F0 DECLINATION IN RUSSIAN REVISITED

Daniil Kocharov, Nina Volskaya, Pavel Skrelin

Department of Phonetics, Saint Petersburg State University, Russia
kocharov@phonetics.pu.ru, volni@phonetics.pu.ru, skrelin@phonetics.pu.ru

ABSTRACT

This paper deals with F0 declination in Russian. The study was conducted using statistical data derived from the Corpus of Professionally Read Speech. The results confirm the relationship between F0 slope and the utterance length for Russian. At the same time they reveal a) individual strategies in pre-planning declination slope of the phrase or utterance; b) strong dependency of the F0 slope on the intonation pattern of the utterance: thus complete final declaratives have steeper slope than non-final units, at the same time interrogatives (yes-no questions) with rising nuclear tone display no declination in the pre-nuclear part. These results support the idea that declination is linguistically controlled.

Keywords: declination, pre-planning, declination and intonation type

1. INTRODUCTION

Declination, defined as the tendency for fundamental frequency to glide gradually down during the course of an utterance [10], [3], has been studied in many aspects and for many languages, tonal languages included [11], [20], and it is considered to be a universal [17], [9], [5]. It is said to characterize sentences spoken in isolation, read aloud and (less so) spontaneously produced speech, its pattern and slope may vary with style and sentence length [9], [1], [6]. For Swedish, for example, a difference was defined in degree of declination between the two speaking styles: read-aloud speech was reported to have steeper slope and a more apparent time-dependency than spontaneous speech [14]. Similar results were reported for tonal languages. On the other hand, the variability in data is so large, that there are growing doubts about universality of declination [16].

Despite numerous studies of this phenomenon the question remains whether it is conditioned by physiological factors or it is linguistically controlled and is rather due to the speaker's intentions.

If we assumed that declination was systematically determined by dropping sub-glottal pressure, we could easily model all intonation types in a particular language, but the intonation models for speech synthesis, using a uniform declination for all utterances of the same length and type proved to be too simple [3]. In fact the situation is more complicated: for some languages, for example, Danish [15], Dutch [4], and Russian [13], [8], [18] an effect of sentence type on the declination slope was observed which supports the view that declination is linguistically controlled.

2. DATA AND METHOD

2.1. Material

For the present study, we analyzed recordings from the Corpus of Professionally Read Speech made from 8 professional: 4 female (F) and 4 male (M) speakers of Standard Russian [12].The material had been prosodically annotated. Here we concentrated on two prosodic constituents: the intonational phrase(IP) [7] and the prosodic word (PW). The latter is used here in its traditional sense for a content word and its clitics, which include all items that lose their lexical stress and thus form one rhythmic unit with a "properly" stressed word. In Russian many function words may be unstressed or weakly stressed but unaccented, so a PW is the one which is both stressed and carries a pitch accent.

IPs, selected from the CORPRES, differ in size (from 3 to 6 PWs) and represent different types of utterances: final complete declaratives, non-final declaratives of the most common type and intonation pattern, and general questions. They have different (polar) intonation contours (IC): falling for complete final statements, rising for non-final units and questions. The total material analyzed includes 13321 IPs.

2.2. Measurements

F0 declination was estimated by the top-line of F0 contour. The top-line was calculated using F0 data (in semitones) for each successive pitch accent in the IP as the difference (in semitones) of the F0 maximum of the accented vowel in the PW and the F0 maximum of the accented vowel of the first PW in
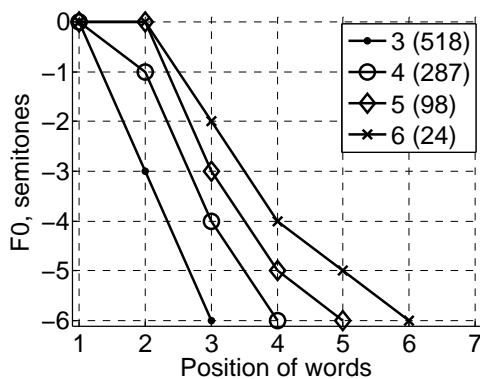
the IP.

3. DATA ANALYSIS

Plots of F0 declination for IPs of different intonational types produced by different speakers are presented in figures below. They illustrate the length-slope dependency of F0 declination and show the averaged F0 values for each PW in an IP. The F0 values are calculated as described in section 2.2. The legends contain the information on the length of intonation units in PWs and the number of analyzed samples (in brackets). The position of PWs in IPs is shown on the x-axis. The F0 value in semitones is shown on the y-axis. Final and non-final declaratives are illustrated by IPs of 3–6 PWs long, and general questions are illustrated by the IPS of 3–5 PWs long.

