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Preliminary Investigations Into the Effects of Changing the Attentional Target on Left Hemisphere Function in Aphasic Patients

Marilyn Selinger and Thomas E. Prescott

The relationship between attention and aphasia has enjoyed increased discussion in the past decade (McNeil, Odell, & Tseng, 1991; Peach, Rubin, & Newhoff, 1994). Although attention is believed to be involved in multiple processes in the central nervous system, it is generally accepted as a process of selection. Attention can be defined as the selection of a specific type of sensory information on which to focus, with a concomitant reduction or elimination of concentration on other impinging sensory information (Robinson & Petersen, 1986).

In an elegant discussion calling for the integration of attention and resource allocation theory with concepts of aphasia, McNeil et al. (1991) suggest that aphasia is more than a disruption in specific attributes of language. They propose that aphasia might result from decreased abilities in arousing and directing processing energy to the task at hand. The notion that aphasia may be a deficit in attention and resource allocation should provoke further research.

Attention can be examined by presenting a test manipulation and observing either overt behaviors or changes in brain activity that result from it. The evoked potential paradigm presented in this chapter attempts to answer questions concerning aphasic patients' changes in brain activity resulting from differences in instructional set.

For the most part, evoked potential studies designed to test hemispheric changes in brain activity have used tasks defined as consistent with the processing styles of each hemisphere. The left hemisphere has been found to process information in a sequential or analytical manner (e.g., language). The right hemisphere has been found to process information in a holistic manner (e.g., music). Consequently, music and language are presented to the subjects and resulting asymmetries are measured (Brown, Marsh, & Smith, 1976; Friedman, Simpson, Ritter, & Rapin, 1975; Shucard, Shucard, & Thomas, 1977).

The evoked potential technique reported here, known as a probe paradigm, involves imposing a task-irrelevant sensory stimulus on an ongoing complex task. Conclusions are subsequently drawn about the hemisphere most involved in the complex task based on each hemisphere's response to the irrelevant probe. Assumptions of this paradigm are based on the notion that the brain is a limited capacity system; that is, the brain is limited by more than structure in the number of things it can do at one time, and increasing the demand of a task causes some performance deterioration. Such degradation of performance may result from the brain's reduced attentional allocation for the task.

Task demand has been compared to the attentional allocating abilities for the individual (Allen, 1983; Crossley & Hiscock, 1987). A task that requires a great deal of effort also requires the allocation of increasing amounts of processing resources. A task that is simpler or more familiar requires less attention (Crossley & Hiscock, 1987) and decreased resources. Laterality differences using evoked potentials may be related to the effort required to complete the task. A severely impaired aphasic patient may need increased effort for language processing, whereas a less impaired patient may use less effort to perform language tasks. It is suggested that when the amount of attention needed for the task surpasses the capacity of the specialized hemisphere, additional processing is shifted to the other hemisphere.

Using a directed attention task, Thomas, Shucard, and Selinger (1980) and Thomas and Shucard (1983) tested the hypothesis that interhemispheric asymmetries change as a function of the instructional set given to the subject, even though the physical properties of the stimuli are held constant. They hypothesized that holding the stimuli constant and varying the instructions to the subject may result in cerebral asymmetries based on the subjects' attention to the stimuli and the resulting specialized processing style they apply to the task. In the Music condition of these studies, subjects received ongoing classical musical passages with irrelevant superimposed tone pairs. The subjects were instructed to ignore the tones, listen to the music, and identify recurring melodies within the music. In the Tones condition (where the stimuli were identical to the music condition), the subjects were instructed to ignore the music and to count various sequences of pairs of tones; the tones thus were no longer irrelevant to the task.

Using this paradigm, the results with normal subjects indicated that the pattern of interhemispheric activation when the subjects ignored the tones differed from when they counted the tones. In the Tones condition, the evoked potential amplitude response was larger over the left hemisphere. In the Music condition, either there was no hemisphere differentiation, or the amplitude response was larger over the right hemisphere.

