

BULGARIAN VOWEL CLUSTERS AND STATISTICS

BY 30 MALE AND 30 FEMALE SPEAKERS

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ABSTRACT

In this paper the output is presented of the computer aided analysis of the Bulgarian vowels in /b-b/ context uttered by 30 male and 30 female professional speakers in stressed and in unstressed position, namely the print out of the populations (or vowel clusters) in the F1 vs. F2 plane of equally labeled vowel utterances together with their cluster statistics: means, standard deviations, maximums, minimums, skewnesses and kurtosises.

1. INTRODUCTION

In a previous paper [1] an algorithm has been reported which makes use of phonetic knowledge to perform computer aided analysis of speech followed by formant tracking. It has been described lately how this algorithm has been applied to the processing of a phonetic material [2] from the Bulgarian Central Allophones Data Base [3]. Here will be presented in more details the direct output of the computer processing of this phonetic material.

2. VOWEL CLUSTERS

Central (b-VOWEL-b) allophones of the vowels: /i/, /e/, /ə/, /a/, /u/, /o/

are uttered in Standard Bulgarian by 30 male and 30 female professional speakers in stressed and in unstressed position. The allophones are imbeded in words (See APPENDIX) uttered with falling intonation at the end of a standard carrier sentence. The labeled sound recordings of the vowel utterances are verified by a group of 20 listeners so that the uncorrect utterances to be rejected by the computer and only the correct ones to be admitted to further processing. The analog speech signal is digitalized with a sampling frequency of 20 kHz and then processed with an IBM 360/40 computer. The computer performs a FORTRAN program based on the subroutine FORIT from the SSP [4] and builded up according to the algorithm [1]. The computer produces, except of output listings of the labeled points

(FO, F1, F2, F3) /x/
where LABEL

LABEL = /phonemic symbol
/presence or absence of
stress/sex of speaker/

also two dimensional plots of the sets of equally labeled points in the space of the first two vowel formants (See Fig. Fig. 1 to 4). It

can be seen that the number of points in the clusters on the plots is sometimes smaller than the number of the speakers in each group. This effect is obtained because of: 1) The uncorrect utterances rejected by the group of listeners; 2) The coinciding points in the F1 vs. F2 computer print out; 3) Some single points very distant from the clusters nuclei which got out of the F1 vs. F2 computer print out. There are in fact only three such points exclusively in the female utterances, namely two points in the /i/ cluster above the upper limit of the graph and one more in the cluster of the vowel /a/. The number of coinciding and out-of-the-graph points is presented in the last column of Tab. 1 to 4.

3. CLUSTER STATISTICS

The statistical processing of all vowel utterances verified by the listeners is performed by a FORTRAN program which makes extensive use of the SSP subroutines [4], among them the subroutine TALLY to compute means, standard deviations, maximums and minimums and the subroutine MOMEN to help by the computing of the skewnesses and kurtosises. These statistical estimates, computed for each cluster of equally labeled points, are presented in Tab. Tab. 1 to 4. In the bottom part of each table are presented the statistics of the overall population of the six vowels above.

4. DISCUSSION

As the behavior of the vowel clusters in dependence of the sex of the speakers and of the kind of uttering

them is discussed elsewhere [2] it will be only mentioned now that the results of the computer processing of the raw experimental material reported here support the inferences deduced from the sets of manually determined closed loops in [2].

5. CONCLUSION

The phonetic data presented in this paper may be of use to the scientific community by trivial and computerized comparative phonetics studies and by machine synthesis and recognition of Bulgarian speech.

6. REFERENCES

- [1] CHRISTOV, Ph. (1983), "An algorithm using linguistic information and its application to the analysis of speech in the spectral domain", Proc. XI ICA, Paris, 4, 161-164.
- [2] CHRISTOV, Ph. (1987), "Computer aided analysis of stressed and unstressed Bulgarian vowels from 30 male and 30 female speakers", Proc. XI ICPhS, Tallin, 3, 121-124.
- [3] CHRISTOV, Ph., (1987), "A large Bulgarian central allophones data base", Proc. XI ICPhS, Tallin, 5, 232-235.
- [4] IBM (1970), Application program system/360 Scientific subroutine package, Version 3-th, Programmer's manual, 5-th edit., IBM Techn. Publ. Dpt., New York.

