Neuroelectric Correlates of Hemispheric Asymmetry: Spectral Discrimination and Stimulus Competition

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Abstract  
In an effort to explore further the role of the right hemisphere in auditory processing, this study utilized brain event-related potentials (ERPs) to investigate hemispheric asymmetry for the processing of complex spectral tones. Subjects participated in two pitch discrimination tasks, one diotic, the other dichotic. ERP components were recorded from 28 electrodes on the scalp and analyzed via individual/group average area measurements. Results showed that ERPs recorded in response to the dichotic target pairs exhibited a larger P3 area when the target tone was presented to the left ear, while the N1 area showed no significant difference. ERPs recorded in the diotic condition showed a larger P3 area and smaller N1 area compared to the dichotic conditions. Finally, all experimental tasks showed that topographic hemispheric activation patterns were asymmetric to the right hemisphere. Findings support the notion that ERP topographic asymmetries may be dependent on specific cognitive task demands (e.g., diotic vs. dichotic modes of presentation). In addition, the data suggest that the P3 component may better reflect interaural advantages for complex tones than the N1 component and may, therefore, be a more sensitive indicator of hemispheric specialization.

Key Words: N100, P300, ear advantage, interhemispheric processing, laterality

Abbreviations: REA = right-ear advantage; LEA = left-ear advantage; ERP = event-related potential; GFP = global field power; VEOG = vertical electro-oculographic activity; DIO = diotic; DIC = dichotic; CT = complex tone

Sumario  
En un esfuerzo por explorar adicionalmente el papel del hemisferio derecho en el procesamiento auditivo, este estudio utiliza potenciales cerebrales relacionados con el evento (ERP) para investigar la asimetría hemisférica ante el procesamiento de tonos espectrales complejos. Los sujetos participaron en dos tareas de discriminación subjetiva del tono, una diótica y la otra dicótica. Los componentes del ERP fueron registrados a partir de 28 electrodos en el cráneo y analizados a través de mediciones promedio de área, tanto individuales como grupales. Los resultados mostraron que los ERP registrados en respuesta a los pares dicóticos exhibieron un área P3 mayor, cuando el tono meta era presentado al oído izquierdo, mientras que el área N1 no mostró diferencia significativa. Los ERP registrados en la condición diótica mostraron un área P3 mayor y un área N1 más pequeña, en comparación con las condiciones dicóticas. Finalmente, todas las tareas experimentales mostraron que topográficamente, los patrones de activación hemisférica fueron asimétricos con respecto al hemisferio derecho. Los hallazgos apoyan la noción de que
It has been well established that specific dichotic auditory tasks yield perceptual interaural asymmetries in normal participants. Specifically, there is a right-ear advantage (REA) for the processing of linguistic stimuli (Kimura, 1961) and a left-ear advantage (LEA) for the processing of nonlinguistic stimuli (Yund and Efron, 1975). Ear advantages have been interpreted as indicators of hemispheric specialization due to the structural advantages resulting from the prepotence of crossed auditory pathways (Kimura, 1967; Bryden, 1988; Hellige, 1993).

For example, Sidtis and Bryden (1978) and Sidtis (1981) showed that the LEA for pitch discrimination was the complement of the right-ear advantage (REA) for speech syllables in normal adults. In other words, in a complex tone task, dichotic stimuli compete for access to a right-hemisphere processor in a fashion analogous to the competition between dichotically presented speech sounds for access to the left-hemisphere processor.

Research on right-hemisphere dominance (or LEA) for nonlinguistic stimuli has been recently addressed with neuroimaging techniques. Zatorre and Belin (2001) used PET imaging to investigate auditory cortical responses to spectral and temporal variation. Findings showed that responses to spectral features were weighted toward the right hemisphere, while responses to temporal features were weighted toward the left hemisphere. This provides evidence that the right hemispheric cortical belt areas of the auditory cortex (i.e., anterior superior temporal gyrus) may be specialized for spectral, and thus complex, pitch perception (for a more detailed description, see Zatorre et al., 2002).

