SENTENCE INTONATION FOLLOWING UNILATERAL LEFT AND RIGHT HEMISPHERE LESION

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ABSTRACT

The results of an instrumental analysis of acoustic attributes of sentence intonation in the speech of six Francophone patients show that subjects with left anterior lesion have relatively intact range and frequency of use of F_0 movements whereas subjects with right anterior lesions show reduced F_0 range and frequency of movement.

INTRODUCTION

A. Prosodic modification following left anterior lesion

The question of the status of prosodic systems following unilateral brain damage has received considerably less attention than deficits of phonetic, phonemic and morpho-syntactic systems. One can perhaps attribute this to the fact that the status and function of prosodic systems has remained a topic of controversy within the framework of linguistics as a whole. Prosody is often seen as a musical or emotional supplement to speech which has a minimal linguistic role. There has been a recent renewal of clinical interest in the subject of prosody following unilateral brain lesion, but the phonetic and clinical data do not as yield a clear interpretation.

There are a number of clinical observations of prosodic modification following unilateral left anterior lesion. A number of case reports describe patients whose speech output began with a period of quasi-mutism and then evolved to the utterance of a few monosyllables with modulations of intonation [1][2][3][4]. These observations suggest that in the initial stages of Broca's aphasia, prosody seem to be relatively well preserved.

However, in further stages of evolution of language disorders following left anterior lesion, specific prosodic modifications called dysprosody, appear. Dysprosody can be divided into two major categories: a) "foreign language dysprosody" (accent change) and b) "flat, discontinous speech melody".

Case reports of foreign language dysprosody are numerous. The first such case was reported by A. Pick [5]. Pick observed a young male Czech patient with a left anterior lesion, who took on a "Polish" accent because he systematically misplaced word level accentuation which, in Czech falls on the first syllable of the word, to the penultimate syllable. G. Monrad-Krohn later reported the case of a young female Norwegian patient, with a large anterior left hemisphere lesion who had recovered fluent articulation, but was unable to produce the tonal distinction which, in Norwegian differentiate "Bönder" (farmers) from "Bönner" (prayers or green beans) [6][7]. In these two cases, it is legitimate to say that the "foreign prononciation" is directly linked to a prosodic modification.

On the other hand, a number of researchers have used the term dysprosody to designate any and all cases of strange prononciations which seemed to show traces of a foreign accent, as for example, the cases reported by Alajouanine and Lhermitte [8], Cole [9], Critchley [10], Engl and Von Stockert [11][12], Nielson and McKeown [13], Pilch [14], and Whitty [15]. In most of these cases it does not seem that the accent change can be attributed to a primary and isolated modification of prosodic systems but rather to general difficulties in phonetic realization.

The second major type of prosodic disorder that has also been termed dysprosody, is associated with subjects suffering from severe non-fluent aphasia accompanied by agrammatism. H. Goodglass [16] was probably the first to use the term dysprosody to describe the flat and discontinuous quality of the melodic line in the speech of patients with severe non-fluent aphasia. For Goodglass, this type of aphasic patients are unable to use intonation to demarcate constituent boundaries.

There are relatively few instrumental studies of prosodic modification following left anterior lesion. In a corpus of spontaneous speech produced by aphasic subjects, Danly, De Villiers and Cooper [17] observed that F_0 sentence declination was present and that major falls in F_0 occured at the end of sentences. However, sentence final syllable lengthening was absent.

In a second study based on a corpus of read sentences, Danly and Shapiro [18] were able to confirm the existence of major frequency falls in sentence final position, and the absence of sentence final syllable lengthening. Furthermore, F_o sentence declination was found to apply to smaller domains as compared to normal speech and aphasic subjects with left frontal lesions were found to make more frequency rises than normal subjects and they did not encode sentence length by choosing a high initial F_o peak.

Ryalls [19] found that eight subjects with Broca's aphasia showed a restricted frequency range. In a second study, this author noted that subjects with large anterior left hemisphere lesions had a higher average F_o than control subjects [20].

According to Cooper et al. [21], Broca's aphasics show a relatively flat frequency contour, their subjects did however, produce sentence final word lengthening.

In general, the portrait of Broca's aphasics shows considerable disorders in the phonetic production of fundamental frequency. F_o is flat and discontinuous with restricted overall range. Sentence final syllable lengthening is usually absent, but sentence final intonational falls seem to be intact.

