CEREBRAL DOMINANCE FOR LANGUAGE: SOME ASYMMETRICALLY REPRESENTED PERCEPTUAL STRATEGIES

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A THESIS

in

The Department

of

Psychology

Presented in Partial Fulfillment of the Requirements for
the Degree of Master of Arts at
Sir George Williams University
Montreal, Canada

September, 1972

ABSTRACT

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CEREBRAL DOMINANCE FOR LANGUAGE: SOME ASYMMETRICALLY REPRESENTED PERCEPTUAL STRATEGIES

The two experiments in this thesis were designed to press the analysis of what constitutes cerebral dominance for language. The first study required subjects to recall dichotically paired nonsense sequences delivered in two conditions of intonation. Intonated sequences were recalled significantly better than those delivered in a monotone. Also, in both conditions of intonation, the right-ear sequences were recalled better than those delivered to the left ear. This suggested that the cues to grammatical structure provided by intonation enhance left-hemispheric dominance for the processing of phonemic sequences. The second study assessed the perceptual displacement of a click introduced during the presentation of dichotically paired sentences differing in syntactic structure. Only those clicks introduced into normally intonated sentence pairs were systematically drawn to constituent boundaries, and this only occurred for the right-ear sentences. This suggested that the left hemisphere is specialized for analyzing a sentence into its constituent phrases.

ACKNOWLEDGEMENTS

This research was supported by the National Research Council of Canada Grant No. APA-291 awarded to Dr. Edgar B. Zurif.

The author's sincerest thanks go to Dr. Zurif who directed this study for his very generous and helpful advice.

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INTRODUCTION

For over a century, the cerebral hemispheres of man have been recognized as functionally asymmetrical, one hemisphere, usually the left, being specialized, or dominant, for language. However, many questions remain concerning the nature of the lateralized mechanisms serving language. It is to some of these questions that the present thesis is directed.

The concept of hemispheric dominance originated with the observation that a close association existed between damage to the left hemisphere and various language impairments. However, until recently our knowledge about this aspect of human brain functioning stemmed solely from neuroclinical observations. It was not until 1961 that Kimura (1961a) reported the use of a technique permitting the study of hemispheric asymmetry in the normally functioning brain. This technique, termed dichotic listening, involves the simultaneous presentation of different digits to each ear.

Kimura (1961a) found in this competitive situation that normal adults were able to recall more of the digits presented to the right ear than those presented to the left ear. She attributed this lateral difference to the functional superiority of the contralateral auditory pathways over the ipsilateral pathways in transmitting verbal information to the language dominant hemisphere (Kimura, 1961b). This interpretation appears to be well founded. Physiological evidence of stronger contralateral connections in the cat (Rosenzweig, 1951), dog (Tunturi, 1946), and man (Bocca, Calearo, Cassinari, and Migliavacca, 1955) have been demonstrated. Also, confirmation of the superiority of crossed over uncrossed pathways stems from the dichotic listening situation itself. Specifically, when patients with corpus callosectomies were tested, they were unable to report any material from the left ear (Milner, Taylor, and Sperry, 1968; Sparks and Geschwind, 1968). This suggested that material delivered to the left ear in a dichotic listening situation was normally occluded on its ipsilateral path and could only reach the language areas of the left hemisphere by travelling an indirect route: contralaterally to the right hemisphere and then, via the corpus callosum to the left hemisphere.

Dichotic presentation has now become an established technique in the study of hemispheric asymmetry in the intact human brain (Bryden, 1963; Dirks, 1964; Satz, Achenbach, Pattishall, and Fennell, 1965) and has been used to elaborate even further upon the central auditory system in man. For example, special functions of the minor, or right, hemisphere have also been demonstrated using this technique of auditory competition. Recognition of non-speech sounds such as melodies and environmental noises is better for material presented to the left ear than for that delivered to the right (Curry, 1967; Kimura, 1964). Further, when such material is presented to brain-damaged patients, those with right-hemispheric lesions are less impaired than are patients with left-brain damage (Shankweiler, 1966).

