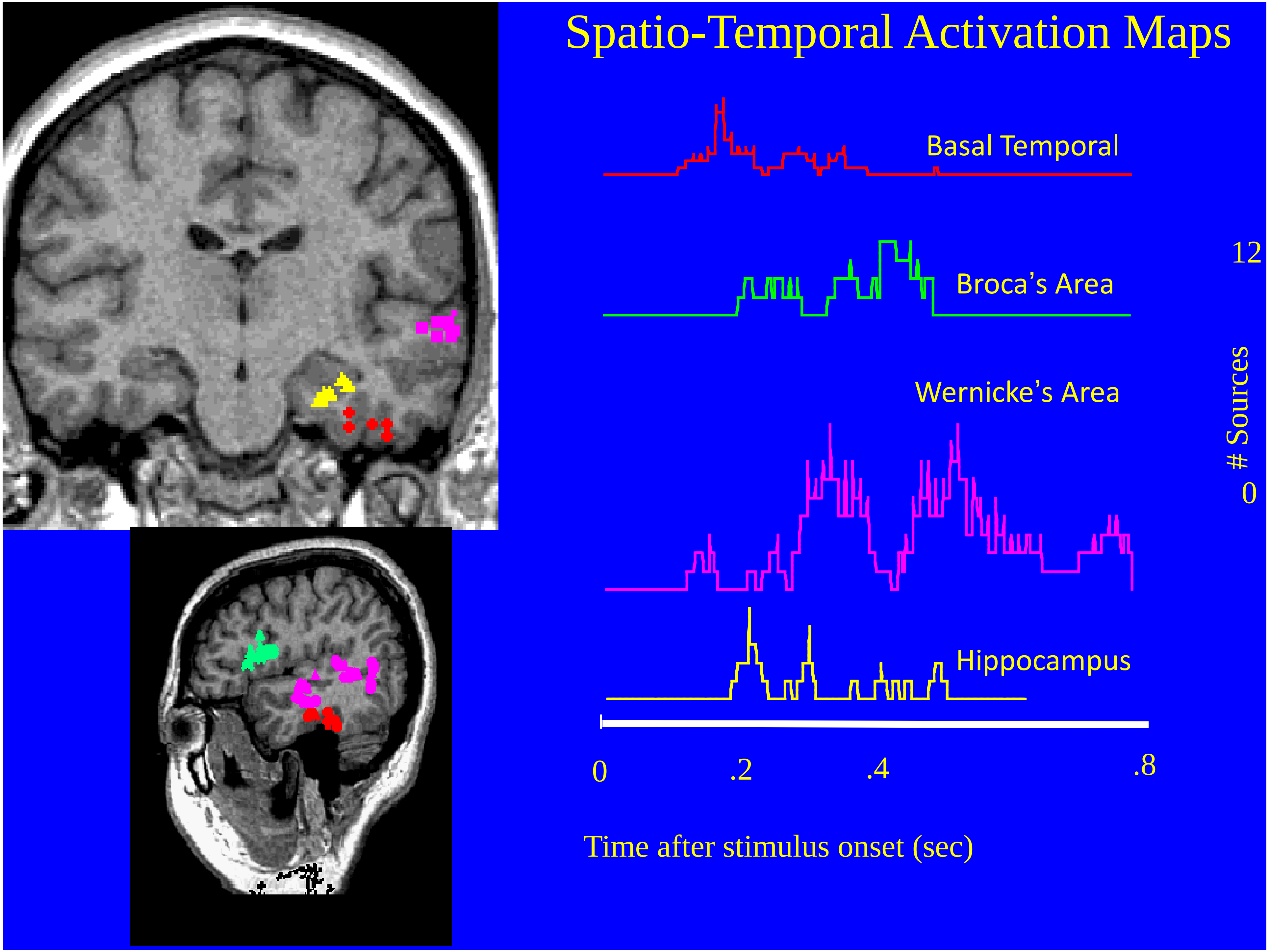

LH
RH

Summary of MEG Recording and Analyses



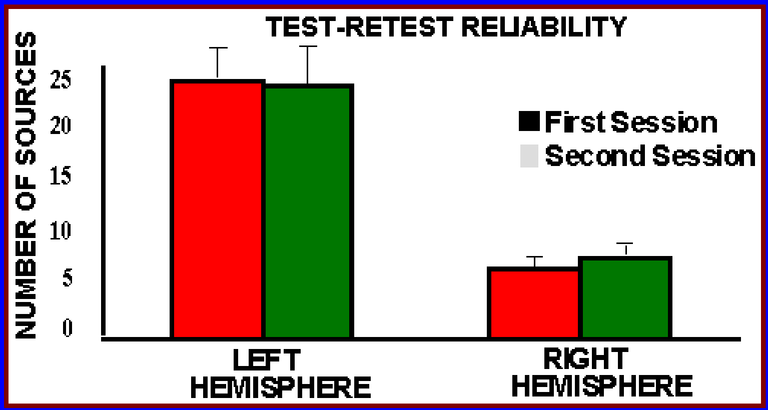


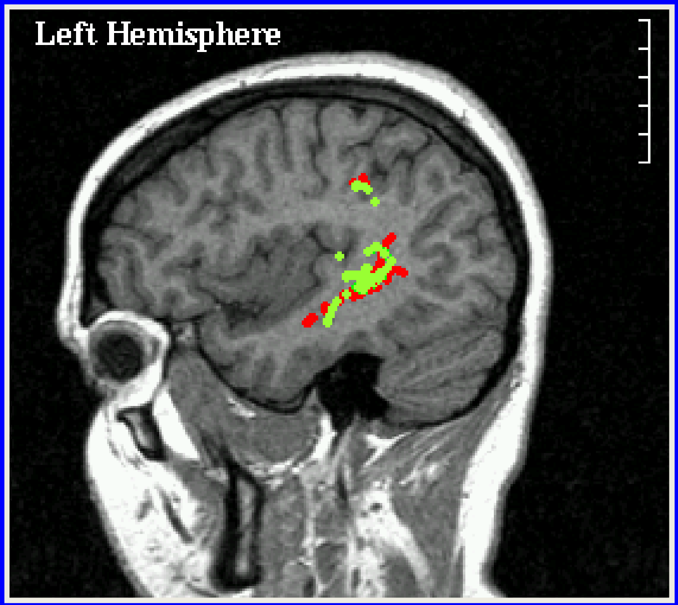



Spatio-Temporal Activation Maps
Basal Temporal
Broca's Area
Wernicke's Area
Hippocampus
12
Sources
0
0
.2
.4
.8
Time after stimulus onset (sec)

Task: Continuous recognition of words (CRM)

Dependent variable: late activity sources (200-850 msecs) sources.





Papanicolaou, A.C., et al. Journal of Neurosurgery, 90(1):85-93, 1999

Laterality Ratios

(1) Selecting activity sources computed during the late portion of the ERF waveform for each hemisphere and testing session (i.e., > ~ 200 ms),

(2) Determining the number of automatically clustered activity sources in "perisylvian" regions for each hemisphere and testing session separately (see above for the method of cluster derivation),

