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TOWARD ToRI, A MANUAL TRANSCRIPTION SYSTEM OF RUSSIAN INTONATION

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Abstract

The aim of research project ToRI (2002−2006) is a description of phonetic, phonological and functional properties of Russian intonation with a manual transcription system using unambiguous symbols that will be adapted for and implemented on the Internet as a free interactive research tool and learning module ToRI: Transcription of Russian Intonation. The intended result is a reliable and reproducible transcription system for spoken corpora of Russian (Moscow and St Petersburg varieties). To our knowledge, ToRI will be the first transcription of its kind in which experimentally verified relations between form and contextual function are expressed in unambiguous symbols. ToRI will be designed in such a way that it can be used as a learnable system for linguists and advanced students, as a research tool for (field)work on Russian dialects and intonational contact phenomena of Russian dialects with local languages in Russia, and for comparative and language typology studies. It might also be useful for the development of speech synthesis and, possibly, speech recognition. In this paper[1] some aspects and some first results in the process toward ToRI will be discussed.

1 Background

There exist a large number of publications on Russian intonation. For example Bryzgunova (1977, 1980, 1984), Kodzasov (1996, 1999), Nikolaeva (2000), Svetozarova (1982), Fougeron (1989), and Keijsper (1980, 1983, 1992). In these articles and monographs we find excellent descriptions of Russian intonation, but without a transcription of forms and communicative functions, which was also not the intention of most authors. My own work (Odé, 1989) presents a perceptual description of Russian intonation.

I now propose a course with a description and transcription of forms and communicative functions of intonation, based on an experimental-phonetic analysis in such a way, that forms and functions can be studied and learned by any linguist, teacher or student with a sufficient background in phonetics. Intonation can then be taught to anyone, even without teacher and without having musical ears. ToRI will be an audiovisual, interactive course, available free of charge on the Internet. The

[1] Parts of the present article have earlier been published in Odé (2003a,b,c; forthcoming).

description will consist of an introduction in the necessary terminology with audio examples, and an inventory will be presented of perceptually relevant pitch movements, pitch accents, intonation patterns and contours (for a definition of these terms see section 3). In Odé (2002) problems have been described that led to the development of ToRI.

Inspired by ToDI (Transcription of Dutch Intonation), the suggested transcription of Russian intonation expresses forms in unambiguous symbols. These symbols, developed by intonologists of the autosegmental approach (Arvaniti & Baltazani (1999), Beckman & Ayers (1997), Beckman et al. (2004), Gussenhoven et al. (1999), Gussenhoven (2004)), are nowadays widely used. However, like Gussenhoven (2004), I do not apply the break indices developed by Beckman & Ayers (1997). Though I do not belong to the autosegmental school, I nevertheless believe that the symbols expressing forms of intonation have the advantage of enabling us to compare language-specific forms of intonation occurring in other languages. In my transcription, symbols indicating Russian forms of intonation are based on the results of perception experiments with native speakers. This means that these experiments are crucial for the transcription: the results of the experiments decide from the point of view of the Russian listener which forms they must distinguish and what their phonetic specifications are. Likewise, communicative functions will be expressed in the symbols based on experimental evidence with native listeners. ToRI will thus be developed on the basis of experimental-phonetic analyses and results of experiments, using computer programmes for speech processing PRAAT (Boersma, 2002) and GIPOS (Vogten, 2002). At present a preliminary set of symbols for the form of Russian intonation is available; symbols for the communicative functions are under development.

2 Steps toward the development of ToRI

Steps toward the development of ToRI are the following:

- an experimental evaluation of forms of pitch accents according to Odé (1989);
- a study of contextual functions of types of pitch accent; contextual functions will be experimentally verified with native speakers in perception, production and writing tests;
- a classification of pitch accents and sequences of pitch accents into types with contextual functions and an experimental verification;
- a classification of perceptually relevant pitch movements marking boundaries between strings of words;
- a selection of a new corpus (larger fragments, instructional utterances) for ToRI, consisting of approximately twenty minutes of spontaneous (monologues, dialogues) and prepared speech (theatre/film, news, interviews, literary texts) in the Moscow and St Petersburg varieties pronounced by male and female speakers (adults and children);
- the development of unambiguous symbols for ToRI with direct correlates to their phonetic form and contextual function; testing of the symbols in pilot experiments;
- the transcription of the corpus using provisional ToRI symbols by me and by experienced transcribers of the Moscow and St Petersburg varieties;
- experimental verification of transcription and symbols: experienced transcribers of the two varieties translate utterances into symbols (writing test); another group of experienced transcribers who have not yet participated in experiments for ToRI translate the symbols back into utterances by reading the

transcribed utterances aloud (production test); ideally, the utterances read aloud are perceptually equivalent to the utterances originally used for the transcription; the perceptual equivalence will also be tested by comparing original realizations of utterances translated into symbols with realizations produced on the basis of these symbols; symbols will also be tested with native and non-native students;

- a description of phonetic and functional properties of intonation contours;
- the development of exercises, instructions and feedback for the courseware of ToRI;
- the adaptation and implementation of ToRI on the Internet.

