To the problem of multilanguage phonetic database formation: vibrants in English, German, Russian and Chechen

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Abstract

This paper outlines more results of the research on vibrants in different languages and is a kind of continuation of what was presented at the conference SPECOM'2005. The phoneme /r/ has always attracted the attention of linguists and become an object for research. It is outstanding for great intraspeaker and interspeaker variability. Because of great interspeaker variability /r/ is often described as having high speaker-discriminating power. For example, trilled [r]-sounds can differ across subjects in terms of the number and amplitude of taps. So one can speak of vibrants as one of the clues in solving the tasks of speech recognition and speaker identification. The problem can arise from intraspeaker variability in such cases. There are still a lot of uncertainties about some features of vibrants and they are to be studied. The undertaken research aims at forming a phonetic database of vibrants in English, German, Russian and Chechen and performing a comparative analysis of vibrant systems in these languages in order to find some universal and distinctive features.

1. Introduction

One can speak of some universal tendencies typical for vibrants across languages:

- vibrants consist of vocal and consonantal components;
- vibrants usually have one consonantal component in their trilled realizations; etc.

In acoustical terms vibrants in the languages under discussion can be described in the following way:

Typical *English [r]* is a voiced oral post-alveolar approximant which exhibits considerable labialization so that the following vowel can be labialized. The configuration of the vocal tract is rather complicated for this sound: there are three constrictions while articulating it: between the tip of the tongue and the alveopalatal zone, between the dorsum and the pharyngeal wall and in the area of the lips (as it is labialized) [1]. Apical approximants are typical for British English whereas American English is abundant in retroflex approximants.

German /r/ is represented by either an apical-alveolar vibrant [r], or postdorsal-uvular [R], [ʁ], postdorsal-prevelar [ɽ], laryngeal /r/, vocalic allophone [ɐ]. According to the latest material apical-alveolar sounds are as widely-spread as uvular vibrants [2].

The distinguishing feature of *the Russian vibrant system* is the presence of the palatalised vibrant alongside with the nonpalatalised one. They are front cacuminal alveolar rolled sounds.

Articulatorily *Chechen vibrants* are similar to Russian ones, but they are tenser. The palatalised sound is borrowed from the Russian language. The Chechen vibrant system stands out for the voiceless phoneme /r^h/ and the long /·r/.

Distinctive and similar articulatory features of the sounds under discussion are reflected in the following acoustic features:

The typical F-picture of *English approximants* is very similar to that of the retroflex vowel [ə˜] (that is why /r/ is frequently called a semivowel) and can be characterized by the following frequencies: F_1 ~ 300 Hz, F_2 ~ 1000 Hz, F_3 ~ 1600 Hz (a very low F_3 can be regarded as a peculiarity of this English sound) [3]. Formant frequencies of the *German apical-alveolar* vibrant are higher in comparison with those of the English sound: ~ 500 Hz, 1200 Hz, 1970 Hz. *Uvular vibrants* which are said to be even less frequent in German nowadays have the formants F_1 ~ 490 Hz, F_2 ~ 1150 Hz, F_3 ~ 2310 Hz [4]. For *Russian vibrants* formant frequencies are the following: F_1 ~ 400-600 Hz, F_2 ~ 1300-1600 Hz, F_3 ~ 1800-2300 Hz [3] (see fig.1). Information on this aspect of Chechen vibrants is lacking in literature and presents a wide field for investigation.

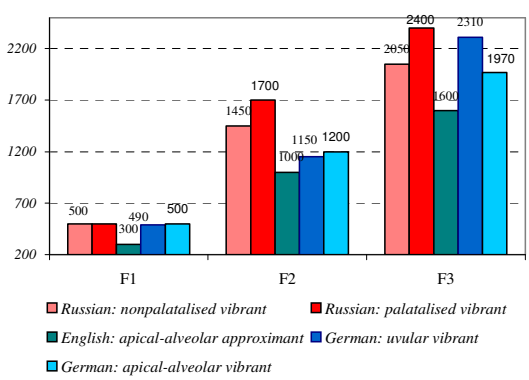

Figure 1: Vibrant formant frequencies (theory)

2. Experimental research

2.1. Speech Material

For the study of *English [r]-sounds* was taken a part of the database Corpus IViE (Intonational Variation in English, UK ESRC award R000237145) formed by Oxford Phonetic Laboratory and Cambridge Speech Center. This part contains

data obtained from adolescent speakers (6 male, 6 female) from Cambridge, Cardiff, Dublin and covers different types of speech activity. The sampling rate of the English speech material was 16000 Hz, with quantization size 16 bits.