The purpose of the present study was to determine whether left-hemisphere-damaged patients exhibit hemispheric asymmetries when the relevant targets in a task are changed through instructional set while the stimuli themselves remain constant.

The study addressed the following specific questions:

1. Is there an interhemispheric amplitude asymmetry change between conditions as subjects change their problem-solving strategies for each task?
2. Is there an intrahemispheric amplitude asymmetry change between conditions as subjects change their problem-solving strategies for each task?
3. Are there hemispheric or task differences in the latencies of the evoked potential responses?

METHOD

Subjects

The aphasic patients studied were 5 premorbidly right-handed males (as measured by the Handedness Questionnaire [Raczkowski, Kalat, & Nebes, 1974]) between the ages of 60 and 64 (x = 61.7; SD = 1.67) whose only episode of hemisphere damage was on the left side. Table 1 shows results for *Boston Severity (Boston Diagnostic Aphasia Examination)* (Goodglass & Kaplan, 1972) and the *Porch Index of Communicative Ability* (PICA) (Porch, 1967).

Procedure

To examine effects of changing instructional set on hemispheric response to the same stimuli, two conditions were given to each aphasic subject. The stimuli consisted of five classical music pieces with simple recurring melodies. In the Music condition, subjects were instructed to listen to the music and identify the presence of a recurring melody while ignoring the tones. In the Tones condition, subjects were instructed to ignore the music and count the tone pairs in the recurring sequence of two pairs, three pairs, then four pairs.

Table 1. Subjects' Age and Test Result Data

Subject	*Age (years)*	*PICA[a] Overall*	*PICA[a] VI*	*PICA[a] X*	*Boston Severity*
1	60	89	74	73	4
2	64	88	99	99	4
3	62	97	99	99	4
4	60	92	99	99	5
5	62	65	99	99	2

Note: PICA scores are reported as percentiles.
[a]*Porch Index of Communicative Ability.*
Boston Severity from *Boston Diagnostic Aphasia Examination (BDAE).*

A third condition was added as a comparative measurement of hemispheric response to language. The Verbal condition consisted of several short stories with irrelevant tone pairs superimposed on the passage. Subjects were instructed to identify a recurring word within a story.

During each task the subject was seated in a sound-attenuated, electrically shielded room. The subjects kept their eyes closed during each 3-min segment. The subjects were instructed to listen to each stimulus and to respond by exhaling through their nostrils each time a recurring word occurred in the verbal task or a recurring melody occurred in the music task and at the correct series of tone pairs in the tones task. A specified key word, melody, or tone sequence was presented to the subjects prior to the onset of the appropriate segment. In addition, two multiple-choice questions were asked following each verbal segment. These behavioral tasks were used as indicators of the subjects' alertness and their understanding of and ability to perform the task. Each target item occurred 6 to 14 times within each segment.

Approximately 20 pairs of 600-Hz, 100-msec tones with an interstimulus interval of 2 sec and an interpair interval of 4 to 6 sec were superimposed on each musical selection. The AEPs were recorded from T4-to-Cz and T3-to-Cz electrode placements (Jasper, 1958) during all three conditions. Grass gold-plated disk electrodes were affixed to the scalp sites. Impedances from each electrode were measured at the beginning and end of each session; none was greater than 5 kΩ.

Auditory AEPs were averaged online and separately for Tone 2 of each pair as the subjects performed the tasks. The number of measurements of evoked potentials to the second tone of the pair ranged from 55 to 80 across subjects.

A Modular Instruments Signal Averaging system, interfaced with an AMDEC computer, generated the tones and averaged and scored the data. Microvolt amplitude and msec latency scores were obtained for each subject on the AEP component known as N2, a negative-going peak with a mean latency of 294 msec. This peak tends to represent processing of information in more associative stages. N2 has previously been found to be most sensitive to hemisphere asymmetries reflecting higher or later cortical processing (Shucard et al., 1977; Shucard, Cummins, Thomas, & Shucard, 1981).