The LEA phenomenon has also been investigated in ERP studies. For example, Tenke et al. (1993) recorded the ERP activity to a dichotic complex tone task in normal adults. Findings showed that subjects with a strong LEA had greater late positivities (P350 and P550) in the ERP over the right hemisphere, which related to analogous behavioral asymmetries. In a study conducted by Kayser et al. (1998), subjects heard complex tones binaurally. Findings revealed hemispheric asymmetries to tonal stimuli for ERP component amplitudes, suggesting that ERP topographies can reveal hemispheric lateralization in the processing of nonlinguistic stimuli.

The nature of the experimental paradigm is an important factor in the investigation of the neural substrates of hemispheric specialization and interhemispheric processing. Although there have been relatively few ERP studies of this issue, behavioral studies have shown that the degree of competition between ipsilateral and contralateral information can significantly affect the magnitude of perceptual asymmetry (Sidtis, 1981). Recent neuroimaging studies have begun to provide some insight into this issue. For example, an fMRI study by Hashimoto et al. (2000) investigated brain activation to diotically (same signal to the two ears) and dichotically (different signals to the two ears) presented speech sounds. These investigators showed...
that diotic and dichotic presentation can evoke different levels of activation. Moreover, they suggest that these activations may represent differences in the amount and kinds of processing required to perform each type of task (diotic vs. dichotic). In another study, Wioland et al. (1999) studied ERP responses elicited by both dichotic and diotic pairs of pure tones. Results showed that ERP responses to dichotic as compared to diotic target pairs showed longer latencies for both the N2 and P3 components. In sum, both ERP and functional imaging studies dealing with modes of stimulus presentation and hemispheric asymmetry show differential levels of activation between diotic and dichotic modes of presentation. Dichotic presentation of stimuli appears to reinforce lateralizations, yet the exact nature of the mechanisms involved remains unclear. Whether these effects are the result of attentional load/factors or cognitive load/factors has yet to be elucidated.

In the auditory domain, hemispheric specialization can be quantified by ERP studies in two ways, by degree of interaural asymmetry and by degree of asymmetry in hemispheric topography. The purpose of the present study was to investigate both interaural asymmetry (i.e., the LEA) and asymmetry of hemispheric topography when both dichotically and diotically nonlinguistic stimuli were presented to normal adult subjects. We sought a better understanding of the processes underlying interaural and hemispheric asymmetries during spectrally complex tone discrimination. In addition, we sought to evaluate the effect of experimental paradigm.

**METHOD**

**Subjects**

Subjects for the study consisted of 15 adult volunteers, six males and nine females, ages 19–33 years (mean 26.3, SD 5.4) from the undergraduate student body of the University of Texas at Dallas. All subjects were native speakers of English, revealed no history of neurological or otological illness, and were right-handed as determined by a standard Hand Preference Questionnaire (Annett, 1970). Since previous studies have shown that levels of musical proficiency can affect performance in complex tone paradigms (cf. McRoberts and Sanders, 1992), no subject for this study had more than two years of formal musical training. All subjects passed a hearing screen at 20 dB HL over the frequency range from 500 to 4000 Hz. Informed consent was obtained from all subjects in accordance with University of Texas at Dallas guidelines.

**Equalization of Presentation Levels**

In order to ensure that stimulation was equivalent at the two ears, we determined the interaural intensity ratio that produced sound localization in the median plane. Accordingly, each subject underwent a spatial auditory localization test based on the procedure described in Greenwald and Jerger (2001). A spectrally complex tone was presented from the right loudspeaker at 50 dB SPL. The presentation level from the left loudspeaker was then systematically varied in steps of 2 dB over a 22 dB range, according to a quasirandom sequence. At each level, the complex tone was presented three times. The participant was instructed to indicate the position of the perceived sound in intracranial space. Median plane localization was defined as the midpoint of the range between consistently right-sided and consistently left-sided judgments.

