

## EVOKED POTENTIAL CORRELATES OF RIGHT HEMISFERE INVOLVEMENT IN THE PROCESSING OF A SECOND LANGUAGE

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### ABSTRACT

The probe evoked potential paradigm was used to assess the relative engagement of both cerebral hemispheres in 10 Spanish-speaking subjects and in 12 subjects for whom Spanish was a second language, during the processing of verbal material presented in Spanish while listening to an irrelevant distractor (music), both presented acoustically through the same channel. Although the distractor condition produced attenuation of the probe EP, it was symmetrical in both groups. In agreement with previous findings, the probe EP showed task-specific activation in the left hemisphere during the activity of listening to the verbal material in the Spanish-speaking subjects, for whom the material was in their native language. However, the opposite effect, i.e. right hemisphere activation, was observed in the non-native group, suggesting an increased participation of the right hemisphere in the processing of foreign language information.

### INTRODUCTION

The crucial role of the right hemisphere in the processing of linguistic information in second-language speakers has been pointed out by Albert & Obler (1978) and Obler (1984), mainly based on data from dichotic listening tasks. According to these authors this right hemisphere dominance for a second language occurs especially during the early stages of second language acquisition.

In the assessment of selective hemispheric involvement in different linguistic and cognitive tasks the usefulness of the probe evoked potential (EP) paradigm has been demonstrated (Shucard et al. 1977; Papanicolaou et al. 1983, 1990), although these results have not received much attention until recently (Silberstein et al. 1995).

The above-mentioned procedure involves the recording of EPs to a task-irrelevant probe stimulus, such as a tone, from different sites in the left and right hemispheres during a control condition and during a test condition when the subject is engaged in specific cognitive tasks. The rationale underlying such a method is that if the required operations imply greater engagement of one hemisphere, the evoked response to the probe stimulus from that hemisphere will be smaller during processing as compared to the control condition. The relative task-specific attenuation of the probe response in each hemisphere is expressed as the ratio of the amplitude of the probe EP obtained during the task divided by the amplitude obtained during the control condition. The smaller the ratio, the greater the degree of hemispheric engagement in the task, in spite of the variability in the individual EPs. A significant interhemispheric difference in attenuation should thus not be attributed to attention effects, which theoretically acts symmetrically in both hemispheres.

Typically, dextral subjects show greater attenuations of probe EP in the left hemisphere when involved in semantic or phonetic tasks, and in the right hemisphere during prosodic or visuospatial processing tasks, or in recovered aphasics (Papanicolaou et al 1983, 1988a,b). Nevertheless, we do not have information concerning probe EP data in tasks involving second-language processing.

If the claims of Albert & Obler (1978) and Obler (1984) are correct, semantic processing of the same verbal material would result in greater probe EP attenuation in the left hemisphere if the material is presented in the subject's native language, and in the right hemisphere, if it is in a second language.

## **METHODS**

### **Subjects:**

Ten dextral subjects whose native language was Spanish (group S), ranging in age from 16 to 48 years and twelve subjects for whom Spanish was a second language (group SL) with good levels of proficiency, aged 28 to 57 years were tested. Nine out of the ten SL group had learned Spanish after adulthood and had practiced it for more than five years. Country of origin and first language of SL subjects are displayed in Table 1.

### **Procedures:**

Evoked potentials were recorded from each subject in an isolated dimly-lit room, using a commercial evoked response recording system. Recordings were made using conventional surface EEG electrodes pasted at sites T3 and T4 of the international 10-20 system, with reference to ipsilateral ear; a forehead electrode was used as a ground. Bioelectric activity was filtered between 0.5 and 30 Hz and averaged with an analysis time of 400 ms. Odd and even trials were averaged separately and superimposed to ensure replicability of the waveforms. The probe stimulus was a 1000 Hz tone with a rise-fall time of 10 ms and a plateau of 50 ms. The tones were presented binaurally through TDH-39 earphones at 75 dB SPL at a rate of 0.9 per second under three different conditions: a) Control, in which the task of the subject was to attend exclusively to the probe stimuli; b) Acoustic Distractor, in which the subject was asked to ignore the stimulus and listen to unfamiliar instrumental music presented through a speaker positioned behind the subject's head without processing of it any further; and, c) Processing Task, during which the subject was also asked to ignore the probe stimulus and was instructed to concentrate on the processing of the verbal material presented through the same speakers. During the whole session the subjects were instructed to keep their gaze fixed in a small dot above them in order to minimize ocular movements.

### **The linguistic task.**

An audio-tape of the corpus including 30 abstract common nouns in Spanish was employed. This small corpus had the following features: a) they met the high-frequency/low imagery requirements established by Papanicolaou et al; b) the list of words was phonologically representative of the Spanish language, i.e. the list included more paroxytone (penultimate-syllable stress) words, than oxytones (final-syllable stress) and than proparoxytones (antepenultimate-syllable stress) words. c) The list was extracted from the Sociolinguistic Corpus of Mérida City, hence it met the requirement of including common, high-frequency words.