The dichotic listening technique has also been used to explore the relationship between cerebral dominance and handedness. In this respect, although a right-ear superiority for verbal material has been reported for predominantly right-handed groups (Curry, 1967; Curry and Rutherford, 1967), left-handed groups show more variability in terms of ear asymmetry (Curry, 1967; Curry and Rutherford, 1967). These findings appear to reflect the fact that handedness is a much better predictor of cerebral dominance for language in right-handers than in left-handers (Milner, Branch, and Rasmussen, 1964; Rossi and Rosadini, 1967). However, work with the dichotic listening technique has not only served to generalize neurological statements, it has been the source of additional information concerning cerebral organization in left-handers. Specifically, Zurif and Bryden (1969) reported that left-handers with no direct familial history of left-handedness are as right-ear dominant as are right-handers, whereas those with a familial history of left-handedness do not show any significant ear superiority. This suggests, of course, that cerebral dominance for language is indeterminate only in familial left-handers, a notion that has since been confirmed by a study of unilaterally brain-damaged patients (Hácaen and Sauguet, 1970).

Perhaps, however, the most important gain accruing to the dichotic listening technique has been in the elaboration of what constitutes the linguistic processes of the left hemisphere. An important finding in this respect is that the engagement of the lateralized language mechanisms is not contingent upon the stimuli being verbally meaningful. Specifically, discrete speech sounds (consonant-vowel and consonant-vowel-consonant syllables) also appear to be processed by the left-hemisphere (Kimura and Folb, 1968; Shankweiler and Studdert-Kennedy, 1967). Moreover, it appears that hemispheric dominance for the processing of phonetic structure is not based on asymmetrical auditory capabilities (Studdert-Kennedy and Shankweiler, 1970). Each hemisphere appears to be capable of extracting the auditory parameters of speech, but only the left hemisphere seems to interpret these auditory patterns as complexes of linguistic features (Studdert-Kennedy and Shankweiler, 1970).

Thus, one aspect of laterality may lay with the phonological information contained in the acoustic structure of speech.

However, the left hemisphere may also have the capacity to extract other levels of language structure. For example, it may be more sensitive than the right hemisphere to the syntactic organization of speech and the acoustic pattern which is so intricately associated with it. Recent studies by Zurif and his co-workers (Zurif and Sait, 1970; Zurif and Mendelsohn, 1972) tend to support this suggestion. In one study, Zurif and Mendelsohn (1972) presented dichotically paired sequences which contained nonsense syllable stems, bound morphemes, and function words. These sequences were grammatically ordered in the sense that if the nonsense stems were replaced by English stems, a grammatical sentence would result. The pairs of sequences were dichotically delivered under two different conditions; in the first, the sequences were characterized by the acoustic correlates of constituent structure (i.e., they were read with normal intonation and "prosody"); and in the second, the sequences were delivered in a monotone. Subjects, faced with an auditory multiple-choice situation immediately after each dichotic presentation, showed a significant right-ear superiority for the sequences characterized by the acoustic correlates of constituent structure, but not for those delivered in a monotone. These results suggest that although prosodic analysis itself may not be lateralized (Blumstein and Cooper, 1972), the mechanisms which linguistically utilize prosodic information are. Thus, when overt rhythms of an utterance-like sequence are not present, the language mechanisms may be less able to operate upon the phonetic properties of speech. And while syntactic appreciation may theoretically generate detailed perception of phonetic structure (Chomsky and Halle, 1968), there is quite likely an interpenetration of effects such that intonational contours also help to organize the processing of phonetic structure.

But, why should the lack of intonation work against hemispheric dominance for the processing of phonetic structure? That is, why when there are only cues to grammatical structure should the dichotic presentation of phonetic sequences not generate a right-ear superiority? The answer may lay conjointly with two factors: first, the type of response Zurif and Mendelsohn (1972) required of their subjects: and second, the mechanisms determining ear asymmetry.