**Test Stimuli**

Participants completed several auditory tasks that were based on the Complex Tone Test (CTT) of Sidtis (1980). The spectrally complex tones (CT) were square waveforms with fundamental frequencies corresponding to six notes in the octave between C4 and C5 on the major scale. This includes C4 (264 Hz), D (297 Hz), E (330 Hz), F (352 Hz), G (396 Hz), and A (440 Hz). Complex tones were generated by the Cool Edit Pro software package (Syntrillium Software Corp.), at a 22,050 Hz sampling rate. Tones were 250 msec in duration, with rise-decay times of 20 msec.

**Recording System**

Electroencephalographic (EEG) activity was recorded from 28 scalp locations, using silver/silver-chloride (Ag/AgCl) electrodes attached to an elastic cap (Neuromedical Journal of the American Academy of Audiology/Volume 14, Number 8, 2003
Supplies Inc.) and a Neuroscan amplifier/stimulator with the Neuroscan recording software. Eye movements and eye blinks were monitored via two electrodes, one positioned medially above the left eye and one at the outer canthus of the left eye. All 28 channels of EEG were referenced to linked mastoid electrodes. Individual sweeps of EEG activity, time-locked to the stimuli, were stored for off-line analysis. Each sweep was initiated by a trigger placed at the onset of each probe tone. The stored epoch encompassed 1200 msec (including a 200 msec prestimulus baseline) relative to stimulus onset. All electrodes impedances were below 5 kΩ. Ongoing EEG activity was amplified, analog filtered from .15 to 70 Hz (1 to 100 Hz for the VEOG channel), and then digitized through the Neuroscan acquisition interface system.

Continuous analog-to-digital conversion of the EEG and stimulus trigger codes was performed on-line by the Neuroscan acquisition interface system. Signal averaging was conducted after off-line artifact rejection and baseline correction. Individual epochs were examined and rejected whenever electrical activity in either VEOG channel or the frontal channels (FP1, FP2) exceeded ±50 µV. Successfully averaged evoked-potential waveforms were then digitally low-pass filtered with zero phase-shift at 20 Hz with a filter slope of -48 dB per octave in order to remove ambient electrical noise and muscle artifact. In addition, epochs from each electrode site were baseline corrected by subtraction of the average prestimulus voltage data points. Finally, topographic brain maps of the ERPs were constructed via interpolation of voltages between adjacent electrodes, using a four-point linear-interpolation algorithm. The resultant voltage matrix was then assigned colors to represent the range of observed voltages.

Procedure

The participant was seated comfortably in a medical examining chair. Target stimuli were delivered from two phase-matched loudspeakers at ear height and 1.5 meters to either side of participant’s ears. A 48.3 cm computer screen, placed at eye level 2.2 meters in front of the subject, presented directions pertaining to the procedure.

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<thead>
<tr>
<th>Procedure</th>
<th>S1</th>
<th>S2</th>
<th>Response</th>
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<tr>
<td>LE</td>
<td>440 Hz</td>
<td>440 Hz</td>
<td>“Ye” or “Same” or “Match” Judgment</td>
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<tr>
<td>RE</td>
<td>440 Hz</td>
<td>352 Hz</td>
<td>“No” or “Different” or “Mismatch” Judgment</td>
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**Figure 1** The Complex Tone Test (CTT) paradigm and the S1-S2-R design in the DIOTIC condition. Upper panel illustrates a “match.” Lower panel illustrates a “mismatch.”

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**Figure 2** The Complex Tone Test (CTT) paradigm and the S1-S2-R design in the DICHOTIC condition. Upper panel illustrates a “match” for a left-sided target. Lower panel illustrates a “mismatch.”