German speech material was formed from the read and spoken texts (male and female speakers of different age) from CDs and the Internet radio (HR2). The German material comprised such types of speech activity as reading and spontaneous and quasi-spontaneous speaking. The speech material is of 3 hours' duration; recordings of 10 speakers were analysed. The sampling rate of the material from the CDs was 11025 Hz and from the Internet 22050 Hz, with quantization size 16 bits.

The analysis of *Russian [r]-sounds* was performed on the basis of the database created by a group of specialists under the head of Chuchupal [5]. The database comprised 510 phonetically balanced phrases of 3-5 words read by 6 speakers. The correlation between nonpalatalised and palatalised vibrants in the material is approximately equal to that in Russian speech in general. The sampling rate of the Russian speech material was 22050 Hz, with quantization size 16 bits.

Chechen speech material was collected in the course of the research conducted at the Chair of Applied and Experimental Linguistics (supervisor Prof., Ph.D., Sc.D., Academician of the International Informatization Academy R. K. Potapova) from the Internet-sites of the broadcast "Svoboda" and "Chechnya Free". It comprises 20 hours: the greater part of it (nearly 12 hours) is spontaneous and quasi-spontaneous speaking, the rest is reading. There are recordings of 96 male and 35 female speakers. The sampling rate of the Chechen speech material was 22050 Hz, with quantization size 16 bits.

2.2. Procedure

The speech material was segmented and analysed in the programme Multi-Speech Signal Analysis Workstation and transcribed with the help of the IPA (International Phonetic Alphabet) and the modern phonetic machine-readable alphabet Sampa.

Experimental research included the measurement of the following parameters:

- three formant frequencies F_1, F_2, F_3 of vibrants;
- mean formant frequencies $\overline{F}_1$, $\overline{F}_2$, $\overline{F}_3$ for vibrants in different contexts;
- three formant frequencies F_1, F_2, F_3 of neighbouring vowels and of transitions between vowels and vibrants;
- duration of the sounds under consideration and of their components.

2.3. Results

The analysis of the English speech material has revealed that *English [r]-sounds* are mainly realised as approximants, less frequently as rolled [r]-sounds with 1-2 vibrant components, flaps. As far as linking /r/ is concerned, women tended to stay away from pronouncing it in spontaneous speech unlike men, which coincides with what Laurie Bauer claims [6]. As for the quality of linking /r/ it was mainly pronounced as an approximant (see fig.2) which is congruent with the statement made by some linguists, for example [6]. As it is well-known, some phoneticians insist on its being a flap [7], and it was actually sometimes the case. Very rarely one could come across vibrants in this position (see fig.3).

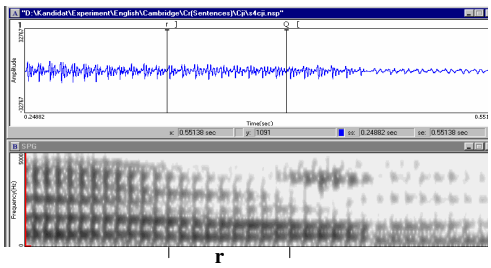

Figure 2: English linking /r/ as an approximant

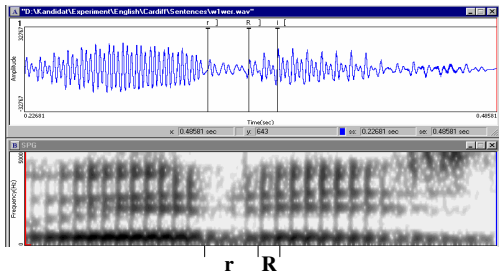

Figure 3: English linking /r/ as a vibrant

German vibrants they were realised as uvular vibrants in 38,39% cases. Fig.4 illustrates the waveforms and spectrograms of such an allophone in the initial position of a word before a stressed vowel on a word-boundary. Vocalic allohones were found in 56,4% cases in contexts where they were expected.

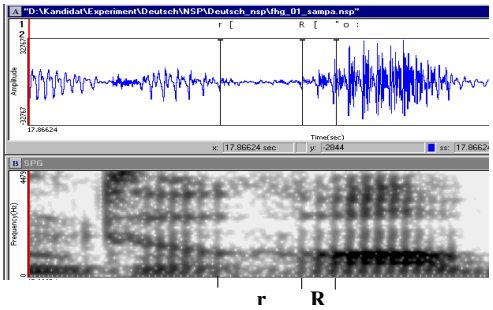

*Figure 4: German uvular vibrant in the word '**R**oboter'*

The next figure shows the vocalic [ɐ] after the stressed long back [o:].