RESULTS

Our first two questions referred to inter- and intrahemispheric amplitude differences in the three conditions. Because of the preliminary nature of this investigation and its application to only five subjects, we used descriptive statistics to examine differences in mean latencies and mean amplitudes between tasks and hemispheres.

We compared the latencies (time of occurrence) between the tasks and the hemispheres for N2. The mean latency across tasks for N2 in the right hemisphere was 297 milliseconds; for the left hemisphere it was 292 milliseconds. Mean latencies for the tasks described by hemisphere are shown in Table 2.

Amplitudes in microvolts for each hemisphere and each task were also examined; these measurements are believed to represent the amount of activation or involvement in each task. Figure 1 represents the differences between the hemispheres on the verbal task. The right hemisphere exhibits a larger response to the task than does the left hemisphere. Figure 2 illustrates the differences between the hemispheres on the tones task. In this task, the left hemisphere is characterized by a larger response than the right hemisphere's. Figure 3 represents the differences between the two hemispheres for the music task. There were no hemispheric differences in responses to this task.

Table 2. Millisecond Results for Peak 3

Task	*Right Hemisphere*	*Left Hemisphere*
Verbal	287 msec	293 msec
Tones	301 msec	294 msec
Music	304 msec	288 msec

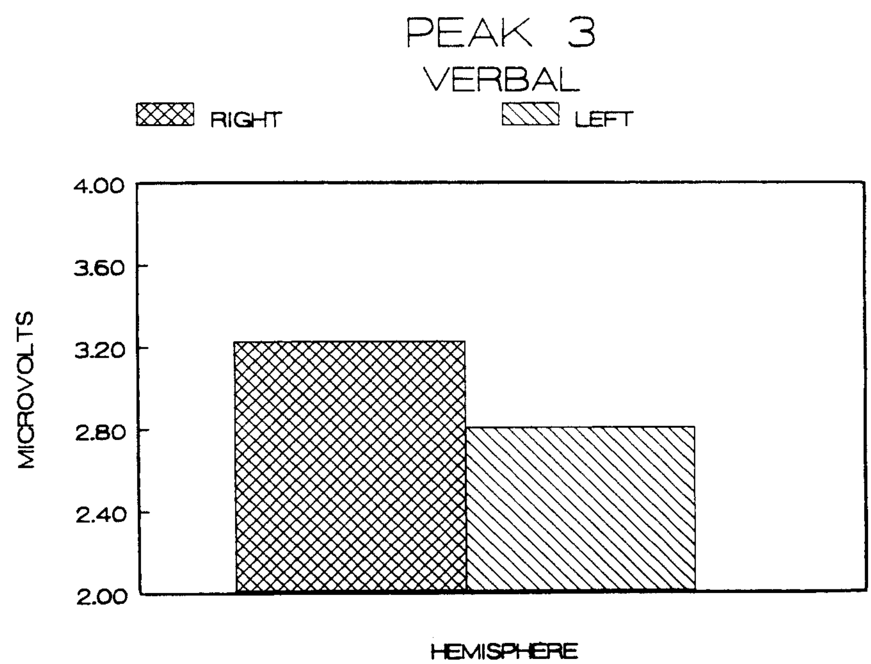

Figure 1. Differences in microvolt amplitudes between the right and left cerebral hemispheres as measured from bipolar temporal to Cz leads on the Verbal task.