The participant performed two different tasks: (a) a diotic pitch discrimination task (DIO—see Figure 1) and (b) a dichotic pitch discrimination task (DIC—see Figure 2). With the exception of the mode of stimulus presentation (diotic vs. dichotic), the overall testing procedure was the same for all tasks and followed a basic S1-S2-R design. In this paradigm a reference signal (complex tone or CT) is followed by a probe signal (CT). The participant’s task is to decide whether the pitch of the probe CT matches the pitch of the reference CT. In the present study, the reference CT was always presented diotically. It was followed, after a 2 sec interval, by the probe CT. The probe CT was either presented diotically (DIO) or dichotically (DIC). In the
DIO condition, the probe CT pair was either the same as, or different from, the reference CT pair. In the DIC condition, one member of the probe-CT pair was either the same as the reference CT pair, or neither probe CT matched the reference CT pair. Participants were instructed to press a response button, labeled “yes,” when the probe CT matched the reference CT and another response button, labeled “no,” if there was no match. The advantage of this design is that it avoids the serial position effects and lengthy stimulus presentations involved in other types of dichotic tasks. Thus, the S1-S2-R paradigm allows more trials per unit time and reduces confounding strategy effects inherent in other designs (Bryden, 1988). Trials were arranged in six 25-trial blocks. In each block, half of the reference stimuli matched a member of the DIC or DIO probe. In the DIC task there were equal numbers of left (DIC-L) and right (DIC-R) targets. Two practice blocks (both DIC and DIO) were also included for each condition to familiarize the participant with the task. Finally, accuracy score data were collected during ERP testing to ensure that the participants understood and were able to perform the tasks.

Data Analysis

Since the latency of the P3 peak can vary widely across subjects, which in turn can attenuate the P3 peak and introduce latency jitter (Kok, 2001), individual averaged waveforms were subjected to measurement of area (amplitude integrated over a specified time interval) between waveform and baseline. Area computation uses the extended trapezoidal rule to estimate area under the curve. That is, it sums all points except the two endpoints (which are given half-weight), and multiplies them by the sampling interval. Area measures were made over the 300 to 900 msec latency range for the P3 component, and over the 50 to 150 msec latency range for the N1 component for all conditions. These latency ranges were chosen to ensure capture of the maximal component peaks for each individual and for group averages. Inspection of the grand-averaged waveforms showed that the maximal peak of the N1 response was at the CPZ electrode for all conditions, while the maximal P3 peak was at the CP4 electrode for the DIC-R/DIC-L conditions, and at CPZ for the DIO condition.

For each subject and each condition, two waveforms were available; the waveform corresponding to a “match” or judgment that the reference and probe CTs were the same, and the waveform corresponding to a “mismatch” or judgment that the reference and probe CTs were not the same. In this article, data analysis is confined to “same” or “match” judgments. Statistical significance was evaluated at an alpha error level of 0.05.

RESULTS

Comparison of Diotic and Dichotic Experimental Tasks

Figure 3 shows the grand-averaged ERP waveforms comparing the DIO and DIC-R/DIC-L conditions at the CPZ electrode. Two-tailed paired t-tests were conducted for the P3 (300–900 msec) area measures at the CPZ electrode between the DIO and DIC-R/DIC-L conditions. Statistical analysis revealed that the P3 area in the DIO condition was significantly larger than the areas in both the DIC-R condition (t[14] = 3.72, p < 0.01) and the DIC-L condition (t[14] = 2.0, p = .05). Statistical analyses were also conducted for the N1 (50–150 msec) area measures among the DIO, DIC-R, and DIC-L conditions at the CPZ electrode. Two-tailed paired t-tests revealed that the N1 area in the DIO condition was significantly smaller than in either the DIC-R condition (t[14] = 5.72, p < 0.01) or the DIC-L condition (t[14] = 4.32, p < 0.01).

Figure 3  Grand-averaged waveforms for DIO, DIC-R, and DIC-L conditions at electrode CPZ.
**Interaural Asymmetry**

Figure 4 shows the grand-averaged ERP waveforms comparing the DIC-R and DIC-L experimental conditions at the CP4 electrode. Two-tailed paired t-tests were conducted for the P3 (300–900 msec) area measures between the DIC-R and DIC-L conditions at the CP4 electrode. Statistical analysis revealed that the P3 area in the DIC-L condition was significantly larger than the P3 area in the DIC-R condition ($t(14) = -2.14$, $p = 0.05$). No significant difference was found for the N1 area between the DIC-R and DIC-L conditions ($t(14) = -0.31$, $p > 0.05$).