3.1. Declination in final declaratives. Classical pattern

All intonational phrases independently of their size demonstrate F0 declination. A classical image of a fairly 'disciplined' F0 downdrift is presented in Fig. 1. The pitch level of all the PWs is strictly scaled and distributed over the IP is such a way as to 'hit' the final pitch level of –6 semitones. It is also evident from the F0 trend that the slope of the declination decreases with growing number of PWs.

The end F0 value of IPs produced by speakers M1 (Fig. 1) and M3 (Fig. 2) shows practically no variation.

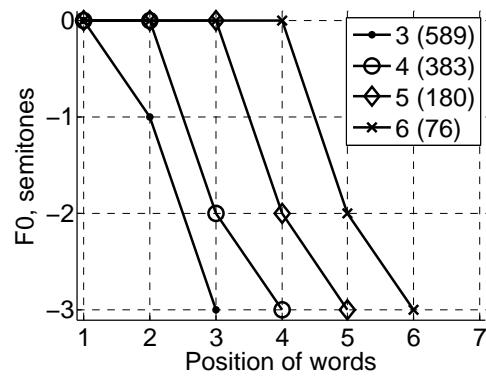**Figure 1:** F0 declination in final declaratives. Speaker M1.

Pitch range adjustment within the IP demonstrates individual strategies to the downstepping of pitch accents in the IU containing more than 5 words. For two subjects having a relatively narrow pitch range it took the form of sustaining the pitch level

of the first 2–4 PWs before resuming F0 downstepping (see Fig. 2). Fig. 2 allows us to compare scaling of the pitch level of successive accents with the increasing number of PWs for the speaker M3: actually, for all the IPs except those containing 3 PWs the declination proper begins with the last but two PWs.

For some speakers the increased size of the IP triggers lowering of the pitch level of the final pitch accent, at the same time declination in the first 3–4 pitch accents is absent (see Fig. 3).

Figure 2: F0 declination in final declaratives. Speaker M3.

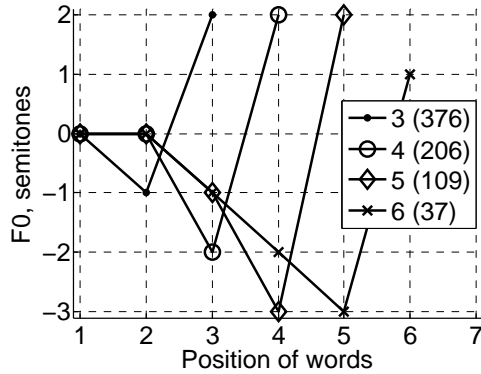**Figure 3:** F0 declination in final declaratives. Speaker M2.
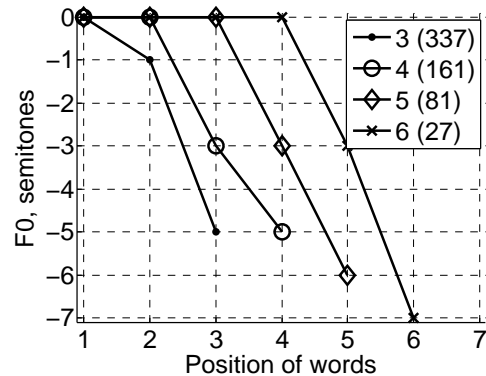
3.2. Declination in non-final declaratives

As we can conclude from our data, in non-final declaratives the declination line is less steep, though it also demonstrates dependency on the length of the intonational unit—for all speakers it increases with the number of the PWs, but does not exceed –4 semitones (see Fig. 4).
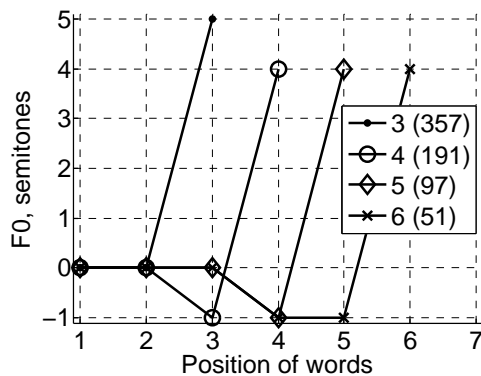
For some speakers the F0 declination takes the

form of lowering the last pitch accent before the rising nucleus and does not exceed 1-2 semitones. It is evident from the F0 trend, but if fact it is not perceived (see Fig. 5).