APPENDIX:

Word list in rough phonemic IPA - transcription:

STRESSED	UNSTRESSED
/b'iblija/	/bibl'ejski/
/b'ebe/	/beb'et ef/
/b'aba/	/babal'ək/
/b'əbrek/	/bəbrekov'iden/
/b'obof/	/bob'ovina/
/b'uba/	/bub'ar/

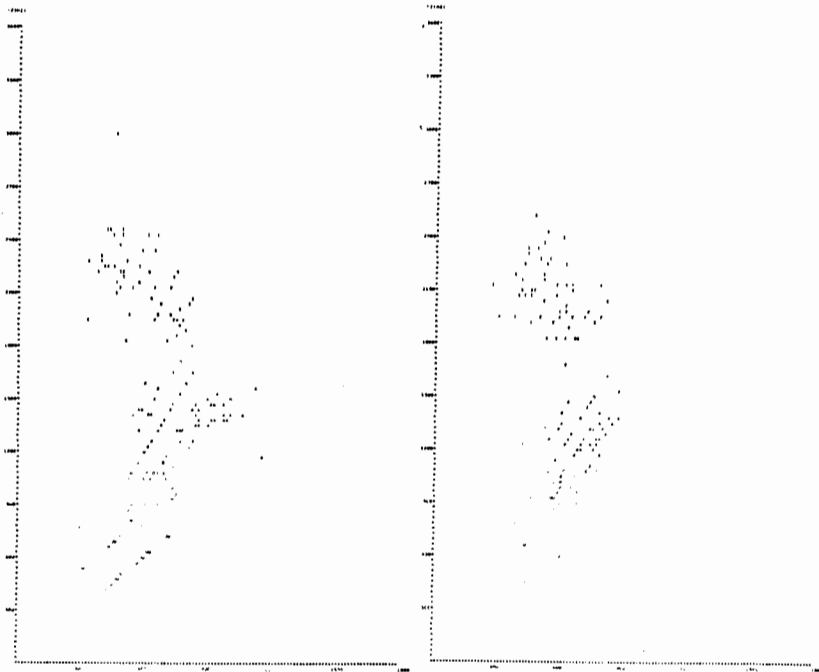


Fig. 1. First two formants computer graph of the six Bulgarian vowels uttered in stressed position by 30 male speakers

Fig. 2. First two formants computer graph of the six Bulgarian vowels uttered in unstressed position by 30 male speakers

TERMINOLOGY:

CLUSTER - a group of objects put together by some resemblant feature (DURAN, B., ODDEL, P. (1974), "Cluster analysis. A survey", Springer Verlag). The term is familiar in the theory of pattern recognition.

LEGEND TO THE FIGURES:

In the computer print outs capital letters from the latine alphabet are used together with the symbol "ape" to designate some symbols of the International Phonetic Alphabet (IPA) as follows:

- I = /i/:
- E = /e/:
- Q = /ɔ/:
- A = /a/:
- U = /u/:
- O = /o/:

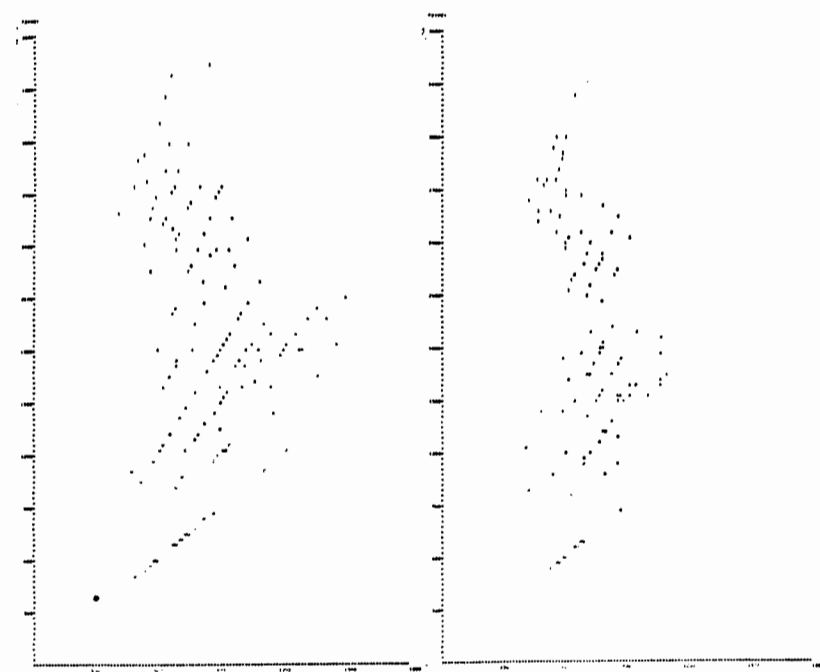


Fig. 3. First two formants computer graph of the six Bulgarian vowels uttered in stressed position by 30 female speakers. There are three points /ɛ/ with rather high second formant which got out of this graph. Two of them are labeled as /'i/, (F1=624, F2=3744) and (F1=850, F2=3825), and one as /'a/, (F1=1176, F2=3864)

Fig. 4. First two formants computer graph of the six Bulgarian vowels uttered in unstressed position by 30 female speakers. The point /ɔ/, (F1=768, F2=1536), which coincides with a point of the /a/-cluster, is not marked on the figure

LEGEND TO THE TABLES:

n - number of vowel utterances admitted to analysis after being verified by a group of 20 listeners

c - number of positions in the F1 vs. F2 plane in which the coordinates of each two or more vowels do coincide or a single vowel gets out of the computer print out

REMARK:

With a single exception (See text to Fig. 4) coinciding points belong to one and the same vowel cluster.