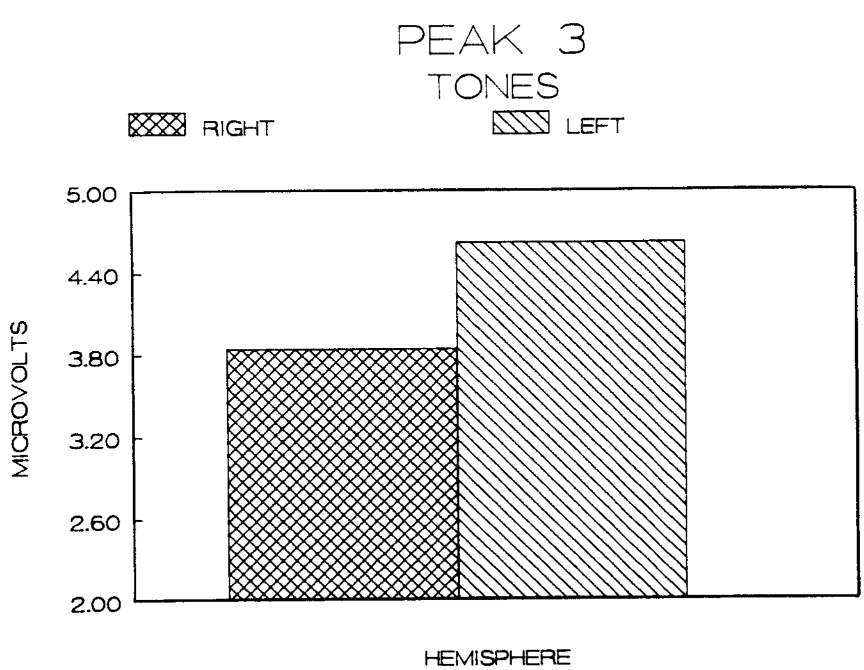

Figure 2. Differences in microvolt amplitudes between the right and left cerebral hemispheres as measured from bipolar temporal to Cz leads on the Tones task.

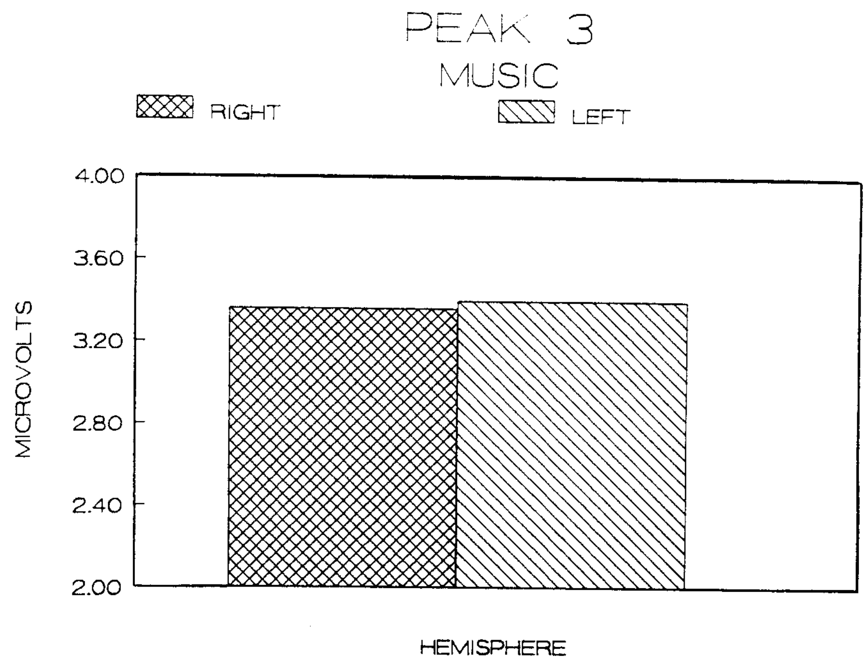

Figure 3. Differences in microvolt amplitudes between the right and left cerebral hemispheres as measured from bipolar temporal to Cz leads on the Music task.