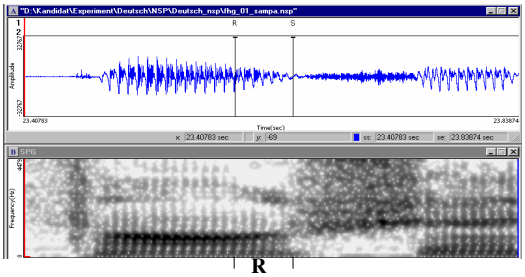

*Figure 5: Vocalic [ɐ] in the word 'For**r**scher'*

In contradiction with modern literature data uvular fricatives, apical-alveolar approximants and vibrants appeared in the analysed material not so often: in 1,42%, 2,37% and 1,42% cases respectively.

Russian fricative *[r]-allophones* were found before voiced and voiceless fricatives for nonpalatalised vibrants (fig. 6). There are cases of both partially and wholly devoiced vibrants in the sentences, it happens before and after voiceless plosives, before a pause, in the phrase-final position (fig.7). This was true both for nonpalatalised and palatalised vibrants. One can also come across approximants (also for nonpalatalised and palatalised [r]-sounds) (fig.8) and nonpalatalised partially nazalised realisations (fig.9).

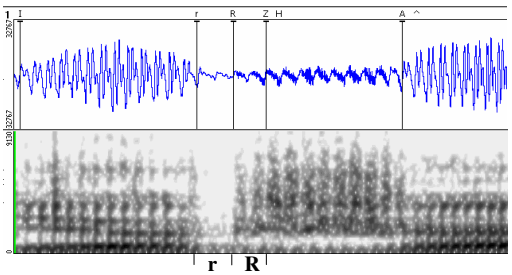

Figure 6: Russian nonpalatalised fricative vibrant in the word 'derzhat'' in the middle of a phrase

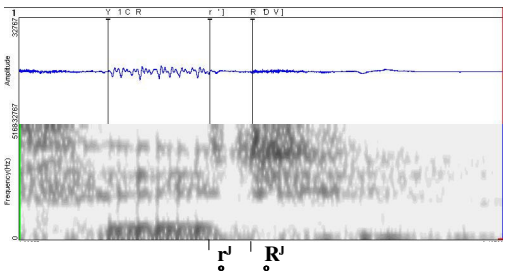

Figure 7: Russian palatalised devoiced vibrant in the word 'pantsir'' at the end of a phrase

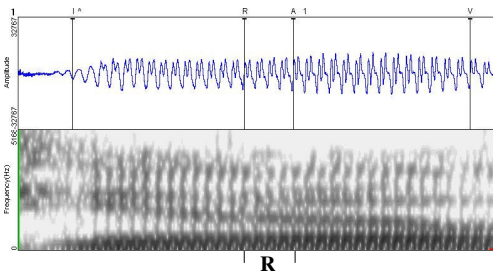

Figure 8: Russian nonpalatalised approximant allophone in the word 'forsiroval' in the middle of a phrase

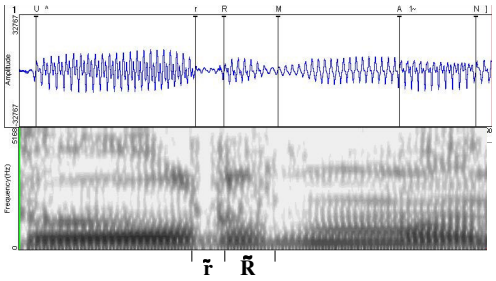

Figure 9: Russian nonpalatalised nasalised vibrant in the word 'shturman' in the initial position of a phrase

As far as the number of closure components is concerned Russian vibrants were also realised in most cases with one vibration (85,65% for nonpalatalised and 89,2% for palatalised vibrants).

The most frequent allophone for *Chechen vibrants* was a vibrant with one vibration (92%); this fact coincides with the observations of Johanna Nichols [8]. As there is no information on acoustic features of Chechen vibrants they were of special interest to us. Isolated realisations of these sounds were examined and the measurements of formant frequencies were taken: F_1 ~ 630 Hz, F_2 ~ 1627-2047 Hz, F_3 ~ 2940 Hz (for a female speaker); F_1 ~ 530 Hz, F_2 ~ 1439-1546 Hz, F_3 ~ 3092-3625 Hz (for a male speaker). Fully and partially devoiced vibrants were found after voiceless plosives, fricative vibrants with distinctive fricative noise under the influence of following voiceless fricatives (figs. 10, 11).