The result of ToRI is an audiovisual, interactive course on the Internet for linguists, teachers and advanced students. The course will be constructed in such a way that Russian intonation can be learned by the linguist or student independently of his/her musical ears and skills to imitate. The time needed and the success depends highly on practical experience and patience of the linguist or student in doing the exercises; visual feedback, keys to exercises and self-control will help them in practising and imitating examples. The course can also be used in the classroom, provided that a computer and audio facilities are available.

ToRI is not just an interactive course for the study of intonation. It can also be used for speech synthesis and, possibly, speech recognition. As far as I know, ToRI will be the first transcription of its kind, and it is expected that it will fill the gap in the field of studying and teaching intonation. Furthermore, ToRI can be used for the analysis of standard Russian intonation in comparison with Russian dialects and other languages spoken in the Russian Federation, e.g. for the analysis of interference phenomena. ToRI with its unambiguous symbols can also be used as a research tool for e.g. the description of prosody in the art of storytelling (legends, myths of origin, folktales). ToRI is thus not only a transcription of intonation in unambiguous symbols, but also an instrument for the description of intonation for all types of speech style.

3 Terminology

In this section I will describe terms with respect to intonation that are widely used by linguists and phoneticians-intonologists, but by no means always in the same sense.

Intonation is defined as a prosodic phenomenon on the level of the utterance, together with such prosodic phenomena on the same level as temporal organization, prominence, and marking boundaries between strings of words. *Prosodic* phenomena, together with lexical, morphological, syntactic aspects, and other phenomena such as gestures, facial expressions and situation, are linguistically relevant and contribute to the overall understanding of spoken messages in the interaction between speaker and hearer. In the process of interaction, intonation is an essential component.

Intonation or *speech melody* is the ensemble of pitch variations in the course of an utterance (according to ’t Hart et al. (1990:10)), of which the phonetic form can be described from the acoustic, perceptual and physiological point of view (see also Odé (1993)). All languages of the world have intonation, but the way it is brought about is highly language-specific. Formal features of intonation are the pitch movements: changes in the fundamental frequency curve are responsible for the perception of melody. However, not all pitch movements are equally relevant for the perception of melody. Which ones actually *are* must be established and verified in perception experiments with native listeners. A description of this complex process in Russian can be found in Odé (1989, 1993).

If in a language with lexical stress, like Russian, a pitch movement or a configuration of pitch movements lends perceptual prominence to a syllable (usually the syllable with lexical stress), the given movement or configuration of movements constitutes a *pitch accent*. Bolinger was the first to define the notion of pitch accent: “any stressed syllable *can* be accented; which ones *are* depends on the intent of the speaker” (Bolinger, 1972:22; if a syllable is accented by means of pitch, the accent is a pitch accent (Bolinger, 1986:10f, 24f). A word with a pitch-accented syllable is more prominent than its surrounding words without such syllable. For instance, a speaker realizes pitch accents in words that s/he wants to emphasize, in order to convey to the listener which words in a given utterance are important, contain new information, contrast with other words, express emotions. Though pitch is a very strong parameter, note that it is not the only parameter to lend prominence to a syllable. There are other prosodic cues like intensity, duration, vowel quality and variations in speech tempo that may lend prominence to a syllable. In Russian, especially important in this respect is the interaction between intonation and word order. This issue will not be discussed here.

Forms of perceptually relevant pitch movements and pitch accents in Russian are described in Odé (1989, 1991, 1992, 1995). Thirteen types of pitch accent, verified in perception experiments with native listeners, have been found to exist. Realizations of one type of pitch accent may not be identical, but must be perceptually equivalent, that is, melodically similar. Realizations of one specific type of pitch accent are considered perceptually equivalent, if they are good imitations of one another within limits of perceptual tolerance. I expect that there must be a correlation between the melodic form and the interpretation of a given type of pitch accent (Odé, 1989:37-39). A type of pitch accent may have different contextual functions, for example “incompleteness” in one context and “question” in another. At the same time, different types of pitch accent may occur in interrogative utterances. Therefore, it must be studied with which contextual functions realizations of one type of pitch accent occur. Within ToRI, the notion *perceptual equivalence* or, if dealing with forms, the *melodic similarity* of realizations of a pitch accent, is extremely important in the sense that a symbol, expressing one type of pitch accent, must contain all perceptually equivalent realizations of that given type.