**Interhemispheric Asymmetry**

In order to evaluate interhemispheric asymmetry, area measures were created for both group- and individual-averaged waveforms. Area measures for this portion of the analysis were made in two stages. In the first stage, the grand-averaged waveforms were used to obtain the area between waveform and baseline at 200 msec intervals across the latency range from -200 msec to 1200 msec for each experimental task. These areas were computed from the grand-averaged waveforms at the centro-parietal (CP4-CP3), parietal (P7-P8), and temporoparietal (TP8-TP7) electrode sites. Next, the right hemisphere area measure was subtracted from the left hemisphere area measure in order to derive an index of interhemispheric asymmetry. Thus, a negative difference would indicate greater positivity on the right-hemisphere electrodes.

The purpose of the stage 1 analysis was two-fold; first, to verify that asymmetry was maximal at the latency interval corresponding to maximal positivity of the event-related potential waveform; second, to ascertain the electrode site yielding greatest asymmetry in each of the conditions. This analysis revealed that the maximal hemispheric asymmetry appeared at the centro-parietal (CP4-CP3) electrode site. Since the purpose of the stage-1 analysis was solely an exploratory search for the electrode site yielding maximal asymmetry, no statistical analyses of these data were carried out.

In the second stage of data analysis we calculated, from individual-participant waveforms, the area between waveform and baseline over the interval from 300 to 900 msec. This interval was selected to ensure that area measures would cover the range of evoked event-related activity of the electrodes that yielded the maximal hemispheric asymmetry in stage 1. In addition, area was calculated separately for target-right and target-left (in the two DIC conditions) and in the DIO condition. Two-tailed paired t-tests were conducted for the P3 (300–900 msec) area difference measures among all three experimental conditions at electrode CP4, the right-hemisphere member of the electrode pair (CP3-CP4) yielding the highest hemispheric asymmetry for all individual waveforms. This analysis revealed a significant difference between the DIO vs. DIC-R condition ($t(14) = -2.97$, $p = 0.01$). The results of the stage 2 analyses of individual subject waveforms in all experimental conditions are summarized in Figure 5. The data are mean area differences ($\mu$V/msec)

**Figure 4** Grand-averaged waveforms for DIC-R and DIC-L conditions at electrode CP4.

**Figure 5** Results of stage-2 area analysis. Mean area differences (left minus right) of hemispheric asymmetry over the latency range from 300 to 900 msec in all experimental conditions. Data are based on individual waveforms at the electrode site yielding maximal asymmetry in the stage-1 analysis.
between the two hemispheres over the latency range from 300 to 900 msec. The bar graphs show the difference between left and right hemisphere areas at the electrode site showing maximum asymmetry in the stage-1 analysis. Importantly, results are plotted separately for all experimental conditions. Clearly, all conditions show a marked asymmetry favoring the right hemisphere.

Global Field Power (GFP) and Topographic Maps

In order to construct topographic brain maps at the peak latency of the ERP, the peak latencies of the ERP responses were first determined using grand-averaged global field power waveform computation. Global field power (GFP) is a measure defined as the standard deviation across multiple channels as a function of time within a sample interval (Skrandies, 1989, 1990). The purpose of GFP is to quantify the instantaneous global activity across the spatial potential field sampled over the scalp. The result of the GFP analysis is a waveform that characterizes the temporal changes in the GFP, and the resultant peaks reflect a maximum of the total underlying brain activity that contributes to the surface potential field (Lehmann and Skrandies, 1984). The benefit of using GFP is that it resolves the problem of determining the specific electrode from which to compute latency (cf. Jerger et al, 1995; Greenwald and Jerger, 2001).

Figure 6 shows a typical example of the onset of the hemispheric asymmetry (shown is the DIC-L condition). Note that positivity begins at the central location of the scalp, then shifts gradually toward the right hemisphere. A similar shift in the activation pattern was observed in all experimental conditions.