(3) Creating a laterality index according to the formula: $(R - L) / (R + L)$, where R represents the number of acceptable late activity sources observed in the right hemisphere and L the corresponding number on the left. Index values between –0.1 and 0.1 were considered as indicative of bilaterally symmetric activation, whereas values >0.1 or <-0.1 as indicative of right or left hemisphere dominance, respectively.

Classification of patients as bilaterally, left or right dominant for receptive language

Patient 1 (14 yrs): Bilateral

Patient 2 (15 yrs): Left-dominant

Patient 3 (14 yrs): Right-dominant

MEG-Wada Comparison:
Summary of Results

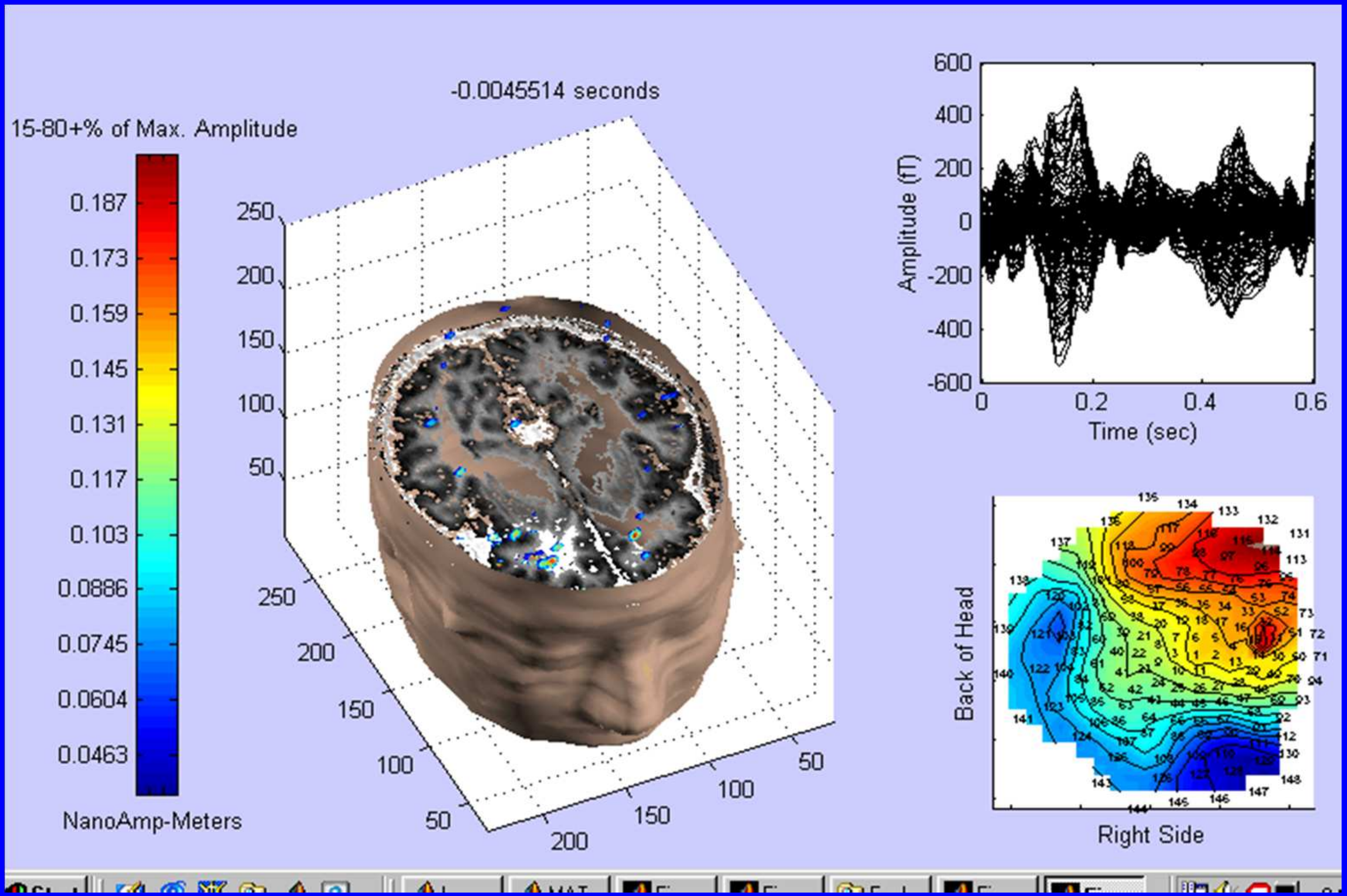
		MEG L	MEG B	MEG R
WADA	L	56	15	-
	B	2	23	-
	R	-	1	2