Furthermore, an intonation *pattern* is defined as a fixed concatenation of pitch accents. An intonation *contour* is a sequence of pitch movements in the course of an utterance between two prosodic boundaries. Such boundaries are marked by a reset upwards or downwards in the fundamental frequency, or by a switch of a pitch movement into another direction between two pitch-accented words. In defining the notions *pattern* and *contour* this way, an utterance can be realized with an intonation contour having one or more pitch accents or intonation patterns.

To end this section, the main functional properties of intonation in different contexts of communication are:

- lending prominence;
- distinguishing between sentence types (e.g. question, statement);
- indicating whether the utterance has been completed or not;
- enabling the speaker to organize the utterance and the hearer to perceive which words belong together (prosodic grouping);
- indicating whether the speaker has finished and the hearer may speak (turn-taking);
- expressing the relationship between speaker and hearer;
- expressing emotions and emphasis.

I would like to repeat that not only intonation, but also other prosodic parameters, or rather the ensemble of these parameters that are beyond the scope of this article, can fulfil these communicative functions. However, research project ToRI deals with pitch phenomena that are highly responsible for the perception of the functions mentioned above in this section.

4 First experiments

The first step toward ToRI symbols was the evaluation of the classification in my thesis (Odé, 1989) in eleven experimentally verified types of pitch accent occurring in spontaneous and prepared speech (two types were not included in the evaluation, see below). Two experiments were conducted to verify the perceptual equivalence of the types with realizations of types in spontaneous and prepared speech by other speakers. The aim of the two experiments was to check whether my classification of Russian pitch accents described in Odé (1989) covers all existing types, and thus would directly be usable for ToRI, or needs to be adjusted. In other words, is the then used corpus of 15 minutes of spontaneous and prepared speech with eight male and three female speakers (henceforth: corpus A) an exhaustive representation of types of Russian intonation? The results show (see below, this section) that the answer to the question is positive: the classification can serve as a basis for the development of ToRI symbols for the form of Russian pitch accents, if taking into account the limits of perceptual tolerance of the types of pitch accent. Changes in the realization of intonation during the last two generations may also be an issue, but this phenomenon is not studied yet. The classification was tested in the two experiments as follows.

I compared realizations of one type of pitch accent from corpus A to melodically similar realizations in a new corpus in order to verify their perceptual equivalence, that is, one realization being a good imitation of a melodically similar realization. The new corpus (henceforth: corpus B) consists of not yet analysed spontaneous and prepared speech from other speakers than corpus A. The digital recordings used for corpus B have recently been made in St Petersburg; speakers are from 18 to 50 years old. On the basis of perceptual equivalence I tentatively classified realizations of pitch accents in corpus B into one of the eleven types of pitch accent for verification in a paired-comparison experiment. I expected that listeners could have problems with corpus B realizations of types of pitch accent with phonetic specifications at the extreme of the limits of perceptual tolerance of that type. These extremes are the minimum and maximum values of the phonetic specifications of pitch accents: excursion size, posttonic part, timing. According to the results of perception experiments and the phonetic specifications described in Odé (1989), stimuli were still within those limits. I expected stimulus pairs that are *not* realized at the extreme of those limits to score high as to perceptual equivalence. Realizations in corpus B of which the type of accent could not easily be identified by myself were not included. In order to find out to which type those realizations belong, or to see if any new types of accent would be revealed, I selected them for a classification experiment.

For the *paired-comparison* 110 stimuli were selected from corpus A and B, 10 for each of the eleven types of pitch accent. Speakers were two female and eight male speakers from corpus A, and two female and three male speakers from corpus B. Since new symbols for ToRI are still under development, the eleven pitch accents are described with names after their phonetic specifications according to Odé (1989). They are the following: Rh-, Rl-, Rm-/+, rl-/+, rm-/+, Fl-, Fl+, Fnl-, Fnl+, Fh-, f-/+. The five rising pitch accents have a large excursion (R), a small excursion (r), three different posttonic parts, high (h), mid (m) and low (l), and different timing (the position in the accented syllable where the end frequency of a pitch movement is reached), namely early (-) or late (+). The six falling accents have a large excursion (F), a small excursion (f), three different posttonic parts, low (l), non-low (nl) and high (h), and different timing, early (-) or late (+). Two types were not included in the experiment: type Rø- and type F^n+: the former has no posttonics and is a neutralization of types Rl- and Rh-, the latter is a repeated realization of type Fnl+/Fl+.

The *classification* experiment consisted of 50 stimuli, 25 by two female and 25 by three male speakers, with unidentified types of pitch accent selected from corpus B. As reference accents, two series of eleven short utterances with a representative realization of each type were selected from corpus A and stored under two rows of eleven buttons: one row with realizations by two female and one row with realizations by six male speakers. Those realizations of reference accents were selected such that they have, according to Odé (1989), the most frequently occurring phonetic specifications.