The verbal material to be processed was presented at a rate of approximately one per second, and at a sound level comparable to that of the probe stimulus. The list was repeated three times in order to comply with the time required to complete the EP collection. The subjects were instructed to memorize the nouns, and at the end of the session they were tested by free recall in order to ensure compliance with the task.

The N100-P200 peak to peak amplitude of the probe EP obtained in each condition at each site was measured, and ratio scores of these amplitudes, (i.e., Acoustic Distractor/Control, and Processing Task/Control) were computed.

## **RESULTS**

Figs. 1 and 2 show the typical EP morphologies recorded at T3 and T4 in the three conditions for groups S and SL respectively. Both Acoustic Distractor and Processing Task conditions produced marked attenuation and morphology distortion of probe EP in both hemispheres in both groups. However, no significant interhemispheric differences in attenuation were found in the Acoustic Distractor condition according to a paired t-test, while in the Processing Task all S-group subjects showed greater attenuation at T3 ( $t=3.23$ ;  $p=0.0006$ ), and ten out of twelve subjects from the SL group showed greater attenuation in the right hemisphere, also highly significant ( $t=-3.75$ ;  $p=0.0001$ ). The reliability and specificity of the phenomenon of differential hemispheric involvement in the linguistic task between groups S and SL were assessed through a

group-by-task-by-hemisphere mixed design analysis of variance (ANOVA). This analysis resulted in a highly significant interaction effect ( $F= 7.661$ ;  $p=.007$ ) between group and hemisphere, as displayed in fig 3. However, two of the SL subjects failed to show right hemisphere attenuation. Instead, these subjects showed marked LH attenuation in the Processing Task, as was observed in Spanish-speaking subjects. Nevertheless, these subjects were atypical in the sense that they had learned Spanish before age 5.

## DISCUSSION

Increasing evidence suggests that the right hemisphere is not only instrumental in the mediation of higher non-linguistic functions, but also in some language-related functions (Blumstein, 1974; Weintraub et al, 1981; Araya et al, 1989; Cavalli et al, 1981; Schneiderman and Saddy, 1988; Delis et al, 1983; Joannette and Goulet, 1990; Papanicolaou, et al. 1987; Bottini et al. 1995). The present data provide an experimental demonstration of the assumption of different relative hemispheric engagement in the processing of verbal material depending on the native/non-native character of the language presented. Our results thus support previous findings by Albert & Obler (1978), and Obler (1984) regarding the role of the right hemisphere in the processing of a second language. This study presents the first demonstration of the predominant right hemispheric involvement in the processing of a second language using evoked potentials. Our data from Spanish-speaking subjects also support former findings of Papanicolaou et al. in English-speaking subjects revealing predominant engagement of the left hemisphere in the processing of the verbal material.

The absence of a significant hemispheric difference in EP attenuation in both groups during the Acoustic Distractor condition indicates that such sustained hemispheric difference is secondary to the relatively higher engagement of each hemisphere in the linguistic task and not a random effect of the lack of attention to the probe stimulus. It thus supports the assumption underlying the probe evoked potential methodology of the limited neural resources which, during a particular task, differ in the two hemispheres. The selective filtering of competing inputs in the same modality (i.e., probe vs. distractor; probe vs. verbal material) would produce uniform attenuation in both hemispheres. This was the case only for the Acoustic Distractor.

**TABLE I : SECOND LANGUAGE GROUP**

Subject	Country	First language	Age at test	Age of learning	Years of practice
HT	France	French	54	26	28
GP	India	Tamil	52	33	19
TP	India	Tamil	57	39	19
AP	France	French	38	33	5
MB	USA	English	48	26	22
SK	Japan	Japanese	55	33	22
AB	Germany	German	28	18	10
IW	UK	English	50	28	22
AB	UK	English	56	30	16
RK	USA	English	48	37	11
EP	Italy	Italian	48	5	43
VS	Germany	German	39	5	34