N= 100 epileptic patients

Sensitivity = .98 Specificity = .83

Time Evolution of Language Processing imaged by MR-FOCUSS

Normal Reading Subject during: Picture Naming

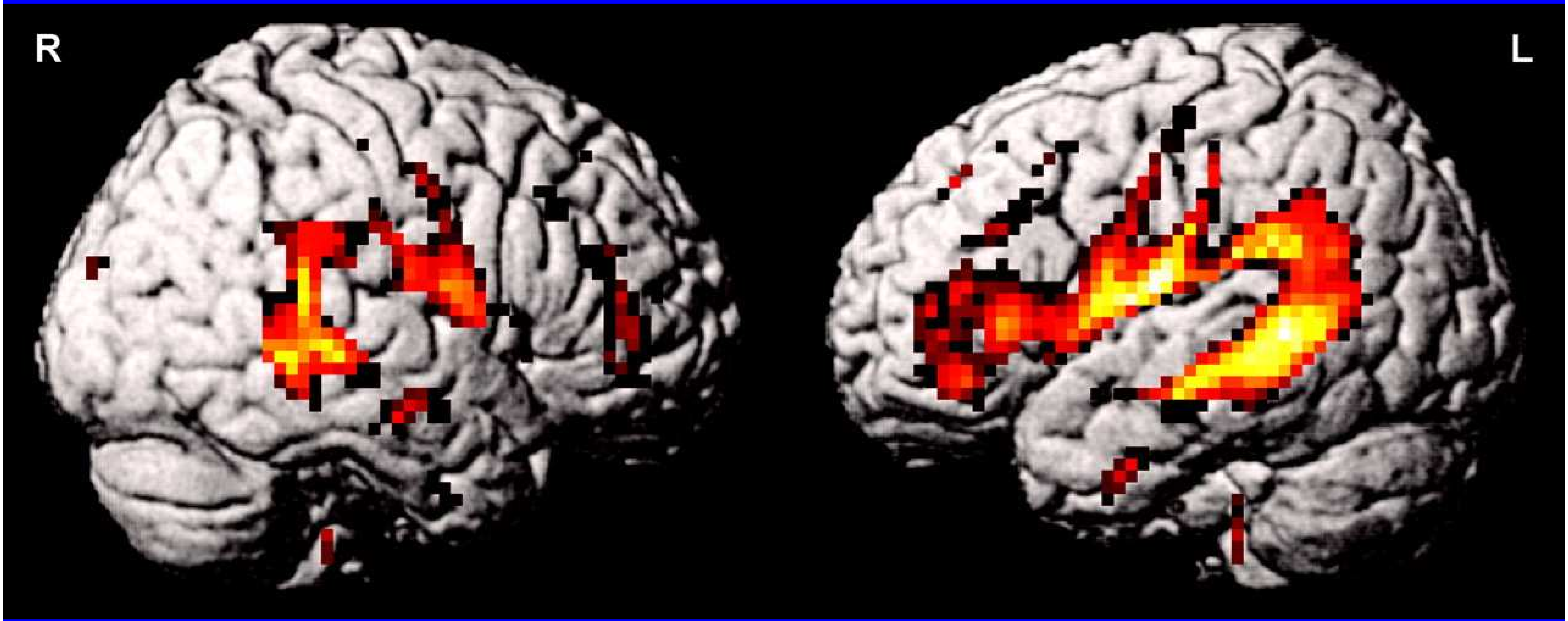


Bowyer et al 2004 Neurology

VALIDITY
Comparison of MEG and Wada Language Lateralization Studies

Study	Number of Patients	Degree of Agreement with Wada
Breier *et al*. (1999a)	26	Excellent agreement in all 26 cases
Breier *et al*. (2001)	19	Strong correlation (r = 0.87)
Maestu *et al*. (2002)	8	Agreement in 7/8 cases
Papanicolaou *et al*. (2004)	100	87% concordance (MEG sensitivity/selectivity of 98/83 %)
Hirata et al. (2004)	19	95% concordance
Bowyer *et al*. (2005)	27	Agreement in 24/27 cases
Merrifield *et al*. (2007)	10	90% concordance (MEG sensitivity/selectivity of 86/100 %)