The experiments were carried out in St Petersburg and Moscow in 2002. Twelve subjects took part in the paired-comparison experiment. Controlled by a computer, their task was to indicate the perceptual equivalence of the type of pitch accent of each randomly presented pair by pressing a button "same" or "different". Six subjects participated in the classification experiment in two runs with a sorting task: they compared each stimulus to the eleven types of pitch accent and, by pressing one of the eleven buttons under which the eleven types of pitch accent were stored, matched the accents. In the second run a twelfth button was added: "no match". Detailed instructions preceded the two experiments; stimuli were presented without text. For a detailed description of stimuli, subjects and task the reader is referred to Odé (2003a).

4.1 Paired-comparison experiment

The results for the paired comparison are presented in Figures 1 and 2. The histograms show real numbers of same/perceptually equivalent (white) or different/not perceptually equivalent (black) realizations, with on the y-axis the number of stimulus pairs (maximum 110), on the x-axis the types of pitch accent. Figure 1 shows that falling accents Fl-, Fl+, Fnl-, and Figure 2 that rising accents Rh-, Rl- and Rm-/+ give the highest score for perceptual equivalence; falling accents Fnl+, Fh-, f-/+, and small rising accents rl-/+ and rm-/+, score almost chance. The time needed to fulfil the task was from one hour to 15 minutes.

After completing the experiment, subjects reported their problems with the task. Most of them did not know what to concentrate on if the duration of stimuli or the number of accents in the stimuli were not equal. The stimulus pairs with supposedly perceptually equivalent pitch accents were indeed not always equal as to their duration and number of pitch accents occurring in them. In this respect there were three types of stimulus pairs: 1) pairs with one pitch accent in each stimulus, 2) pairs with two different pitch accents in each stimulus, and 3) pairs with an unequal number of pitch accents. Note that if two accents occurred in one stimulus, there was in my perception only one type in each stimulus that could possibly be compared, the others being completely different. Therefore, in Figures 3 and 4 the results are presented separately, taking into account the inequality of stimuli: same/perceptually equivalent pairs in "equal" pairs (white), same/perceptually equivalent pairs in "unequal" pairs (diagonal stripes), and different/not perceptually equivalent pairs in "equal" pairs (black) and different/not perceptually equivalent pairs in "unequal" pairs (horizontal stripes). For a further discussion with examples of equal and unequal pairs see section 6, Figures 6-10.

By looking at the scores averaged over the 11 types of pitch accent for subjects individually, I found that according to the Chi-square test for equality of distributions, there is a significant difference between them of $p<0.000000$. Their scores are shown in Figure 5. Some subjects had less problems with “unequal” pairs.

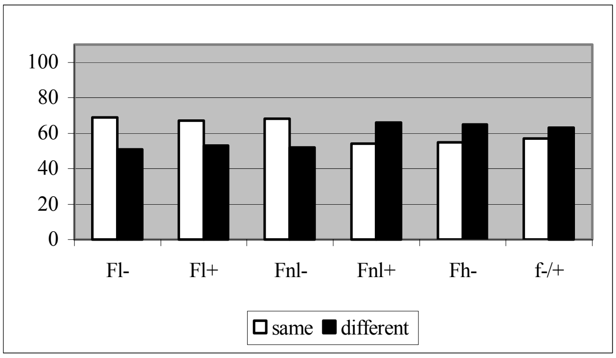

Fig. 1. Results for the six *falling* pitch accents. The histograms show real numbers of same/perceptually equivalent (white) and different/not perceptually equivalent (black) realizations. On the y-axis the number of stimulus pairs (maximum 110); on the x-axis the types of pitch accent.

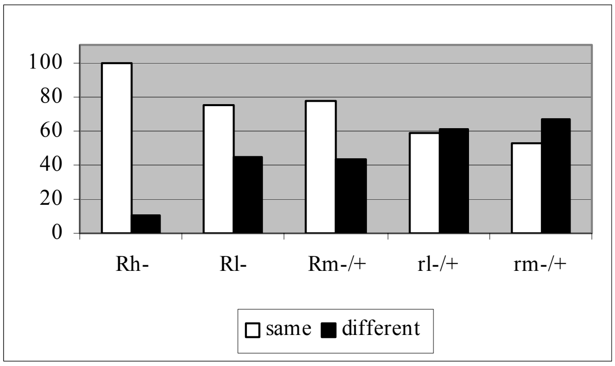

Fig. 2. Results for the five *rising* pitch accents. The histograms show real numbers of same/perceptually equivalent (white) and different/not perceptually equivalent (black) realizations. On the y-axis the number of stimulus pairs (maximum 110); on the x-axis the types of pitch accent.