Figure 7 shows the topographic brain maps at the positive peak of the GFP waveform (Bivalent color scale) comparing the DIO and DIC-R/DIC-L conditions. Note that, in all conditions, the topographic distribution of the response is clearly in the direction of the right hemisphere in the region of the centro-parietal electrode. This agrees with the result of the stage-1 analysis of the hemispheric asymmetry analysis, which showed the maximal hemispheric asymmetry to be at the centro-parietal (CP4-CP3) electrode site for these conditions.

Symmetry of Median-Plane Localizations

It is appropriate to ask whether the hemispheric asymmetries in any group might be the result of systematic asymmetries in the intensity levels of the spectrally complex tones at the two ears, resulting from the initial procedure defining median-plane localization. To investigate this possibility in each subject, calculations of the deviation from physical equality of the presentation levels were made from the two loudspeakers by subtracting the level at the right side

![Figure 6](image6.png)  
**Figure 6** Topographic maps at the latency defined by the peak of the grand-averaged GFP waveform for the DIC-L condition in the latency range of 170 to 400 msec, depicting the onset of hemispheric asymmetry. View is from above. Nose is at top of each map. Right side of brain is at right side of each map. Positivity is coded by red colors, negativity by blue colors.

![Figure 7](image7.png)  
**Figure 7** Topographic maps at the latency defined by the peak of the grand-averaged GFP waveform for the DIO, DIC-L, and DIC-R conditions. View is from above. Nose is at top of each map. Right side of brain is at right side of each map. Positivity is coded by red colors, negativity by blue colors.
the level at the left side. In no participant did the mean deviation exceed 1.53 dB.

**Behavioral Scores**

Table 1 summarizes the mean accuracy scores of the participants for each task. A Friedman $X^2$ test was performed between the DIC-R, DIC-L, and DIO-S tasks. Across all participants, the accuracy scores for matching probe tones to reference tones were significantly higher ($p < 0.001$) in the DIC-L condition than the DIC-R condition. Due to ceiling effects, no other statistical analyses were performed on the behavioral scores.

**DISCUSSION**

The results of the present study replicate previous findings in showing a behavioral asymmetry (the LEA) for discrimination of spectrally complex tones (Sidtis, 1981, 1988). More importantly, the behavioral asymmetry was also found to have an electrophysiological correlate, namely the area difference in the P3 component between the DIC-R and DIC-L conditions. Specifically, the P3 area measure in the DIC-L condition was larger than the P3 area measure in the DIC-R condition. Such interaural differences in ERPs have not been previously demonstrated (Tenke et al, 1993; Wioland et al, 1999). If the amplitude/area of the P3 component is proportional to the discriminability of the target stimulus (Kok, 2001), then the present results demonstrate better discriminability of left-sided, as compared to right-sided, targets. In contrast, data from the DIC-R and DIC-L conditions showed no difference in the N1 component, thus indicating that early sensory attentional processes do not seem to be related to ear advantages for complex tones. This concurs with other studies of dichotic pitch discrimination that have also found no laterality effect in the N1 component to dichotic complex tones (Tenke et al, 1993; Bruder et al, 1998). The fact that the P3, but not the N1, component showed an LEA can be interpreted as indicating that interaural interference occurs at a later stage of processing than the attentional processes related to the N1 component.

Overall, data from this study seem to suggest that the P3, and not the N1, component may better reflect a laterality effect for complex tones. Moreover, findings imply that ear-advantage may not be affected by early attention as some suggest (Kinsbourne, 1970) but, rather, may depend upon stimulus evaluation, classification, and short-term memory, the three processes that have been shown to modulate the P3 component (for a review see Kok, 2001). The current findings also parallel those of ERP studies using dual visual and auditory tasks (Singhal et al, 2002), visual nonverbal and verbal tasks (Gevins et al, 1995), supporting the notion that these effects may derive from modality-independent, higher-order cognitive processes.