Consider the latter first. The right-ear advantage in dichotic listening appears to arise because of an information loss to the left-ear signal during its relatively extended and indirect transmission route. In this sense then, the absence of a significant right-ear superiority may point, not to an absence of cerebral dominance, but to the circumvention of transmission loss (for a more extended discussion of transmission loss, see Studdert-Kennedy and Shankweiler, 1970).

Since the response required of the subjects in the Zurif and Mendelsohn (1972) task was one of multiple-choice recognition rather than recall, subjects may have circumvented transmission loss by adapting the strategy of attending to only a few elements in each of the paired sequences, that is, by basing a correct response on only partial information. However, this is more likely to have been the case for the unintonated sequences than for those that were intonated. The cohesive force provided by intonation may have prevented subjects from treating the elements comprising the intonated sequences as a series of discrete syllables to be processed individually.

The above is one possible explanation for the results obtained by Zurif and Mendelsohn (1972). It is equally plausible, however, to suggest that the left hemisphere is not dominant for unintonated phonemic sequences. Intonation is an important component of speech. It serves to distinguish different sentence types (He has come. vs. He has come?) and is in fact the basis for one of the first linguistic distinctions that a child can make (Kaplan and Kaplan, 1972). In effect, the perception of prosodic sequences may be an important part of the speaker's implicit knowledge of his linguistic system (Zurif, Personal communication).

Thus, although the left hemisphere may be specialized for processing consonant-vowel combinations (Shankweiler and Studdert-Kennedy, 1967), and intonated phonemic sequences (Zurif and Sait, 1970; Zurif and Mendelsohn, 1972), it may be capable of processing sequenced phonemic information when the normal prosodic accompaniments are absent.

Accordingly, the first study of this thesis was designed to investigate these alternative possibilities. Is the left hemisphere not dominant for unintonated phonemic sequences? Or, did the lack of asymmetry reported by Zurif and Mendelsohn (1972) result from a circumvention of transmission loss to the left-ear stimulus?

EXPERIMENT 1

Method

Stimulus Material

The sequences for both the intonated and unintonated conditions were constructed by substituting single nonsense syllables for syllables contained in the formatives of five-to-six word English sentences (Table 1). Some bound morphemes and function words were not replaced and their order in the sequences remained the same as in the sentences from which they were derived. The resulting meaningless sequences were easily pronounceable. The two types of stimuli differed only in the manner in which they were transcribed. The "unintonated" (UN) stimuli, those containing none of the overt rhythms of speech (stress, intonation, pitch), were recorded in a monotone; each UN sequence was read as a list of words attempting to eliminate all possible acoustic correlates of constituent structure. The "intonated" (IN) stimuli, containing the overt rhythms of speech, were read in a normal voice as if they were grammatically correct sentences. Thus, two separate types of dichotic stimuli were constructed, UN and IN, each consisting of eight pairs of sequences. That is, the competing sequences were either both unintonated (UN condition) or both intonated (IN condition). The members of each pair were recorded on separate channels of a stereophonic tape-recorder in order that one sequence could be delivered to the left ear, while at the same time, the other could be delivered to the right ear, via earphones.

Procedure

All subjects were presented with both the UN and IN material.

TABLE 1

Dichotic stimuli of experiment 1

Channel 1

(a) Hebful neasing, sej da viseltive.
(b) Hudly nee bul gu.
(c) Kiff zum shab for wenda.
(d) Ta hurped a geppen.
(e) Durvendly ha flijjes rab.
(f) Ra vip aj the lud mik.
(g) Gie daggeds a wubby voom.
(h) Qua sav habbing dod.

