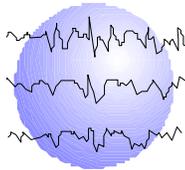


# **RIGHT HEMISPHERE LANGUAGE MAPPING USING ELECTROCORTICAL STIMULATION IN PATIENTS WITH BILATERAL LANGUAGE**

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## **ABSTRACT**

**RATIONALE:** The configuration of language cortex in the left dominant hemisphere, based on electrocortical stimulation, has been described in detail in the literature. However, language representation in the right hemisphere remains unclear in patients classified with bilateral language based on the intracarotid amobarbital procedure (IAP). Herein, we report 5 patients with bilateral language who underwent placement of a right subdural electrode array (SEA) and subsequent electrocortical stimulation for language.

**METHODS:** The right hemisphere language maps of 5 patients, with bilateral language, who underwent SEA placement at Minnesota Epilepsy Group, between January 1996 and February 2004, were reviewed. In each case, data were critically compared to the colored photograph of the brain and SEA implant taken intraoperatively for anatomical verification. Expressive and receptive language areas were defined based on language errors produced by electrical brain stimulation during the presentation of a formal language protocol, which included assessment of automatic speech, naming, reading, repetition and auditory comprehension.

**RESULTS:** Three of the 5 patients studied demonstrated the presence of language cortex in the right frontal and/or temporal lobe analogous to the localization of classical language areas in the left hemisphere. In each of these cases, data from the IAP suggests the left hemisphere remains primary for language processing. One patient had a widespread distribution of single site language errors over the right lateral hemisphere. The language map of the remaining patient was completely silent.

**CONCLUSION:** Our results identify the presence of language cortex in the right hemisphere in 4/5 patients classified with bilateral language in IAP. These areas are presumed to be accessory language zones to the primary language processing areas of the left hemisphere. Further exploratory studies are needed to clarify these specific findings. The clinical significance of these language areas remains to be determined.

## **Introduction:**

Paul Broca and Carl Wernicke first described left hemisphere language dominance in the nineteenth century. Hughlings Jackson subsequently raised the issue of language in the right hemisphere. Penfield and his associates reported one case of right hemisphere language representation in a left language dominant patient using ECS. This finding was also evidenced by other authors<sup>1</sup>. Some reports revealed the presence of aphasic symptoms associated with right hemisphere lesions in dextral patients<sup>2</sup>. To our knowledge, anatomic localization of right hemisphere language in patients with bilateral language has not been reported in the literature. In this study, we reviewed results of right hemisphere language mapping in 5 patients with bilateral language by IAP.

## **Methods:**

Five patients having bilateral language by IAP and who underwent right hemisphere language mapping between January 1996 and February 2004 at Minnesota Epilepsy Group were retrospectively reviewed. Data collected from their medical records included the following: age at presentation, gender, handedness, age at seizure onset, hemispheric language dominance based on IAP, clinical presentation, surface EEG recordings, MRI findings, surgical procedures and surgical outcomes.

ECS in our center is performed according to the technique of Luders and his associates<sup>3</sup>. SEA was surgically implanted over the right lateral frontotemporal cortex and the patient returned to his hospital room. Language mapping was then conducted on the epilepsy unit by two different epileptologists and one neuropsychologist over several days. The language protocol included the assessment of different modalities: tasks of automatic speech (counting), confrontation naming in response to drawings of common objects, auditory comprehension (following one-step commands), repetition (short phrase) and reading (single words). This protocol was performed in at least two stimulation sessions at multiple electrode sites. Patients were defined as having bilateral language based on IAP according to the classification criteria adopted by Risse<sup>4</sup>.

## **Results:**

Demographic information is shown in Table 1 and patient's paraclinical and surgical information in Table 2.

Language maps: In four of five patients, language cortex was identified in the right hemisphere during ECS. Language errors recorded were elicited during at least one mapping session in these patients (Figure 1).

Patients 1, 3 and 4 showed a clear, well defined representation of language cortex analogous to the classical essential language areas usually found in the dominant left hemisphere. Patient 1 demonstrated only an expressive speech area since the SEA covered only the frontal lobe and the temporal lobe was not mapped for language in this patient. Temporal language areas in patients 3 and 4 involved the superior and middle temporal gyri; in patient 3, language is represented in the posterior part at 6.5 cm from

the temporal tip whereas in patient 4, language extended anteriorly to 4.5cm from the temporal tip. The surface area of both frontal and temporal language cortex varied between 1x1 cm<sup>2</sup> and 4x3 cm<sup>2</sup>.

In patient 2, four single language error sites were identified over the right superior and middle temporal gyri. Three of them had one single error in the following modalities: repetition, comprehension and naming respectively. One site had two language errors of comprehension and repetition. No language cortex was identified in the frontal lobe. However, the stimulation of the area behind the motor strip at 1 cm above the sylvian fissure produced some speech arrest. Initially, the patient had stopped counting but with prompting he was able to start again.

No language cortex was found in patient 5.

## **Discussion**

This report confirms the presence of right hemisphere language cortex in 4 of 5 patients studied whose IAP results indicated language ability in both hemispheres.

The pattern of language distribution identified in the five patients is varied; One patient (Patient 2) had a widespread distribution of single language error sites over the right temporal gyrus, similar to findings previously reported by Ojemann and his coworkers<sup>5</sup>. Others (patients 1,3,4) had better-organized language areas analogous to the essential classical areas of the dominant hemisphere. In addition, language errors found were mainly of the expressive or motor speech type in the frontal lobe and of the receptive type in the temporal language cortex. The absence of language in response to ECS mapping in patient 5 was attributed to the placement of the SEA, which in this particular case may not have covered the classical language areas.

## **Conclusions:**

In most cases, it appears that the right language cortex is a duplication of functions that are well established in the left hemisphere. Whether these duplicated language areas are necessary for normal language behavior is unknown since, to date, these areas have been spared in the surgical resection. We speculate that these language areas might have an accessory role in language production, as could be predicted from the IAP results. Further focused studies needed to be performed in the future.

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Table 1

## Patient's Demographic Data

Patient	Age at Surgery	Age at Seizure Onset	Gender	Handedness	FSIQ
1	18 y	2 ½ y	M	L	82
2	34 y	18 y	F	R	84
3	8 ½ y	4 y	F	R	114
4	9 ½ y	9 y	M	R	83
5	11 y	10 y	M	R	118

y=years, M=male, F=female, L=left, R=right

Table 2

## Presurgical Diagnostic Procedures

Patient	Surface EEG	MRI	SPECT	PET	Surgery	Sz Outcomes
1	RF	N	N	RT	RFTL & MSR	Sz. Free
2	RT	N	RF	RFT	RFTL & MSR	60% Reduction
3	RF	N	R MTS	RFT	RFTL & MSR	Sz. Free
4	RT	RT Dysplasia and R MTS	N/A	N/A	RTL & MSR	Sz. Free
5	RT	Mesial Temporal Tumor	N/A	N/A	Tumor Resection	Sz. Free

R=right, F=frontal, T=temporal, FT=frontotemporal, N=normal, MTS=mesial temporal sclerosis, N/A=not

Figure 1