fMRI



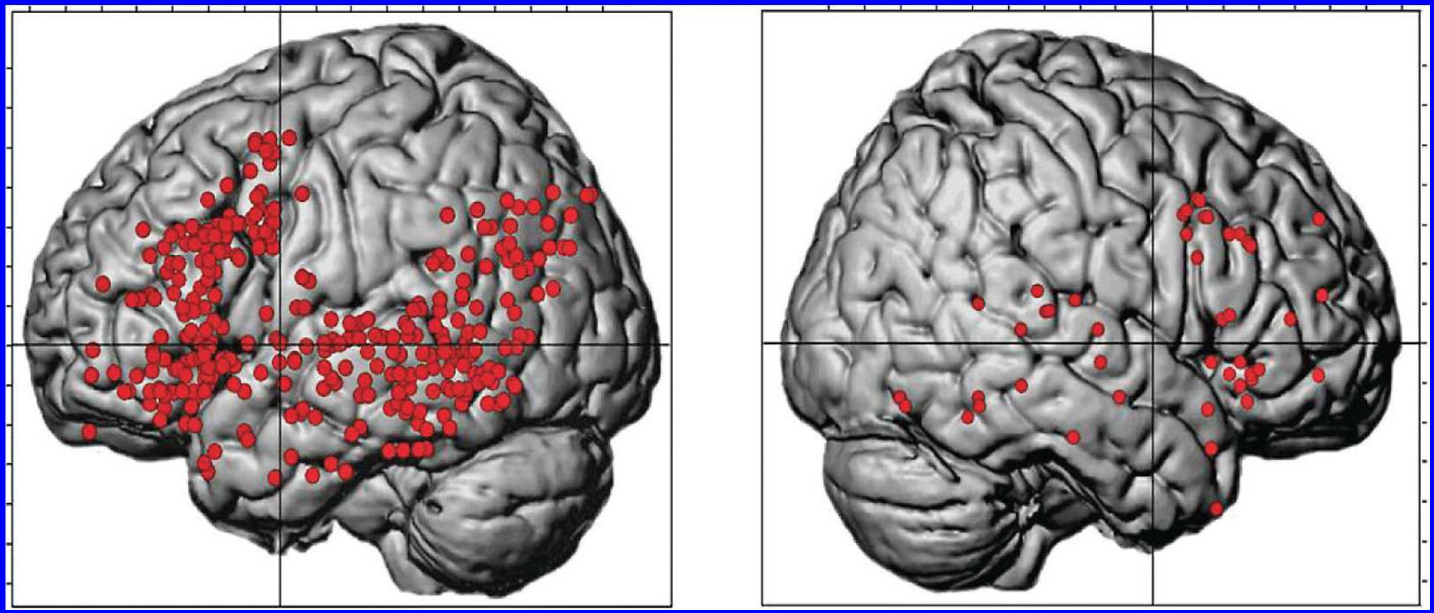
Conjunction of articulation and retrieval: The results show brain areas that are activated in both conditions; only areas activated in both tasks are shown. The fixed-effect group result is thresholded at P\0.0001, corrected. Results are rendered on the MNI standard template with SPM. Shared activations include the classical perisylvian language areas, lateralized to the left hemisphere (see Table 3), additionally bilateral STS/MTG and precentral gyri.

Kemeny S, Xu J, Park GH, Hosey LA, Wettig CM, Braun AR. Temporal dissociation of early lexical access and articulation using a delayed naming task--an FMRI study. Cereb Cortex. 2006 Apr;16(4):587-95.

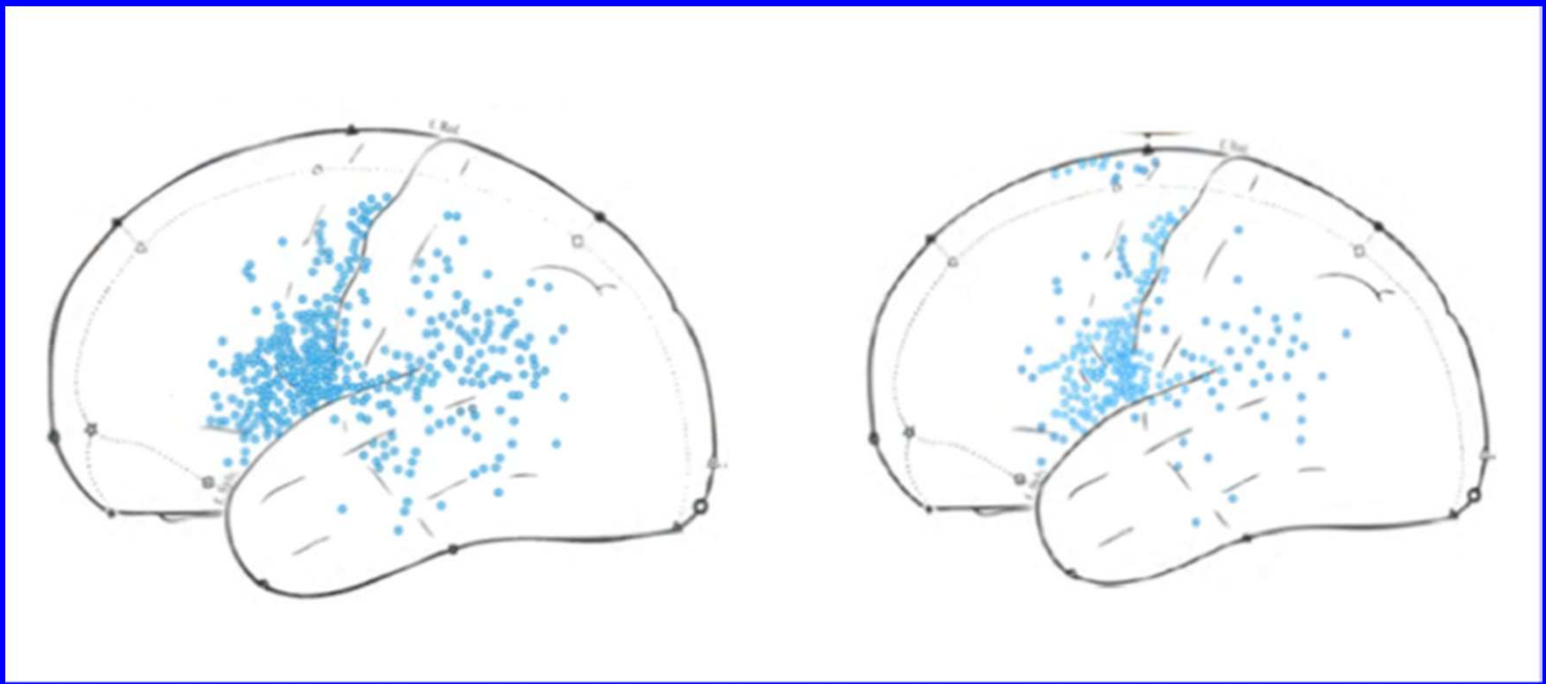
VALIDITY
Comparison of fMRI and Wada Language Lateralization Studies