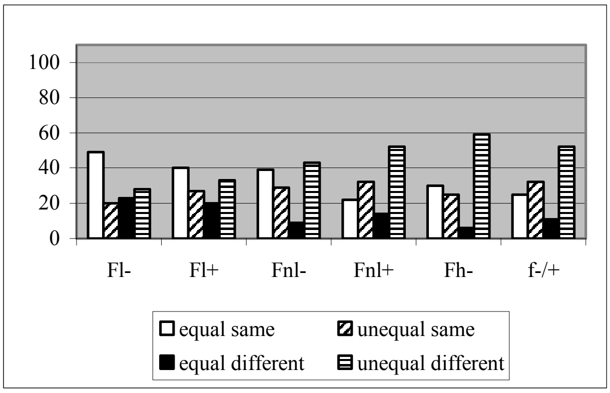

Fig. 3. Results of “equal” vs. “unequal” pairs for *falling* pitch accents. The histograms show real numbers of same/perceptually equivalent realizations in “equal” (white) and “unequal” (diagonal stripes) pairs, and different/not perceptually equivalent in “equal” (black) and in “unequal” pairs (horizontal stripes). On the y-axis the number of stimulus pairs (maximum 110); on the x-axis the types of pitch accent.

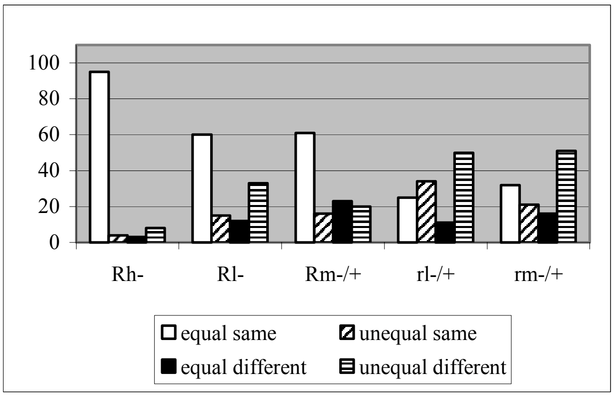

Fig. 4. Results of "equal" vs. "unequal" pairs for *rising* pitch accents. The histograms show real numbers of same/perceptually equivalent realizations in "equal" (white) and "unequal" (diagonal stripes) pairs, and different/not perceptually equivalent in "equal" (black) and in "unequal" pairs (horizontal stripes). On the y-axis the number of stimulus pairs (maximum 110); on the x-axis the types of pitch accent.

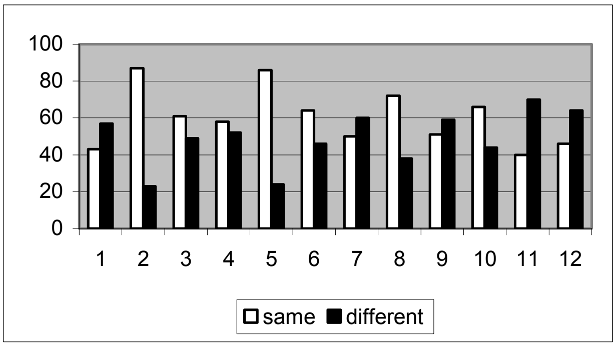

Fig. 5. Results of the paired comparison (averaged over all 11 types of pitch accent) for the individual subjects. The histograms show real numbers of same/perceptually equivalent (white) and different/not perceptually equivalent (black) realizations. On the y-axis the number of stimulus pairs (maximum 110); on the x-axis the twelve subjects.

Finally, I expected problems with realizations of types of pitch accent with phonetic specifications at the extreme of the limits of perceptual tolerance (an example can be found in Figure 10). Yet stimuli at those extremes were also included in this paired comparison experiment for verification, because, ideally, my classification should cover *all* realizations of a given type. The issue is further discussed in section 5.

4.2 Classification experiment

The aim of the first run of the classification experiment was to find out to which of the eleven reference accents from corpus A, the 50 yet unidentified realizations from corpus B were perceptually equivalent (forced choice); in the second run subjects were allowed to indicate that a given realization was not perceptually equivalent to any of the eleven reference accents ("no match"). The six subjects did not much agree among each other and among themselves. For example, one female stimulus was for two subjects perceptually equivalent to accent Rl-, for two to Rh-, for one to Rm- and for one to Fh-, all different and rather salient types of accent. There are many such examples. The number of stimuli that were matched with the same reference accent in both runs varies per subject from 10 to 22 stimuli with a total of 96 stimuli out of 300 (50 stimuli x 6 subjects) or 32%. The number of stimuli that in the first run were matched with another reference accent than in the second run varies per subject from 15 to 29 stimuli with a total of 134 out of 300 or 44%. The number of "no match" stimuli in the second run varies per subject from 4 to 19 with a total of 70 out of 300 or 23%. The results for the second run of the classification experiment as compared to the first run are presented in percentages in Table 1 below. Note that from whatever point of view one arranges the results, stimuli have been scattered seemingly randomly over the eleven reference accents.