Channel 2

(a) Yaffing guselshug, the queffle froed.
(b) Sig the bajee wugs.
(c) The doos mag niffing gug.
(d) Gri nunc to sig yed.
(e) Fash er a bodious siggen.
(f) Lo soont jeg ub shavving.
(g) Quees murgy zu dakking teffs.
(h) The wak jud shendily.

Half of the subjects were first presented with the UN sequences, and half with the IN sequences first. As the number of function words and bound morphemes was not matched for each pair of sequences, ears and channels were balanced. That is, each subject was presented with each of the stimuli twice. The second time, the earphones were reversed. Within each order of presentation, half of the subjects heard channel 1 in the right ear first, and half heard channel 2 in the right ear first. Thus, each subject was presented with a total of 32 trials.

Subjects were instructed to listen carefully to both ears and to report back as much of the material as possible. The subjects' verbal responses were recorded on a tape-recorder for later analysis.

Scoring

Scores for each subject were based on the number of syllables correctly recalled for each ear. The responses were scored according to the Item-plus-Sequence method described by Graham (1968). Each syllable recalled could receive a maximum of three points. One point was awarded if the syllable was present. This was augmented by a second point if it was preceded or followed by the correct syllable or sequence boundary (beginning or ending of sequence), and further increased to three points if it was both preceded and followed by the correct syllable or sequence boundary. As each channel was presented to each ear in both conditions, the maximum possible score for each ear was 309 points; there being a total of 103 syllables in the two channels. The recorded verbal responses were scored twice; once by the experimenter, and again by an individual who was completely naive concerning the nature of the experiment.

Subjects

The subjects were 20 male undergraduates between the ages of 18 and 25 attending Sir George Williams University. All subjects were right-handed and native English speakers, with no auditory defects of which they were aware.

Results

Spearman Rank-Order correlations comparing the degree of agreement between scorers yielded coefficients ranging from .64 to .72 ($N=20$, $p<.01$ for all coefficients) across four conditions (right ear, intonated; right ear, unintonated; left ear, intonated; left ear, unintonated).

The data of the two sets of scores were averaged and an analysis of variance applied. As indicated in Table 3, subjects were significantly more accurate in reporting the material delivered to the right ear than reporting that delivered to the left ear ($F=31.33$, $p<.01$). There was also a significant condition effect; i.e., subjects were more accurate in their recall of the IN than UN material ($F=32.18$, $p<.01$). However, there was no significant interaction between ear and condition of intonation; as stated above, the right ear was superior in each condition of intonation.

Discussion

The intent of the first study was to determine whether or not the left hemisphere is dominant for the processing of unintonated phonemic sequences. The findings in this respect are quite clear. The significant right-ear superiorities that emerged in both conditions of intonation strongly suggest that the left hemisphere is specialized not only for perception of single lexical items and consonant-vowel

TABLE 2

Mean correct scores of experiment 1

	Left ear	Right ear	*t* test
IN condition	30.6	56.7	4.39*
UN condition	19.1	33.9	4.43*
t test	4.38*	4.22*	

*$p < .01$ (two-tailed test)

combinations, but also, for the processing of utterance-length phonemic sequences, be they intonated or unintonated. Thus, the lack of asymmetry reported by Zurif and Mendelsohn (1972) seems to be due to the response mode incorporated in their task. That is, strategies attendant to a multiple-choice recognition task appear to circumvent information loss to the left-ear signal when both ears receive unintonated phonemic sequences.

However, why should intonation enhance the perception of phonemic sequences in the free recall task? Or, for that matter, why should intonation preserve the right-ear superiority even when the response is one of recognition rather than recall?

One answer is that intonation serves to cohere the elements of a sequence. In this respect, it may be that processing the effects of intonation serves to better activate the articulatory mechanisms underlying speech. This notion, of course, is related to the view of speech perception evolving in the Haskins Laboratories. For example, Liberman, Cooper, Shankweiler, and Studdert-Kennedy (1967) suggest that the processes of speech involve appropriate linkages between sensory and motor components. Thus, it may be that the articulatory mechanisms serving speech are more active when all of the sound components, normally present in an utterance including intonation, are also in the dichotically paired signals.