Study	Number of Patients	Degree of Agreement with Wada
Desmond *et al*. (1995)	7	Agreement in 7/7 cases
Binder *et al*. (1996)	22	Strong correlation (r = 0.96)
Hertz-Pannier *et al*. (1997)	7	Agreement in 6/7 cases
Yetkin *et al*. (1998)	13	Agreement in 13/13 cases
Benson et al. (1999)	12	Agreement in 12/12 cases
Lehericy *et al*. (2000)	10	Correlations between frontal ROI asymmetries and IAP (r = 0.87-0.89)
Carpentier *et al*. (2001)	10	Agreement in 8/10 cases
Gaillard *et al*. (2002)	30	Agreement in 27 cases (3 partial)
Sabbah *et al*. (2003)	20	Agreement in 19/20 cases
Woermann *et al*. (2003)	100	91% concordance
Deblaere *et al*. (2004)	17	Agreement in 17/17 cases
Gaillard *et al*. (2004)	24	Agreement in 21 cases (3 partial)
Benke *et al*. (2006)	68	Concordance in 89.3% right TLE and 72.5% left TLE
Szaflarski *et al*. (2008)	28	Varying degrees of correlation between fMRI and IAP (r = 0.652 – 0.735) depending in type of task

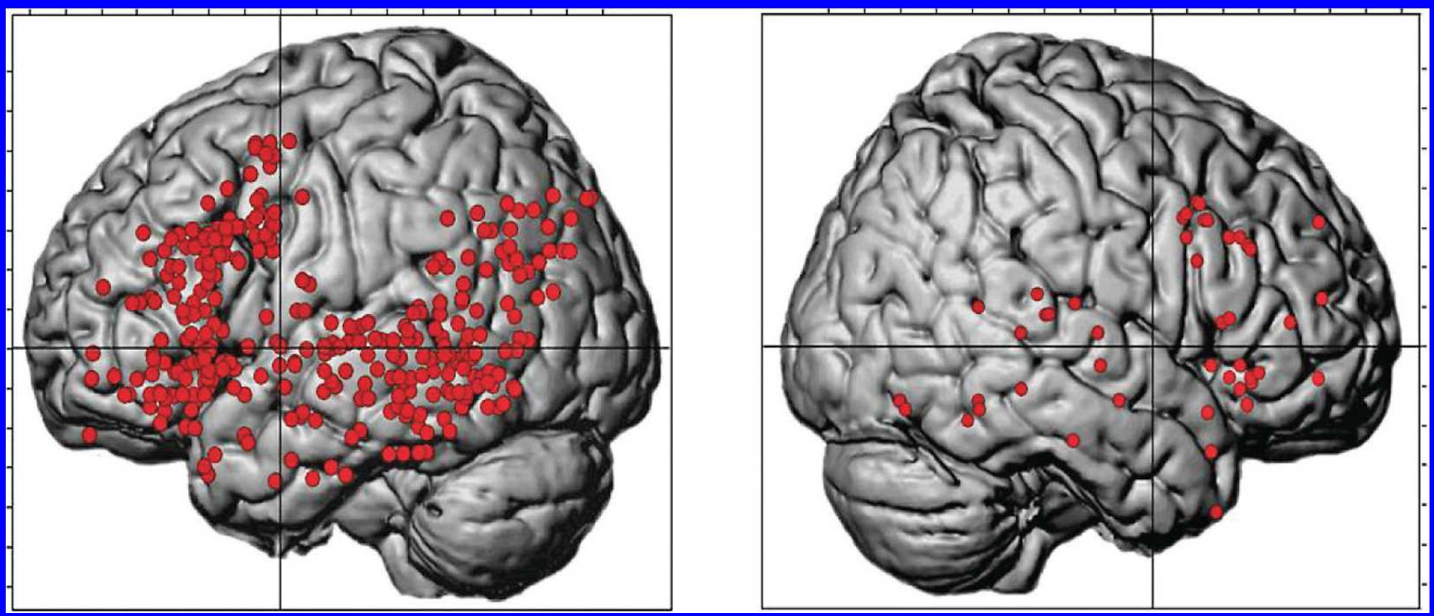
Vigneau et al. (2011)