In addition, data from the dichotic conditions showed greater hemispheric activation over the right hemisphere, specifically in the centro-parietal and parietal regions of the scalp. This is in agreement with other studies of complex tone discrimination (Bruder et al, 1998; Kayser et al, 1998) and implies greater mobilization of resources from the right hemisphere in complex tone discrimination tasks. Moreover, this hemispheric asymmetry parallels findings of PET and fMRI studies that have found evidence of enhanced activation of right temporal lobe structures during complex tone discrimination tasks (O’Leary et al, 1996; Zatorre and Belin, 2001). In addition, data from a PET study (Zatorre et al, 1992) has suggested that right temporal lobe regions might be involved in a network for maintaining tonal information in auditory working/ pitch discrimination memory.

In order to evaluate the stage of information processing at which two competing stimuli arriving at the same time...
through separate channels may interfere, the current study compared ERP responses between diotic and dichotic modes of stimulus presentation. Several studies investigating rCBF changes have shown that diotically and dichotically presented stimuli elicit different activation patterns (Coffey et al, 1989; O’Leary et al, 1996). Similarly, the present study also showed differences in ERP responses to mode of presentation. Specifically, the N1 area measure was smaller, and the P3 area measure was larger in the DIO condition as compared to the DIC-R/DIC-L conditions.

The finding of enhanced N1 components in the DIC-R/DIC-L tasks concurs with other ERP data. For example, Wioland et al (1999) also found greater N1 amplitudes in a dichotic listening paradigm. It is not clear, however, whether these effects are the result of attentional factors such as divided attention or the pitch differences between the target and nontarget tones. Although further investigation is warranted, clearly, it has been shown that attention can affect the N1 component (Hugdahl, 1998). Thus, the difference in N1 area between modes of presentation (DIC vs. DIO) in this study may be explained by the difference in attentional load required to perform the two tasks.

Next, the data obtained indicated a larger P3 area measure for the DIO task then for the DIC tasks. This has not been previously shown and contrasts with another study that failed to show a difference in the P3 component in response to diotic or dichotic modes of presentation (Wioland et al, 1999). However, that study may have utilized an insufficiently difficult task (discrimination between high- and low-pitched simple tones) to elicit differences in the P3 response. Clearly, data from this study indicate that differences in the P3 component are dependent on the mode of auditory presentation (DIO vs. DIC).

Since the P3 has been shown to reflect demands of perceptual processing and stimulus discriminability (Kok, 2001), the decrease in P3 area in the dichotic tasks of this study may reflect greater interference by a nontarget at the contralateral ear. However, the P3 response has also been shown to decrease with attentional load (Hillyard et al, 1995; Kok, 2001), so again modulatory influences attributable to attention cannot be ruled out. Thus, results from this study appear to agree with the emerging view that these effects may be composed of cognitive, neuroanatomical, and attentional factors (Springer and Deutsch, 1981; Geffen and Quinn, 1984; Hugdahl, 1998; Asbjornsen and Hugdahl, 1995; Kayser et al, 1998; Wiooland et al, 1999; Hugdahl et al, 2000). Next, the current data also showed a pattern of slight differences in ERP topography between modes of presentation. Aside from the expected hemispheric asymmetry shown for complex tone discrimination (see discussion in previous section), the DIO condition appeared to show a larger degree of hemispheric asymmetry. This concurs with recent PET and fMRI studies, in which different levels of hemispheric activation were shown for diotic and dichotic conditions (O’Leary et al, 1996; Hashimoto et al, 2000).

Thus, the current data imply that ERP topographic asymmetries may be dependent on specific cognitive task demands such as diotic or dichotic modes of presentation.

In summary, this study investigated hemispheric modes of processing. It provides further insight into the neural substrates of hemispheric modes of processing (i.e., the established dominance of right-hemisphere function in nonlinguistic tasks). Moreover, it investigated the extent to which hemispheric asymmetries are present for the earlier ERP components as well as the later ERP complex (i.e., P3), thus providing electrophysiological evidence on the specific stages of processing in which the LEA occurs.

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REFERENCES


