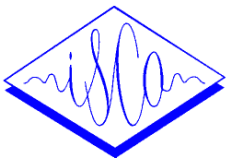

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FUNDAMENTAL FREQUENCY ATTRIBUTES FOLLOWING UNILATERAL LEFT OR RIGHT TEMPORAL LOBE LESION

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ABSTRACT

This paper presents the results of an instrumental analysis of four fundamental frequency (F_o) attributes (range, phrase or sentence final rises, phrase or sentence final falls and non-final variability) in the spontaneous speech output of two matched groups of adult, right-handed, Francophone subjects. Subjects with left temporal lesion produce lower values for all four attributes when compared to subjects with right temporal lesion. Direct comparison of these results does not, however, produce statistically significant results because of the high degree of inter-speaker variability in both groups. This suggests that individual speaker characteristics may still dominate F_o production even when subjects suffer focal unilateral lesion.

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I. INTRODUCTION

The aim of this study is to examine four fundamental frequency (F_o) attributes in the spontaneous speech output of six subjects with unilateral left or right temporal lesion.

Previous clinical and instrumental studies of subjects with focal unilateral left temporal lobe damage (Wernicke's aphasia) indicate that these patients produce fluent speech output with relatively intact but sometimes abnormally variable melodic contours. Duchan et al. [1] report that their patient possessed a rich intonational inventory (contrastive intonation, parentheses, questions). Cooper, Danly and Hamby [2] report that their patient showed overall F_o declination, but that the initial peak was higher than that of control subjects. They also found that their patient made a greater number of F_o resets than did control subjects. Danly, Cooper and Shapiro [3] confirmed these results and reported that frequency declination was applied to smaller domains than in control subjects and that their patients produced a greater number of within sentence F_o rises. Cooper et al. [4] showed that patients with posterior left hemisphere lesions produced unusually high F_o peaks both at the beginning and in the middle of sentences, but apart from this particularity, their speech output was very similar to that of control subjects. Shapiro and Danly [5] found that the prosody of subjects with left posterior damage was similar to that of normal control subjects.

Clinical and instrumental studies of patients with focal unilateral right temporal damage indicate that such subjects also produce relatively intact melodic contours. According to the clinical nosology developed by Ross et al. [6] [7], subjects with right temporal lesion are reported to suffer from "sensory aprosodia" (the patients voice keeps its melodic variations but these are inappropriate for the content of the utterance, repetition and comprehension are disordered).

As far as instrumental studies are concerned, Bhatt [8] observed that, when compared with subjects with right frontal or right parietal lesion, subjects with right temporal lesion did not show either restricted or exaggerated intonational movements in phrase and sentence final position. Shapiro and Danly [5] report that their subjects with right posterior lesions showed exaggerated F_o range and variability. On the other hand, Ryalls et al. [9] did not find any difference between subjects with right anterior or right posterior lesions as far as F_o average and range are concerned.

This study aims to contribute to the overall portrait of the cerebral representation and processing of fundamental frequency by examining F_o attributes as produced in spontaneous conversation by two groups of subjects with unilateral left or right temporal lesion.

II. SUBJECT POPULATION AND SPEECH SAMPLE

All subjects were strongly right-handed unilingual Francophones, with no family history of left-handedness. All had at least primary school education and lived in the Greater Paris metropolitan region.

Group 1 (Subjects A, B and C) consisted of three subjects with verified unilateral **left temporal** lesion:

1) Subject A, a 71 year-old male, suffered an occlusion of the left middle cerebral artery due to an embolism;
2) Subject B, a 50 year-old male, suffered from a cerebral tumor (astrocytoma);
3) Subject C, a 64 year-old male, suffered a cerebrovascular accident due to occlusion of the left sylvian artery.

Group 2 (Subjects D, E and F) consisted of three subjects with verified unilateral **right temporal** lesion:

1) Subject D, a 56 year-old male, suffered from a cerebral hematoma;
2) Subject E, a 54 year-old female, suffered from a cerebral tumor (glioblastoma);
3) Subject F, a 50 year-old male, also suffered from a cerebral tumor (glioma).

The speech sample for all subjects was composed of approximately 300 syllables drawn from the spontaneous speech section of the clinical aphasia battery in use at the St. Anne or Salpêtrière Hospitals in Paris, France.

It is important to note that both the subject population and the speech sample chosen for this analysis are much too small to draw any definitive conclusions. The results presented here are thus intended to provide an initial outline of the speech melody of these patients. Furthermore it is necessary to compare these results based on two groups of brain-damaged subjects to results from a control population of non-brain-damaged subjects in order to evaluate the clinical value of this study.