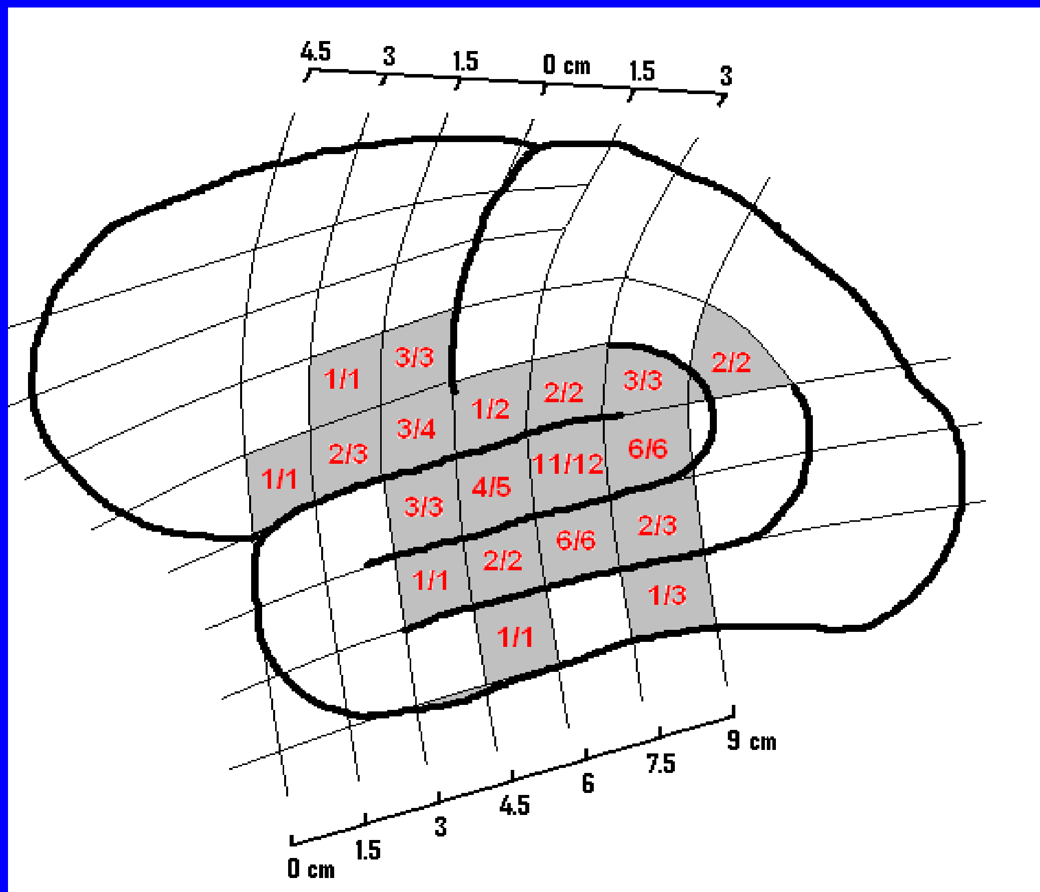


Multiple sites per patient and the complexity of even simple task
intra-patient variability and the need of presurgical mapping
the involvement of non-language areas characteristic of invasive mapping
the desirability of non-invasive mapping, part I: lateralization



Vigneau et al. (2011)





4.5
3
1.5
0 cm
1.5
3
1/1
3/3
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2/2
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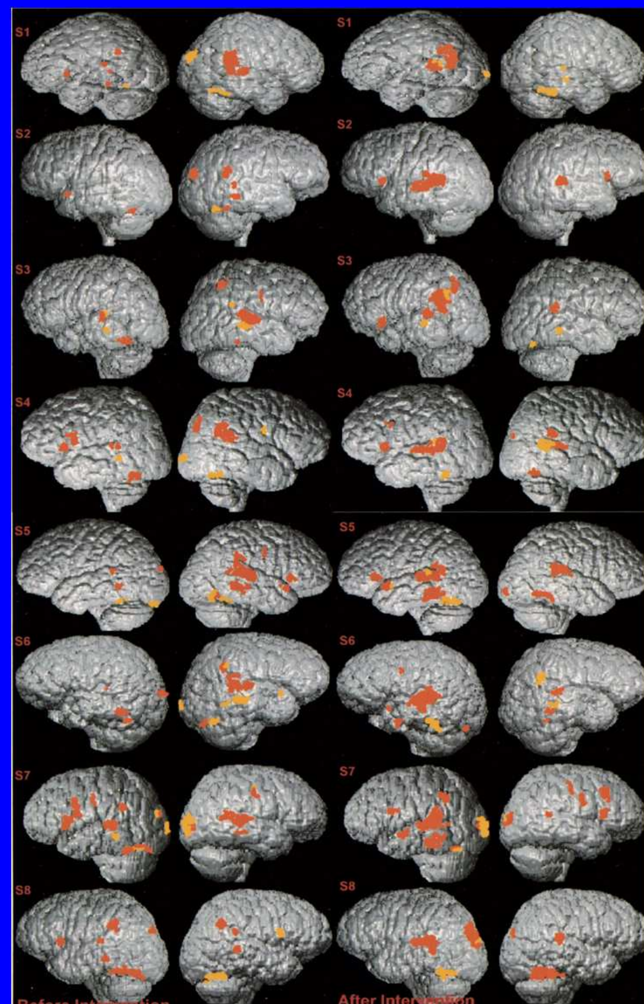
0 cm
1.5
3
4.5
6
7.5
9 cm

Dyslexia
Neurology April 2002



Shortcomings of the iterative single dipole procedure

Subjective judgments on selecting isofield maps for analysis

(correctable)

Extreme under-sampling of task-specific activation

(uncorrectable)