DISCUSSION

The purpose of this study was to establish some preliminary data about the effects of varying instructional set on differential hemispheric involvement as measured by auditory evoked potentials between right and left hemisphere temporal sites. We attempted to measure a change in hemispheric involvement by presenting the same ongoing stimuli to the aphasic patients but directing their attention to different aspects of those stimuli.

When the aphasic patients were instructed to attend to classical music and ignore the superimposed tones, there was no differential hemisphere activation to the task in N2 data. This finding is consistent with previous findings on the music task, with both aphasic and normal subjects exhibiting no strong hemispheric differentiation for this task.

When the aphasic patients were attending to and counting sequences of tone pairs and ignoring the ongoing music, N2 indicated a difference in hemispheric response. That is, aphasic patients showed a higher left hemisphere response during the tones task. The results from the tones task are consistent with previously reported results using this paradigm with normal adults. To obtain a comparative measurement of left hemisphere function during verbal tasks, a language task was also presented to each subject. This task did not use the same stimuli as those reported in the music and tones tasks. The findings indicated that, when our aphasic patients were attending to verbal material and ignoring superimposed tones the right hemisphere showed a higher amplitude response than did the left hemisphere. The findings for the verbal task reflect the results previously reported by Selinger, Shucard, and Prescott (1980) and by Selinger, Prescott, and Shucard (1989). Of particular significance was the relatively larger right hemisphere response that occurred during the processing of verbal information in the aphasic group.

The aphasic patients in this preliminary investigation exhibited changes in the amount of hemispheric activity based on directing attention toward different facets of the same stimuli. Therefore, the required strategy and level of difficulty for accomplishing the task at hand seem to have affected which hemisphere's resources were allocated toward the solution.

Intrahemispheric activity in these aphasic patients was characterized by more variability of responses in the left hemisphere. This is consistent with behavioral observations concerning the variability in aphasia. The left hemisphere exhibited differential specialization of function on the two left-hemisphere-style tasks. This differential function suggests the left hemisphere to have a greater involvement than the right during the counting task and the right to have a greater involvement than the left during the verbal task. Counting is often classified as an overlearned function or more automatic task; thus, it should be easier than processing connected language. This finding suggests that the damaged left hemisphere in aphasic patients is able to respond within normal limits to tasks that are sequential or analytical but do not necessarily place a high task demand on processing complex language. It appears that, when task demand is reduced, attentional allocation of resources does not reach its limit and performance deterioration or shift to other resources is unnecessary.

Our previous findings using the stimuli of language and music had led us to the conclusion that the right hemisphere in aphasic patients had a larger response to language than the left. This conclusion raised the following question: Is the right hemisphere showing increased activation to language, or are we actually seeing that the left hemisphere is unable to respond to the stimuli because of the damage in the left hemisphere?

These data suggest that our aphasic patients exhibited increased activation in the left hemisphere when processing information in a predominately sequential or analytic task (e.g., counting in sequence). The left hemisphere, therefore, was not unable to respond, but it might have been limited in its response according to the increasing complexity or difficulty of the language material. When the task demand fell heavily into verbal processing, the left hemisphere exhibited reduced processing of the information. It appears that our earlier conclusions concerning reduced performance abilities in the left hemisphere may be supported by these data, in that they indicate that the left hemisphere does process left-hemisphere-style tasks that are not heavily loaded toward language. These results imply that directing attention toward tasks at appropriate levels of difficulty may bias the left hemisphere, thereby allowing for practice and use of the left hemisphere's abilities.

Finally, these findings also suggest that our aphasic patients were able to attend appropriately to the directed task in a manner similar to normal subjects. However, it should be remembered that this was a directed attention task and not a dual-task paradigm; that is, it involved attending to one type of target without a concurrent task requirement. It is possible that had we increased the difficulty or complexity of an attention task, our aphasic patients would have exhibited a deficit response pattern. However, this possibility simply reiterates the necessity of attending to the level of task demand when drawing conclusions about behavioral and neurophysiological deficits in aphasic patients.

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