B. Prosodic modification following right anterior lesion

There have been relatively few clinical reports of prosodic deficits following anterior right hemisphere lesion [22]. Recently however, the syndrome of "aprosodia", which according to Ross [23] designates a selective inability to use prosody to express emotional states, and "auditory affective agnosia" [24] which designates the inability to recognize emotional information carried by voice, have lead to a renewal of research on this topic.

As far as phonetic studies are concerned, Dordain, Degos and Dordain [25] reported monotonous voice in nine of seventeen subjects with right hemisphere lesions suffering from right hemiplegia. Kent and Rosenbek [26] also report monotonous voice in two subjects with right hemisphere lesions. In an earlier study of nine subjects with right hemisphere lesion (three frontal, three parietal and three temporal) we were ourselves able to observe that the three subjects with right frontal lesion showed restricted intonational movements in phrase and sentence final position [27]. However, these subjects produced considerable lengthening in vowel duration for phrase and sentence final syllables.

INSTRUMENTAL ANALYSIS

A. Subject population and speech sample

The subjects for this study were six francophone, adult right-handed patients. Three patients (A, B and C) suffered from unilateral left lesions affecting the anterior portion of the left hemisphere. Three other patients (D, E and F) suffered from unilateral right lesions affecting the anterior portion of the right hemisphere. There were four female subjects, A, C, D and E, and two male subjects B and F. As for lesion etiology, subjects A, B, C and F suffered from cerebro-vascular accidents: Subject A, a thrombosis of the internal carotid artery; Subject B, an occlusion of the middle cerebral artery; Subject C, occlusion of the internal carotid artery and Subject F from an rupture of an aneurysm of the internal carotid artery. Subjects D and E both suffered from cerebral tumors, an astrocytoma and a glioma, respectively. At the time of interview Subject A was 23 years of age, Subject B, 63 years of age, Subject C, 36 years of age, Subject D, 38 years of age, Subject E, 47 years of age and Subject F, 35 years of age.

All subjects suffered from severe hemiplegia contralateral to the side of the lesion.

For subject A the clinical interview was carried out 473 days after onset of the accident, for Subject B the interview took place 637 days after onset, for Subject C, 180 days after onset, for Subject D, 17 days after onset for Subject E, 21 days after onset and for Subject F, 14 days after onset. All subjects were in stable neurological condition at the time of interview.

The speech sample submitted to instrumental analysis was drawn from the spontaneous speech section of the clinical aphasia examination battery currently in use at the Salpêtrière and St. Anne Hospitals in Paris, France. The patients were replying to questions about their illness, their profession, etc.

For each subject approximately 300 syllables of spontaneous speech were analyzed.

The speech sample for each subject was was submitted to two parallel instrumental phonetic analyses of frequency, intensity and duration. The first analysis was carried out by a digital real-time fundamental frequency analyzer and the second by a digital real-time colour spectrograph.

B. Results of instrumental analysis

Subjects A, B, and C, with unilateral left anterior lesions were found to have:

a) intact range of F_o movements (Fig.1);
b) relatively frequent use of F_o movements to indicate sentence boundaries (Fig.2);
c) relatively infrequent use of sentence final syllable lengthening (Fig.3);
d) very frequent use of pauses(Fig.4);
e) frequent use of monosyllabic or bisyllabic utterances (Fig.5).

Subjects D, E and F, suffering from unilateral right anterior lesions, when compared to subjects A, B and C, showed:

a) reduced range of F_o (Fig.1);
b) reduced use of F_o movements to indicate sentence boundaries (Fig.2);
c) relatively frequent use of sentence final syllable lengthening(Fig.3);
d) reduced use of pauses (Fig.4);
e) considerably less frequent use of monosyllabic and bi-syllabic accentual groups (Fig.5).

	F_o	Range	Range Coeff.
A	173Hz	150-380Hz	1.329
B	98Hz	80-190Hz	1.122
C	186Hz	135-375Hz	1.290
x			1.247
D	176Hz	130-240Hz	0.625
E	149Hz	130-220Hz	0.604
F	95Hz	70-150Hz	0.842
x			0.690

Range Coefficient t=5.621, p(4)<0.01
Figure 1 Frequency range.

	Occurences of F_o movement	
	Group Final	Sentence Final
A	23.75%	62.98%
B	40.29%	56.25%
C	26.22%	59.10%
x	30.08%	59.44%
D	13.15%	20.87%
E	35.41%	25.00%
F	38.08%	38.47%
x	28.88%	28.11%

Group Final F_o: t = 0.127, p(4)>0.90
Sentence Final F_o: t = 5.535, p(4)<0.01
Figure 2: Percentage of occurences of F_o movement in group and sentence final position.