brainstorm

Tasks and expectations

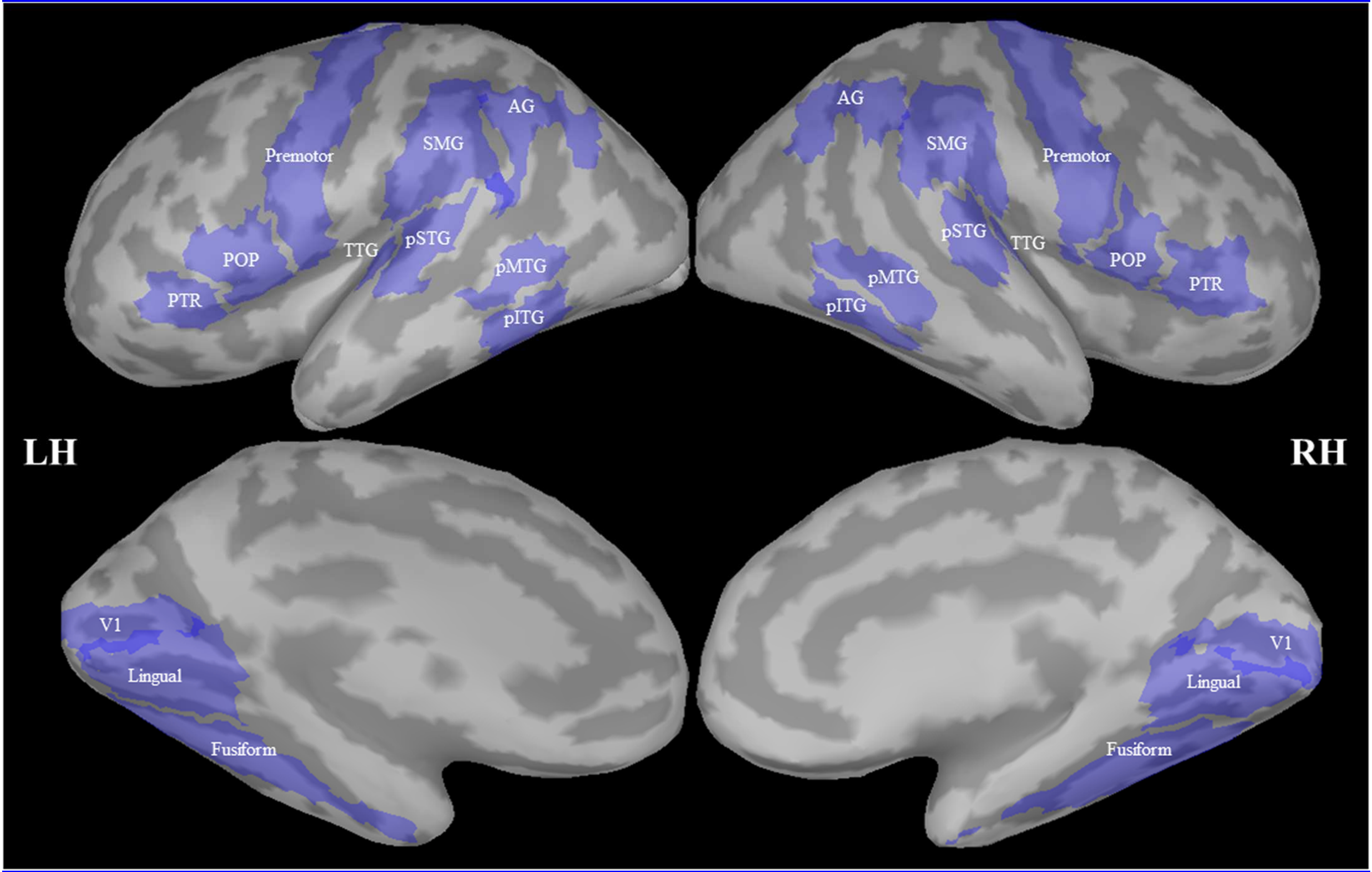
Tone identification: Early bilateral TTG activation
No late activation asymmetries

Word recognition : Early bilateral TTG and late left unilateral temporal and inferior frontal activation

Visual Word Comprehension: Early bilateral VI and late unilateral left temporal and inferior frontal activation

Kaleidoscope Figure Identification: Early bilateral VI and late right posterior activations.