Table 1. Results in percentages for the second run as compared to the first run: same, other reference accent or "no match"; between brackets the minimum and maximum percentages for the subjects.

	chosen accents in %
same reference accent	32 (20-44)
other reference accent	44 (30-58)
"no match"	23 (8-38)

5 Discussion

On the basis of the results for the *paired-comparison experiment* in "equal" pairs I conclude that the classification in eleven pitch accents as described in Odé (1989) needs not to be adjusted as long as pitch accents are realized away from the extremes of the limits of perceptual tolerance. In analysing such realizations close to or at the extreme of these limits I observed confusion among subjects. An example is the stimulus pair with type Rl- which had a score for perceptual equivalence of only 25%. According to Odé (1989) type Rl- has, if measured from the lowest level of the speaker, an average excursion size of 17 semitones. In this stimulus pair, the corpus A realization has an excursion size of 24 semitones, in corpus B of 12 semitones; a picture of this pair is presented in Figure 10. Also, in a given melodic context, an overlap at the formal borderline may occur between two types of accents as, for example, one stimulus pair with type Rm-/+: one member is realized with its minimum excursion size and one with its maximum; the former may bring the type close to or over the borderline with type rm-/+. Keeping the aim of ToRI in mind, viz. a course of Russian intonation, this means that the distance between the minimum and maximum values of the phonetic specifications of the accents that will be translated into symbols for ToRI must be much smaller.

In future experiments, stimuli of different duration with an "unequal" number of pitch accents should thus be avoided. Furthermore, if the aim of an experiment is to verify the perceptual equivalence of types of pitch accent, pairs with different contextual functions are problematic. The question is whether pitch accents that are *in melody perceptually equivalent* can have *different contextual functions* and pitch accents that are *in melody not perceptually equivalent* can have *same contextual functions*. The study of this problem is now at issue.

The confusing results from the *classification experiment* are not so surprising after all. I had some difficulties in identifying the stimuli myself. Obviously, with a few exceptions, neither could the subjects. Stimuli that did not match in the second run were in the first run considered to be perceptually equivalent to types of accents that I would call more or less "neutral" with respect to their contextual function.

Furthermore, I suspect that also for this experiment "unequal" stimuli and realizations of stimuli at the extreme of limits of perceptual tolerance are responsible for this outcome. Another factor that one cannot rule out is the not yet analysed effect of observed changes in intonation during one generation. Many stimuli were pronounced by young speakers from 18 to 24 years old; two subjects who are also from that generation, carried out tasks quicker than the generation above 40. In developing ToRI, all the factors mentioned above must be taken into account.

6 Some final remarks

Subjects had difficulty to compare the speech melody in a stimulus pair, whenever the accent expresses different communicative functions, for example, a question and incompleteness. In the instructions subjects were asked not to pay attention to the content of stimuli, but obviously subjects could not "switch off" their linguistic consciousness. In this respect the following is remarkable. Before the actual experiment, I tested the construction and tasks of the experiment with some non-native listeners, Dutch musicians and a phonetician, in Amsterdam. Note that Dutch, like Russian, is an intonation language with lexical stress. The Dutch listeners were not hampered by the inequality of stimuli pairs. They understood quite well which accents had to be compared, also when one member of a pair had one, the other member two accents. However, accents realized at the extremes of perceptual tolerance were a problem also for them. In Figures 6-10 examples of unequal pairs with realizations of pitch accent Rl- are presented. The scores indicated in the captions of Figures 6-10 are values for the Russian listeners. The texts of the stimuli in Figures 6-10 with an English translation in Russian word order are:

Fig. 6: *a kogda Lenskii poet* 'but when Lensky sings'
kak budto vypolnila 'as it were fulfilled'

Fig. 7: *tam konkurs na samom dele byl* 'there a competition indeed was'
pristaviat menia k stene '(they) put me against the wall'

Fig. 8: *a my poedem* 'but we will go'
khozhu li ia v teatry 'go I to theatres'

Fig. 9: *s deviatogo po odinnadtsatyi klass* 'from the ninth to the eleventh class'
oni studenty 'they (are) students'

Fig. 10: *delo v tom chto ne oni poedut* 'the point is that not they will go'
govorili po frantsuzski '(they) spoke French'

Note that each stimulus pair is always pronounced by either two female or two male speakers.

What we can learn from the results of the paired comparison and classification experiments for the development of ToRI is the following. In presenting examples of the form of pitch accents only one pitch accent with one communicative function may occur. The criterion for the selection of examples must be a salient realization of a given type of pitch accent, and realizations at the extremes of perceptual tolerance must be avoided.