III. INSTRUMENTAL ANALYSIS

The speech sample for each subject 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.

The four following attributes were examined:

a) Total frequency range (this was calculated as highest F_0 peak - lowest F_0 valley / F_0, thus allowing for comparison of ranges across subjects with different F_0 values);
b) average major frequency rise in sentence or phrase final position (this measurement corresponded to a rise of at least 25% of F_0);
c) average major frequency fall in sentence or phrase final position (this measurement corresponded to a fall of at least 25% of F_0);
d) frequency variability within phrase or sentence boundaries (non-final F_0 variability was calculated according to the method used in Dordain, Degos and Dordain [10] which involves measuring the average frequency for vowels in phrase or sentence internal position. This measurement has the advantage of eliminating micro-melodic effects on F_0 due to consonant context).

IV. RESULTS

As far as total frequency range is concerned, the results presented in Figure 1 below show that subjects A, B and C (left temporal lesion) show a wider overall F_0 range than subjects D, E and F (right temporal lesion). Direct statistical comparison of the two groups does not, however produce a significant result mainly because of the high degree of interspeaker variability observed in Group 2 subjects. Subjects D and E show F_0 ranges which are considerable wider than that of Group 1 subjects, whereas subject F's F_0 range is very similar to that of Group 1 subjects.

	F_0	F_0 Min	F_0 Max	F_0 Range
A	116	85	180	0.8152
B	132	105	190	0.6396
C	110	90	180	0.8144
AVG	120	93	183	0.7564
STD				0.0826
D	98	80	195	1.1656
E	181	120	385	1.4601
F	89	65	140	0.8386
AVG	123	88	240	1.1547
STD				0.2538

Figure 1. F_0 range

T-Test Group 1/Group 2:

F_0 Range: t = -2.585 (4 d.f.) p = .0610

	Avg. Rise (Hz)	Avg. Rise (F_0%)	Avg. Fall (Hz)	Avg. Fall (F_0%)
A	24.77	21.25	24.72	21.21
B	33.66	25.32	25.58	19.24
C	39.38	35.63	33.59	30.39
AVG	32.60	27.40	27.96	23.61
STD	6.01	6.05	3.99	4.85
D	33.37	33.82	40.71	41.26
E	112.05	61.73	78.62	43.31
F	29.57	33.06	17.50	19.56
AVG	58.33	42.87	45.61	34.71
STD	38.01	13.34	25.19	10.74

Figure 2. Average F_0 rises and falls

T-Tests Group 1/Group 2:

F_0 rises: t = -1.829 (4 d.f.) p = .1414

F_0 falls: t = -1.630 (4 d.f.) p = .1785

As far as phrase and sentence-final F_0 rises are concerned, the results presented in Figure 2 above show that subjects A, B and C (left temporal lesion) produce smaller F_0 rises in phrase and sentence final position than subjects D, E and F (right temporal lesion). Direct statistical comparison of the two groups does not, however, produce a significant result. Once again this is probably due to the high degree of interspeaker variability in both groups. Subjects A and B show relatively small phrase and sentence-final F_0 rises, while subject C produces F_0 rises which are comparable to that of subjects D and F. Subject E, however, produces much larger F_0 rises than all the other subjects.

As far as phrase and sentence-final F_0 falls are concerned, the results presented in Figure 2 above show that, as was the case for F_0 range and F_0 rises, F_0 falls in phrase and sentence-final position are smaller in Group 1 subjects as compared to those in Group 2. Once again, however, direct statistical comparison does not show a significant difference between the two groups because of the high degree of inter-speaker variability in both groups of subjects. Subjects D and E produce relatively large F_0 falls whereas subject F produces fall which are similar to those of subjects A and B.

As far as Non-final F_0 variability is concerned, the results presented in Figure 3 below show that subjects A, B and C (left temporal lesion) produce less variable non-final F_0 than subjects D, E and F (right temporal lesion). Direct statistical comparison once again does not show a significant difference between the two groups. This is once more attributable to the high degree of inter-speaker variability in both groups of subjects. Subject D produces the most variable non-final F_0 and subject B produces the least variable non-final F_0. All other subjects, however, produce reasonably similar values for this attribute.