	Occurence of syllable lengthening	
	Group Final	Sentence Final
A	12.50%	33.31%
B	24.02%	25.00%
C	21.97%	31.81%
x	19.49%	30.04%
D	47.36%	70.80%
E	60.41%	75.00%
F	64.27%	69.22%
x	57.35%	71.67%

Group Final Lengthening t = 6.081, p(4)<0.01
Sentence Final Lengthening t=13.497, p(4)<0.001
Figure 3 Percentage of occurence of syllable lengthening in group and sentence final position.

	Number of pauses	Total pause duration	Pause percentage
A	98	13631cs	60.44%
B	100	5843cs	38.59%
C	139	13675cs	64.27%
x	112.33		54.43%
D	14	1422cs	19.04%
E	23	1872cs	29.81%
F	34	2576cs	39.81%
x	23.66		29.55%

Number of pauses t=6.096, p(4)<0.01
Pause percentage t=2.488, p(4)<0.05
Figure 4 Pauses.

	Mono-syllabic groups	Bi-syllabic groups	Total
A	59.34%	27.47%	86.81%
B	57.43%	20.27%	77.70%
C	53.37%	22.08%	75.45%
x	56.71%	23.27%	79.99%
D	8.00%	17.70%	25.70%
E	4.69%	15.62%	20.31%
F	14.30%	12.50%	26.80%
x	8.99%	15.27%	24.27%

Monosyllabic groups t=14.360, p(4)<0.001
Bisyllabic groups t=3.033, p(4)<0.05
Figure 5 Percentage of occurence of mono- and bi-syllabic accentual groups.

DISCUSSION

While subjects with anterior left hemisphere lesions produced a high number of pauses and a large number of mono- and bi-syllabic accentual groups, they continued to use a rudimentary system of intonational marking based primarily on F_o movement to indicate phrase and sentence boundaries.

The results also suggest that patients with unilateral left hemisphere lesion do not show a restricted F_o range when compared to subjects with unilateral right hemisphere lesions. This observation is slightly different, but is not incompatible with previous phonetic studies which compared brain-damaged subjects to control subjects. It is however important to note that none of the patients misplaced intonational movements or produced anomalous intonational patterns. The strategy used was simple and consisted in attributing intonational rises to syllables in non-sentence final position and major falls to syllables in sentence final position.

The intonational strategies used by these two groups of subjects have important consequences for clinical analysis of language deficits following focal brain lesions and for theories of cerebral processing of speech.

In terms of the clinical analysis of Broca's aphasia with accompanying agrammatism, these results suggest that the use of the term dysprosodic, which suggests a selective prosodic deficit, to qualify the speech output of these subjects is inappropriate. Moreover, the intonational movements produced by these patients do not have simply a musical or emotional role, they serve to delimit the major constituent boundaries of the utterances.

On the other hand, subjects with right anterior lesions relied more heavily on durational attributes, as opposed to F_o movement, to indicate the principal syntactic units of their utterances. This finding is in agreement with previous results. It is however important to note that the overall F_o contour of these patients is not absolutely flat. The principal difference between these patients and patients A, B and C is the lack of F_o movement in group and sentence final position where the greatest variations in F_o usually occur. This flat final syllable, combined

with a greater degree of syllable lengthening in group and sentence final position give the auditory impression of a flat voice.

As for the clinical interpretation of "aprosodia", these results suggest that the relatively flat F_0 line which is a major component of these patients verbal output may be related to a functional deficit in cerebral processing of F_0 and not to a selective disorder of emotional behaviour.

In terms of cerebral phonetic processing, the use of a rudimentary intonational strategy by subjects with left anterior lesions in the face of massive articulatory deficits, suggests that the cerebral circuits implied in the control, planning and execution of F_0 movements are functionally separate from those responsible for the planning and execution of consonant and vowel segments. Furthermore the difference in intonational behaviour of subjects according to hemispheric lateralization of lesion suggests that there is a degree of functional specialization of cerebral circuits involved in the planning and execution of F_0 movements [31]. Unilateral right anterior lesions appear to be associated with a reduction in range and frequency of occurence of F_0 movements at major constituent boundaries. Unilateral left anterior lesions appear to be associated with a severe reduction in phrase length, causing non-fluent speech output, but with intact placement and range of F_0.

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