In any case, although the first study shows that intonation aids the left hemisphere in the processing of speech sounds, no evidence has yet been put forth concerning the existence of a hemispherically lateralized grammatical decoder, a decoder that operates on actual verbal sequences. This is the aim of the second study.

EXPERIMENT 2

The main concern of this study is to determine whether or not the left hemisphere specializes in processing the internal, logical structure of actual English utterances. Specifically, is dominance for language analyzable in terms of the perceptual strategy of segmenting an utterance into its phrasal constituents?

The technique employed to investigate this problem is an adaptation of what has now become know as the "click" paradigm (Garrett, Bever, and Fodor, 1965; Fodor, and Bever, 1965). This paradigm requires that the listener subjectively report the location of an interfering stimulus (a click) introduced into a sentence. And, as Garrett and his co-workers have shown, when subjects are asked to do so, they tend to perceptually displace the click toward the major constituent boundary of the sentence. Moreover, some evidence has been provided that this form of perceptual analysis does not depend on the presence of the acoustic correlates of phrase structure (Garrett, Bever, and Fodor, 1965).

In any event, in order to discover whether or not this parsing strategy is governed by the left hemisphere, it was decided to observe click displacement under conditions of dichotic competition. Accordingly, sentences sharing identical word segments, but differing in the location of their clause boundaries, were paired for dichotic presentation. These sentences were taken from the work of Garrett, Bever, and Fodor (1965), and an example of how they were paired for dichotic competition follows:

A. In her hope of marrying An|na was surely impractical.

B. Your hope of marrying An|na was surely impractical.

The major constituent break in sentence A is between the words "marrying" and "Anna"; in sentence B, between "Anna" and "was". The slash marks indicate that the click was binaurally positioned over the word "Anna". The intent, then, was to determine which, if any, of the opposing constituent breaks would attract click location.

Method

Stimulus Materials

The five pairs of sentences are presented in Table 3. The single words, in which the clicks were embedded, are underlined. Each pair of sentences had a string of lexical items in common; for example, in the first pair of sentences where the two portions following "George" were the same. However, the initial portions differed, and it was this aspect which established the difference in constituent structure between the two opposing sentences. In sentence (a) of the first pair, the break occurs before the word "George", and in (b), the break occurs after this word.

These sentences were delivered under two different conditions termed "intonated" (IN) and "unintonated"(UN). The first condition, IN, containing the acoustic correlates of constituent structure, was constructed by recording the sentences in a normal voice. In contrast, the UN condition was transcribed in a monotone attempting to eliminate all possible acoustic correlates. The voice of the same person was used in constructing both conditions.

The dichotic stimuli were made in several stages. This processing of the stimuli through several generations was necessitated by the need, not only to produce pairs of sentences which began and ended at the same time, but also to match up corresponding portions (those before and

TABLE 3

Dichotic stimuli of experiment 2

Channel 1

(a) In order to catch his train, George drove furiously to the station.
(b) In her hope of marrying, Anna was surely impractical.
(c) Because it was a most important city, Hambourg was leveled by the war.
(d) During prohibition because many were afraid to give open support, drinking liquor was made illegal.
(e) As a direct result of their new invention's influence, the company was given an award.

Channel 2

(a) The reporters assigned to George, drove furiously to the station.
(b) Your hope of marrying Anna, was surely impractical.
(c) Only the metropolitan district of Hambourg, was leveled by the war.
(d) During prohibition although a majority of people did support drinking, liquor was made illegal.
(e) The retiring chairman whose methods still greatly influence the company, was given an award.

Note.—Sentence (a) of channel 1 was delivered to one ear, while at the same time, sentence (a) of channel 2 was delivered to the other ear.

after the click word) for each dichotic pair.