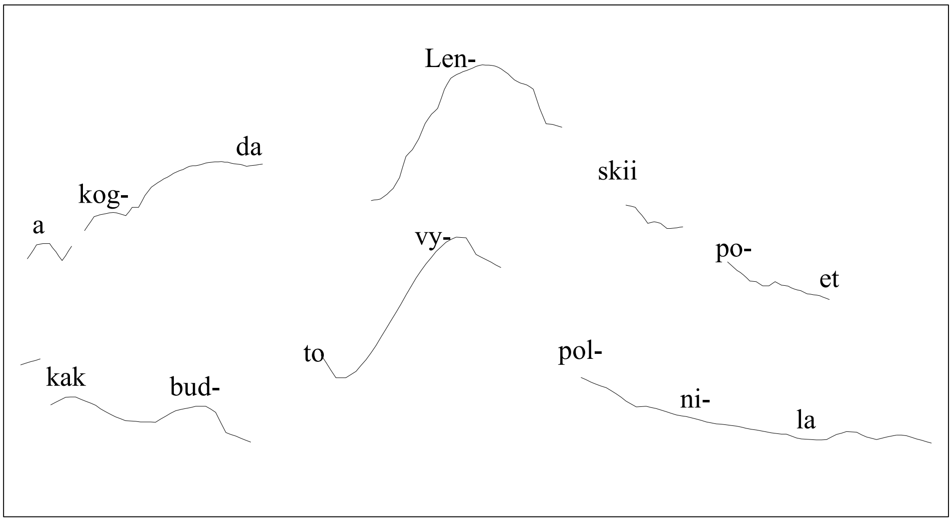

Fig. 6. A pair of stimuli with one type of pitch accent (Rl-) in the words “Lenskii” (top) and “vypolnila” (bottom) and one communicative function (contrast, incompleteness), This pair received the maximum score in the paired comparison.

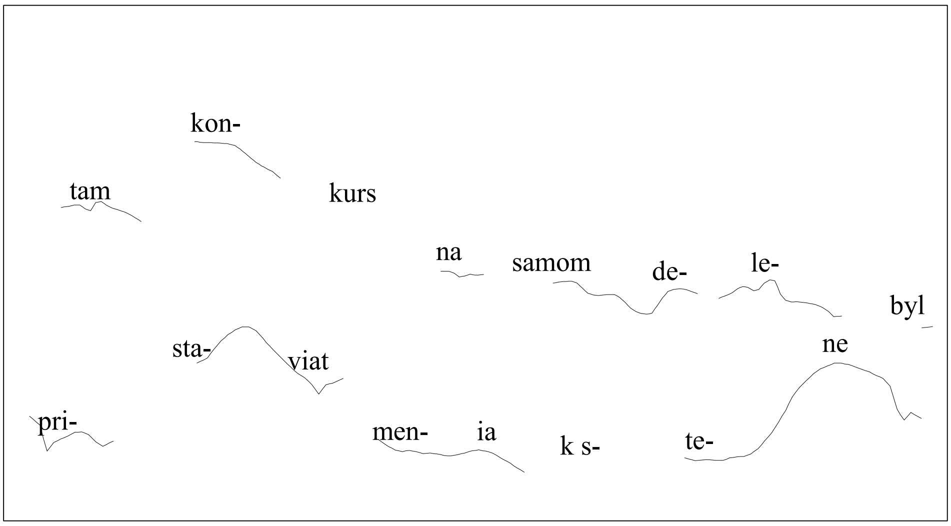

Fig. 7. A pair of stimuli with an unequal number of pitch accents. In the upper contour one pitch accent (Rl-) in the word “konkurs”, in the lower contour two accents in the words “pristaviat” (Rl-) and “stene” (Rm-/+). Of course the first pitch accent, type Rl-, was supposed to be compared. The score for perceptual equivalence was only 16%.