Selection of language-related regions



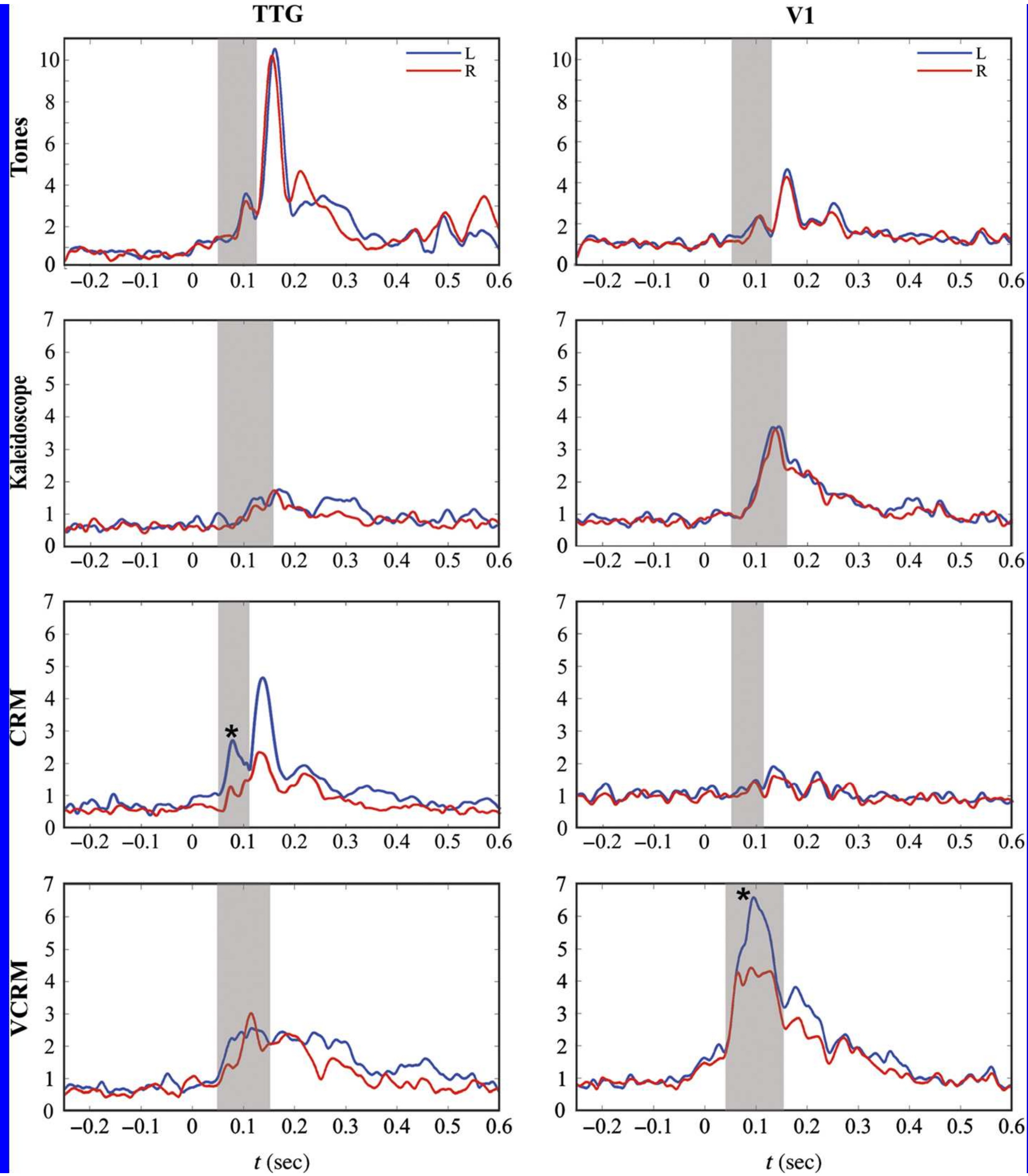
Results

Tone identification: Early bilateral TTG activation
No late activation asymmetries

Auditory Word recognition : Early bilateral TTG Early left lateralized TTG and late left lateralized temporal and inferior frontal activation

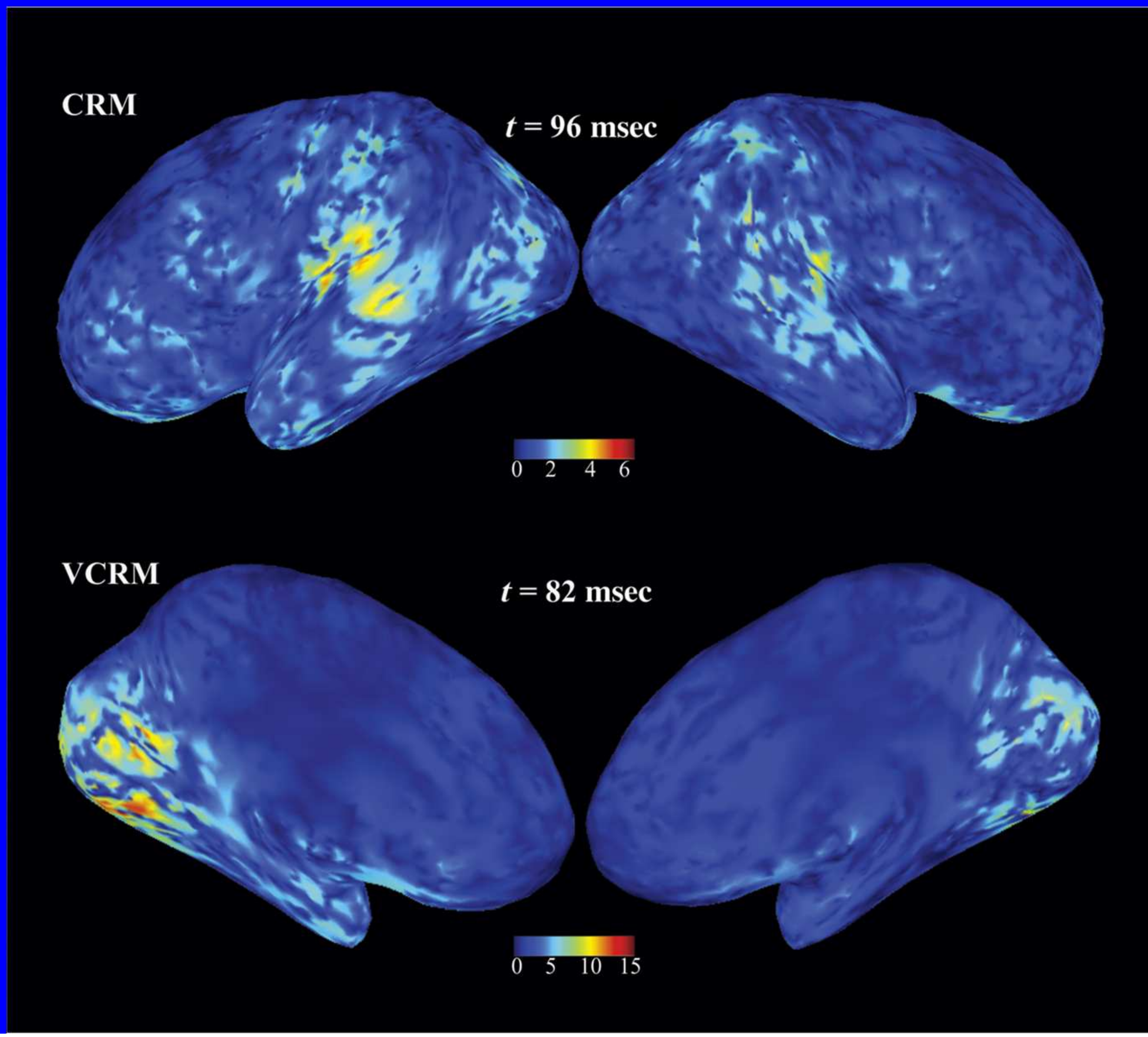
Visual Word Comprehension: Early bilateral VI Early left lateralized VI and late left lateralized temporal and inferior frontal activation

Kaleidoscope Figure Identification: Early bilateral VI and late right Bilateral posterior activations.



TTG
V1
Tones
Kaleidoscope
CRM
VCRM
L
R
*
*
t (sec)
t (sec)

Left lateralized language related activity starts early in the primary projection areas TTG and VI



The Role of the Primary Sensory Cortices in Early Language Processing

Andrew C. Papanicolaou, Marina Kilintari, Roozbeh Rezaie, Shalini Narayana, and Abbas Babajani-Feremi.

***Journal of Cognitive Neuroscience* 2017**