	F_0	F_0 Std. Dev.	Non-final F_0 Variability
A	116	12.66	0.1087
B	132	11.6	0.0873
C	110	14.23	0.1288
AVG	120		0.1083
STD			0.0169
D	98	23.72	0.2404
E	181	24.41	0.1344
F	89	11.32	0.1266
AVG	123		0.1671
STD			0.0519

Figure 3. Non-final F_0 variability

T-Test Group 1/Group 2: t = 7.368 (4 d.f.) p = .0018

V. DISCUSSION

As stated earlier, this study should be interpreted as presenting a number of working hypotheses subject to further empirical investigation and comparison with non-brain-damaged controls. With this caveat in mind, the results presented above indicate that, when compared to subjects with right temporal lesion, the speech output of subjects with left temporal lesion shows:

a) a relatively systematic, but not significant restriction of total F_0 range;
b) a non-systematic and non-significant reduction in size of average phrase or sentence-final F_0 rise;
c) a non-systematic and non-significant reduction in size of average phrase or sentence final F_0 falls;
d) a relatively systematic but non-significant reduction of non-final F_0 variability.

Group 1 subjects thus show some (non-significant) reduction over these four attributes. In the absence of a control group, it is not possible to determine whether or not Group 1 values are abnormally low or whether or not group 2 values are abnormally high for these attributes. These results do, on the other hand, suggest quite strongly that the differences between the two groups are not as strong as has been previously thought. This in turn implies that a strict left-right dichotomy is perhaps not the most pertinent anatomical dimension for capturing the effects of brain lesion on F_0 production.

This lack of difference could also be interpreted as indicating that F_0 is not a significant distinguishing factor between these two sets of subjects. This interpretation receives some support from the presence of a considerable degree of inter-speaker variability in both groups. F_0 production thus continues to reflect speaker-individual characteristics even in the presence of relatively similar focal unilateral brain lesions.

Whichever of these two interpretations turns out to be correct (and it may even be that both are correct), this relative similarity of behaviour suggests that other phonetic dimensions such as temporal variables also play a crucial role in distinguishing the spontaneous speech output of these patients [11] [12].

VI. REFERENCES

[1] J. Duchan, M. Stengel and J. Oliva "A dynamic phonological model derived from the intonational analysis of a jargon aphasic patient", *Brain and Language*, 9, 289-297, 1980.

[2] W. Cooper, M. Danly and S. Hamby "Fundamental frequency attributes in the speech of Wernicke's aphasics." In *Speech communication papers presented at the 97th meeting of the Acoustical Society of America*, J. Wolf and D. Klatt (eds.), New York: Acoustical Society of America, pp. 265-270, 1979.

[3] M. Danly, W. Cooper and M. Shapiro "Fundamental frequency, language processing and linguistic structure in Wernicke's aphasia." *Brain and Language*, 19, pp. 1-24, 1983.

[4] W. Cooper, C. Soares, J. Nicol, D. Michelow and S. Coloskie "Clausal intonation after unilateral brain damage." *Language and Speech*, 27, pp. 17-24, 1984.

[5] B. Shapiro and M. Danly "The role of the right hemisphere in the control of speech prosody in propositional and affective contexts." *Brain and Language*, 25, pp. 19-36, 1985.

[6] E. D. Ross "The aprosodias: Functional-anatomic organization of the affective components of language in the right hemisphere." *Archives of Neurology*, 38, pp. 561-569, 1981.

[7] E. D. Ross and M. Mesulam "Dominant language functions of the right hemisphere?" *Archives of Neurology*, 36, pp. 144-148, 1979.

[8] P. Bhatt "Le fonctionnement du système intonatif et lésions de l'hémisphère droit." In *Neuropsychologie de l'expression orale*, P. Messerli, P. Lavorel and J.L. Nespoulous (eds.), Paris: Editions du C.N.R.S., pp. 194-214, 1983.

[9] J. Ryalls, Y. Joannette and L. Feldman "An acoustic comparison of normal and right-hemisphere-damaged speech prosody." *Cortex*, 23, pp. 685-694, 1987.

[10] M. Dordain, J. Degos and G. Dordain "Troubles de la voix dans les hémiplégies gauches." *Revue de Laryngologie et de Rhinologie*, 92, 178-188, 1971.

[11] P. Bhatt "Temporal variables and fundamental frequency following left anterior or posterior lesion." *Proceedings of the 13th International Congress on Acoustics*, Belgrade: Sava Centar, pp. 441-444, 1989.

[12] P. Bhatt "Temporal variables following unilateral left or right hemisphere lesion." *Proceedings of the 12th International Congress of Phonetic Sciences*, Vol. 5, Aix-en-Provence: Publications de l'Université de Provence, pp. 342-345, 1991.