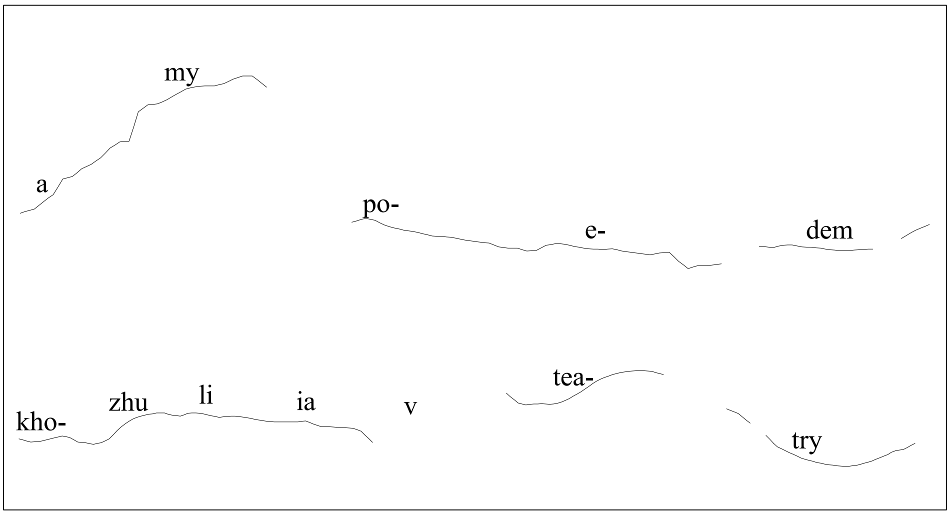

Fig. 8. A pair of stimuli with the same type of pitch accent (Rl-) but with a different communicative function. In the upper contour there is a contrastive accent in the word "my", in the lower contour a question in the word "teatry". The score for perceptual equivalence was only 33%.

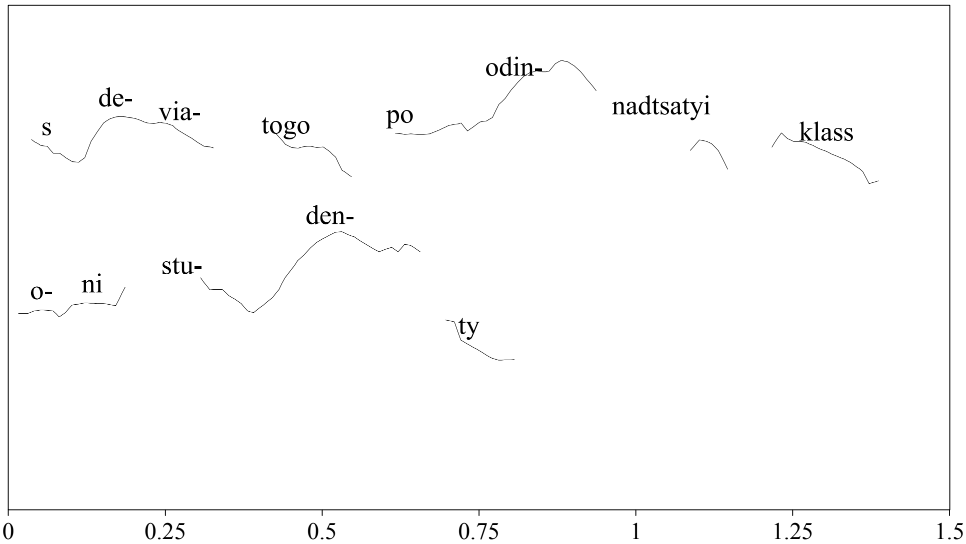

Fig. 9. A pair of stimuli with the same type of pitch accent (Rl-), but with a different duration: the upper contour is twice as long as the lower. On the horizontal axis the time scale is indicated in seconds. This pair scored 50% for perceptual equivalence.

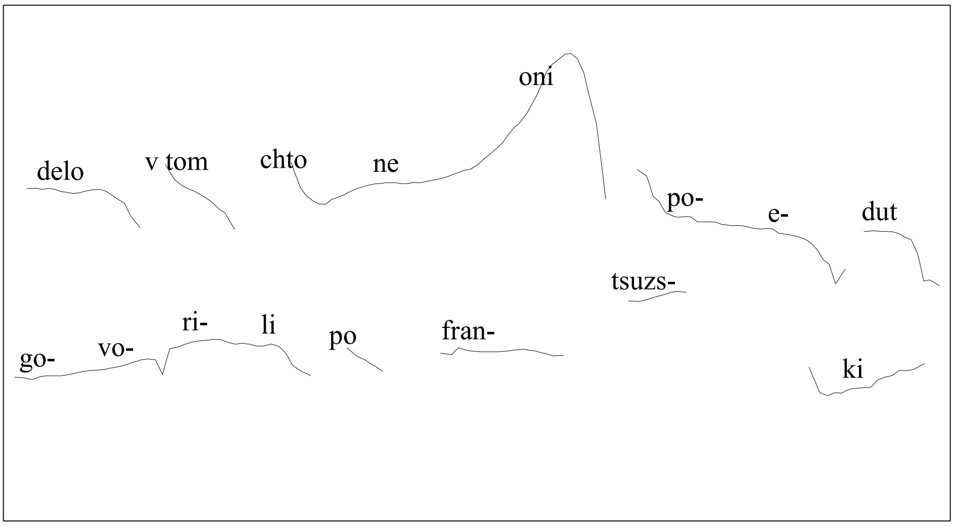

Fig. 10. A pair of stimuli with the same type of pitch accent (Rl-) in the words "oni" (upper contour) and "frantsuzski" (lower contour). The accents are realized at the extremes of perceptual tolerance: salient in the upper contour, weak in the lower. Only 25% of the subjects indicated the perceptual equivalence of the two accents.

Acknowledgments

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