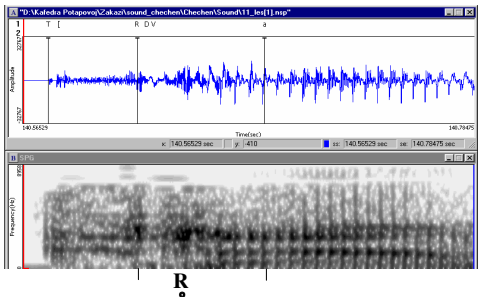

Figure 10: Partially devoiced Chechen vibrant in the word 'tramvajn' ("tram")

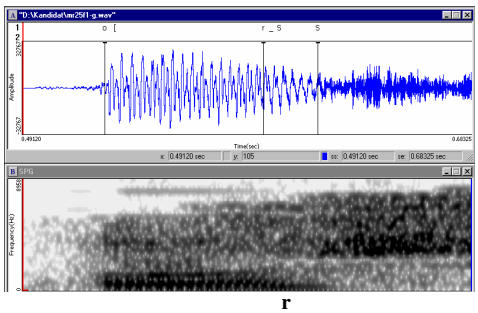

Figure 11: Fricative vibrant in the word 'orshot' ("Monday")

In some cases as Johanna Nichols stated the vibrant in the root 'bar' is really voiceless [8], but it is not a regular case, so

one can hardly speak of a tendency (for comparison figs. 12, 13).

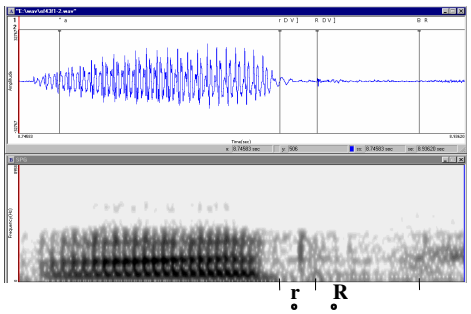

*Figure 12: Chechen voiceless vibrant in the word 'ba**r**' (a female speaker)*

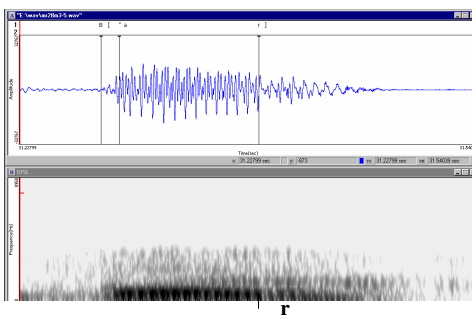

*Figure 13: Chechen voiced vibrant in the word 'ba**r**' (a male speaker)*

According to I.Alirojev, A.Timajev, M.Ovhadov vibrants are weakened at the end of words and phrases [9] and that was the case (fig. 14).

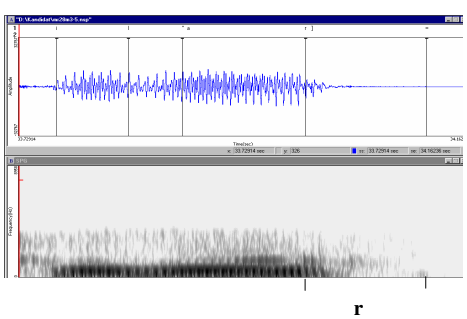

Figure 14: Weakening of a Chechen vibrant in the word 'hilar' before a pause in the middle of a phrase

Mean formant frequencies resulting from the cross-language analysis of vibrants in the speech material are represented in fig.15.

3. Conclusions

The results of the experimental research allow to draw parallels between the vibrant systems of the four languages under consideration and outline some universal features that

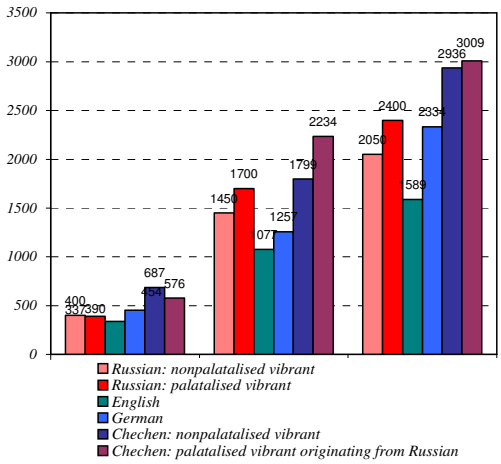

Figure 15: Vibrant mean formant frequencies (experiment)

are congruous with those formulated as a result of the theoretical research:

- rolled [r]-sounds are most frequently realised with one closure component;
- partially and wholly devoiced vibrants appear after voiceless sounds;
- fricative allophones tend to be found before fricatives.

4. References

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