Consider the UN sentences first. The initial stage in their construction consisted of recording the words of each sentence in a monotone and in a random order. These original recordings were then rerecorded while being fed through a suppressor in order to rule out gross frequency range differences. The next stage was to reassemble the randomly ordered words of each sentence into their correct order. That done, an attempt was made to equalize various parameters for each of the sentences that were to be paired for dichotic presentation. Specifically, inter-word splicing ensured that the time from sentence onset to click word was the same for each of the dichotically competing sentences. Of course, this splicing procedure was also applied to the portions following the click word. The corresponding portions were then transcribed from two identical recorders to separate channels of a third stereophonic recorder.

The click word, itself, was generated stereophonically be rerecording the common word (e.g., "George" in the first pair) on the both tracks of a tape for later splicing between the beginnning and ending portions within each sentence pair. At the same time, a short tone burst (800 cps., 30 msec.) was superimposed precisely on the middle of the word on both tracks of the tape. This was done with the aid of an oscilloscope. The tone was equal in intensity to the loudest sound in the word in which it was inserted. The stereophonic click word was then spliced appropriately into the space between the beginning and ending portions of each dichotic pair.

Construction of the IN stimuli differed from that of the UN sequences in the initial stages. Rather than being recorded in a monotone, these sentences were recorded in a normal voice, and of course, the proper word order was maintained. Further, the stereophonic click word, spliced between the appropriate portions for each pair of sentences, was drawn from the UN stimuli to eliminate any biasing effect toward either sentence. Thus, for each pair of IN sentences, the constituent break was accompanied by a normal intonational pause. For example, in the first pair of sentences, the major pauses occurred between "train" and "George" on channel 1 and between "George" and "drove" on channel 2. The resulting corresponding IN sentence pairs started and ended within 20 msec. of each other.

<u>Procedure</u>

The subjects were randomly assigned to one of two groups. One group of 20 subjects received the UN stimuli, and the other group, the IN stimuli.

All subjects were first presented with four practice sentences, delivered binaurally, each containing a single click. The subjects were instructed to turn the next page of a booklet at the termination of each sentence and to indicate (by making a slash mark through the typewritten sentence) the point in the sentence where they beleived the click had occurred. These practice sentences were presented in order to offset a tendency of subjects to prepose the location of clicks early in this type of task (Fodor and Bever, 1965; Reber and Anderson, 1970). The dichotic stimuli were then administered.

Within each condition of intonation, half (10) of the subjects had the right phone on the right ear, and the other half, the left phone on their right ear. Before the presentation of each sentence pair, subjects were instructed by means of a visual cue to attend to only one ear. Pilot work had shown that it was much too difficult for subjects to attempt to attend to both messages. After each presentation ended, subjects turned the page in a booklet and found both messages typed out. They were instructed to make a slash mark where they thought the click was presented in the sentence they attended to. The order of the paired sentences was randomly arranged on the page. In addition, the typewritten sentences were unpunctuated and uncapitalized, except for proper names.

The five pairs of sentences were presented twice. This allowed subjects to attend to both sentences of each pair, one sentence on the first run-through and the opposing sentence on the second presentation. The ear of attention was randomly ordered. Each subject attended to each ear five times in ten presentations.

Subjects

The subjects were 40 male undergraduates between the ages of 18 and 25 attending Sir George Williams University. All subjects were right-handed, native English speakers with no auditory defects of which they were aware.

Results

Of a total of 400 responses in both conditions of intonation, 13.75% were correctly located in the word in which they had been presented (IN, 6.50%; UN, 7.25%). Placement of the click in the incorrect sentence accounted for 27.00% of the responses (IN, 12.50%; UN, 14.50%).

Thus, the majority of the responses were either preposed (28.25%) or postposed (31.00%) from the objective position of the click. In fact, 44.25% of all the responses given in this task were located in the spaces directly on either side of the click word. Since these spaces not only attracted the largest number of responses, but also, and more importantly, represented the major constituent breaks, a more detailed analysis of clicks displaced to these spaces was carried out. χ^2 tests were applied to determine whether a significant difference existed between the observed and expected frequencies of responses in these spaces. The effects discussed below are concerned with only these responses.