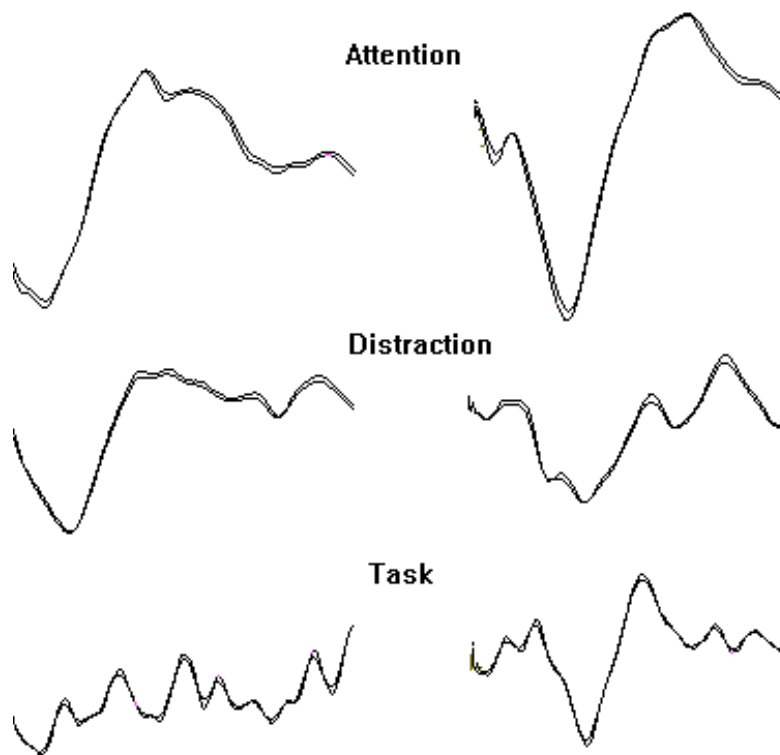


Fig. 1: Probe AEP obtained from a subject of group S. Note the greater attenuation over T3 in the linguistic task (bottom left).

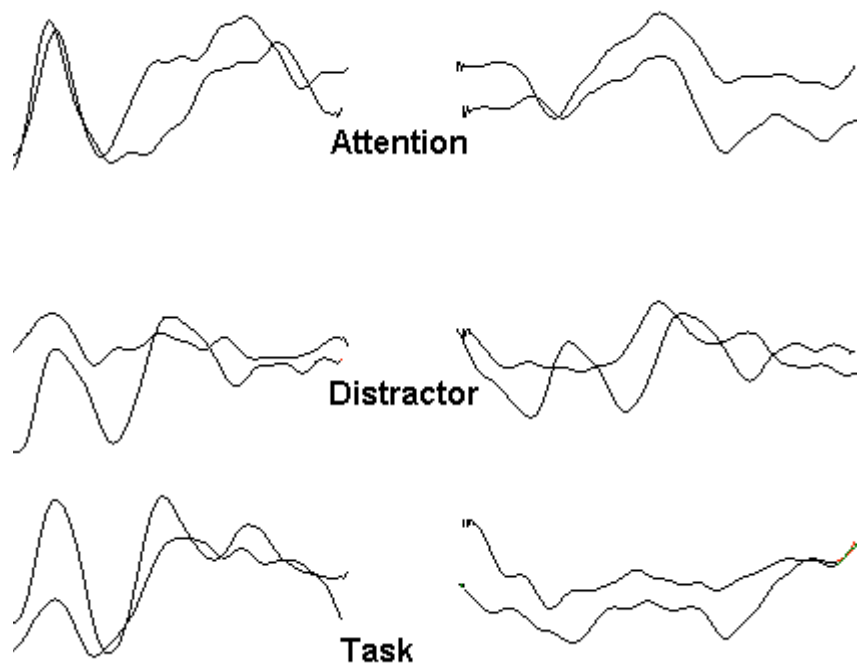
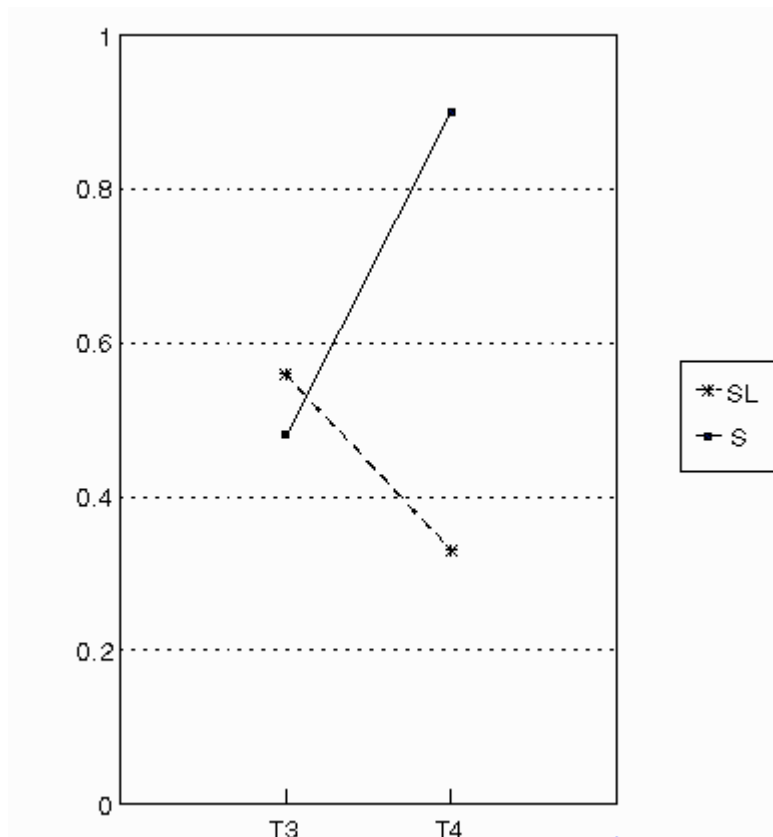


Fig 2: Probe AEP from a subject of group SL. Here the greatest attenuation occurs in the linguistic task over T4 (bottom right).



**Fig 3: Mean attenuation over T3 and T4 in groups S and SL, showing the opposite effects of linguistic task over the side of maximal attenuation.**

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