<u>Intonated stimuli</u>. As indicated in Table 4, when responses were considered across both ears, significantly more clicks were displaced into the constituent break than into the space on the other side of the click word. However, this pattern was mostly dependent on right-ear responses.(see Table 5). For right-ear attended sentences, a significant number of clicks were drawn to the constituent break whether before or after the click word. This was not the case for left-ear attended sentences. In fact, when the subjects were required to attend to the left ear, there was a tendency for them to be influenced by the opposing structure of the right-ear sentences. This tendency was not statistically reliable (constituent break after, $p<.10$) in the present study, but this may have been due to the fact that the effect is a weak one, and the sample size was small: the possibility that this effect was not simply due to chance merits further study. The influence of the structure of the right-ear sentence is seen by the fact that subjects displaced the click not to the constituent break of the left-ear sentence but to the space on the other side of the click word. This space, of course, corresponded to the constituent break of the supposedly unattended right-ear sentence.

TABLE 4

Number of clicks displaced to the space on either side of click word

Condition	Position of constituent break	Response placement Before	After	χ^2 value
Intonated	Before	29	22	4.68*
	After	16	30	
Unintonated	Before	20	18	.44
	After	19	23	

*$p < .05$

TABLE 5

Number of clicks displaced to the space on either side of click word in relation to ear of attention

Condition	Ear of attention	Position of constituent break	Respones placement Before	After	χ^2 value
Intonated	Right	Before	18	8	3.84*
		After	4	25	15.20**
	Left	Before	11	14	.36
		After	12	5	2.82
Unintonated	Right	Before	9	11	.20
		After	17	6	5.26*
	Left	Before	11	7	.89
		After	2	17	11.84**

*p<.05
**p<.01

Unintonated stimuli. Unlike the results obtained for the IN condition, no consistent pattern emerged for the UN sentences. Of the five χ^2 tests applied to the data from the UN condition, only two were significant.

Discussion

In several recent papers, Bever (e.g., 1969, 1970a) has proposed that in the actual application of language a number of perceptual strategies develop that are not directly related to universal properties of speech (e.g., the fact that words have reference). He has suggested that these strategies are directed toward uncovering the syntactic organization of utterances and also that these strategies may be asymmetrically represented in the brain (Bever, 1970b).

The present study supports this suggestion. Specifically, the present findings indicate that the left hemisphere is the locus for those processes that analyze a sentence into its constituent phrases. This is indicated by the fact that (1) when subjects are required to attend to one or the other ear, the phrasal constituents of the right-, but not the left-ear sentences, attract click placement, and (2) the possibility, that even when subjects attend to left-ear sentences, they appear to be influenced by the opposing structures of the right-ear sentences. Thus, as Bever (1970b) has suggested, the notion of hemispheric dominance should be extended. It appears that the left hemisphere also governs the strategy of isolating word sequences in an utterance in such a way as to capture the logical relations these words bear to each other (e.g., actor, action, object).

The present findings, however, are somewhat equivocal about the active or passive nature of this asymmetrically directed strategy. The question here is whether the listener actively provides the structural analysis of the sentence, or whether he responds passively to the acoustic cues (i.e., the intonational contours) marking the structure. One reported study has shown that the effect of syntactic organization is not due to any actual pauses or rhythms in the pronounciation of the sentence (Garrett, Bever, and Fodor, 1965).

On the other hand, the results presented here suggest that these segmentation strategies do rely upon intonational cues. To this point, the left hemisphere exerted its dominance for segmentation only when competing sequences were both intonated.

If it were just a matter of resolving these two findings, the problem would not be too difficult. Intonation may become an important cue only when the perceptual system is overloaded. That is, while in most situations the listener actively imposes a structural analysis on the sentence (Garrett, Bever, and Fodor, 1965), the excessive information provided to him in dichotic listening may force him to passively rely upon acoustic cues to structure.

However, there is evidence in the literature to suggest that the intonation pattern of the utterance plays an important role in determining click location even in a non-dichotic situation (Reber and Anderson, 1970). Also, Wingfield and Klein (1971) have demonstrated that, when intonation and underlying syntactic structure are placed in direct conflict, the former is a more powerful determiner of constituent segmentation than the latter.

At this stage, then, it seems best to take an intermediate position: while segmentation is directed at uncovering the logical relations in an utterance, the acoustic correlates of constituent structure undoubtedly aid in this decoding process.

GENERAL SUMMARY

The two experiments in this thesis were designed to press the analysis of what constitutes cerebral dominance for language. The first study required subjects to recall dichotically paired nonsense sequences delivered in two conditions of intonation. Sequences characterized by the acoustic correlates of constituent structure were recalled significantly better than those delivered in a monotone. In both conditions of intonation the right-ear sequences were recalled better than those delivered to the left-ear. This suggested that the cues to grammatical structure provided by intonation enhance left-hemisphere dominance for the processing of utterance-length phonemic sequences.

The second study assessed the perceptual displacement of a click introduced during the presentation of dichotically paired sentences differing in syntactic structure. Only those clicks which were introduced into normally intonated sentence pairs were systematically drawn to constituent boundaries, and this only occurred for the right-ear, but not the left-ear, sentences. This suggested that the left hemisphere is specialized for analyzing a sentence into its constituent phrases.

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APPENDIX A

Raw Data: Experiment 1

Subject's Scores Of Experiment 1

	Condition: intonated		unintonated	
Ear:	right	left	right	left
Subject				
1	51	34	46	17
2	103	20	49	15
3	25	22	27	13
4	34	59	44	38
5	47	38	38	30
6	69	39	38	31
7	48	25	36	33
8	39	18	46	6
9	50	30	45	23
10	94	34	36	16
11	35	19	34	15
12	84	38	48	18
13	72	34	20	9
14	44	39	14	25
15	17	24	10	16
16	41	9	19	15
17	72	38	57	14
18	69	14	30	20
19	53	56	33	15
20	87	22	9	13

APPENDIX B

Raw Data: Experiment 2

Clicks Located In Spaces

Directly On Either Side Of Click Word

<u>Intonated Stimuli</u>

Subjects 1 to 10: right phone on right ear
Subjects 11 to 20: left phone on right ear

Ear:	right		left	
Click Placement:	before	after	before	after
Subject				
1	0	0	0	0
2	1	0	2	0
3	3	1	1	2
4	0	0	0	0
5	3	1	1	1
6	2	0	1	1
7	3	1	1	0
8	3	1	2	0
9	1	1	1	1
10	2	3	3	0
11	0	0	0	0
12	0	1	0	1
13	2	3	3	0
14	0	1	1	1
15	0	5	0	3
16	0	3	2	1
17	0	4	0	4
18	1	2	2	1
19	0	3	0	1
20	1	3	3	2

Clicks Located In Spaces

Directly On Either Side Of Click Word

Unintonated Stimuli

Subjects 21 to 30: right phone on right ear
Subjects 31 to 40: left phone on right ear

	Ear:	right		left	
	Click Placement:	before	after	before	after
Subject					
21		3	0	0	1
22		1	1	1	0
23		0	0	0	0
24		1	1	0	3
25		0	1	0	2
26		1	1	0	4
27		0	2	0	1
28		0	0	0	0
29		2	2	1	2
30		1	3	0	4
31		3	0	1	2
32		5	0	0	1
33		2	0	1	0
34		0	0	0	0
35		1	1	1	2
36		3	0	2	0
37		0	0	1	0
38		0	2	1	2
39		2	1	3	0
40		1	2	1	0