Figure 4: F0 declination in non-final declaratives. Speaker F1.

Figure 5: F0 declination in non-final declaratives. Speaker F3.


3.3. Declination in general questions

We present data on general questions having maximum 4 PWs, since normally questions are pretty short. F0 trend in Russian general questions (Fig. 6) shows that declination is under control of the speaker and that pre-planning of the whole contour does take place, for in this type of utterance there is no F0 declination regardless of the length of the utterance [18].

3.4. Declination in case of prominence

The description of declination would not be complete without considering its behavior in case of prominence. We regarded two main types of promi-

Figure 6: F0 declination in general questions. Speaker F3.
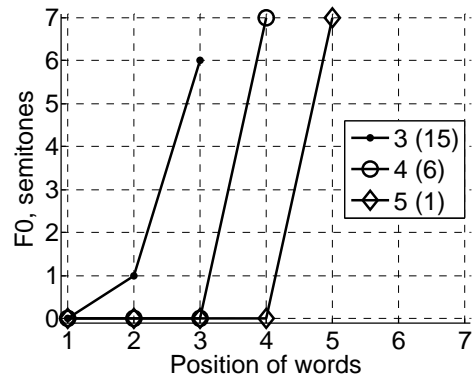
nence: extra emphasis superimposed on the IP nucleus, and the shift of the nucleus from the last word to some other word in the IP.

Figures 7 and 8 illustrate prominence in final declaratives containing 4 PWs pronounced by the same speaker. They show F0 trends in units with and without emphasized word. A solid line shows F0 change within the accented vowel of the prominent word and the arrow indicates direction of the tonal movement: falling or rising. F0 data presented was obtained in the same way as for the previous cases; the only difference is the base value of semitone calculation which is the mean F0 value in IP.
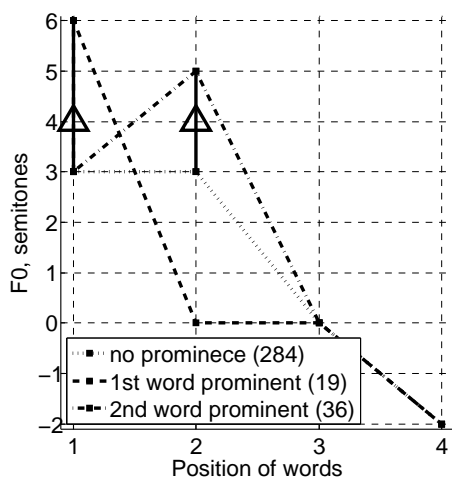
Fig. 7 shows that the emphatic accent is manifested by the declination reset (upstep) and F0 rise within the prominent word. The declination returns to its 'original' trend afterwards; note that scaling of pitch accents between the third and the forth word is independent of prominence. Fig. 8 shows that shifting the accent from the fourth word to the third one does not influence the declination in the beginning of the phrase; the declination slope resumes its trend after the prominent syllable.

Our research shows that in both cases prominence influences the declination locally, but not globally: prominence affects only the F0 of the prominent word.
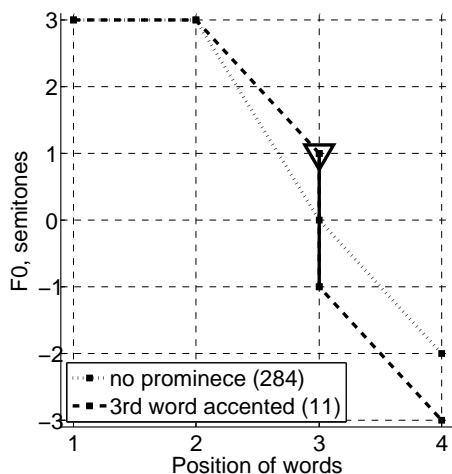
4. DISCUSSION AND CONCLUSION

The results of the study based on the analysis of large data from the corpus of professionally read Russian speech confirm the tendency for F0 to decline to the end of final declaratives in Russian. At the same time our approach to calculating topline declination (using F0 values of accented vowels) revealed various strategies speakers follow to complete the downstepping trend within the intona-

Figure 7: F0 declination in case of emphatic accent

terance length. Ideally, it implies decreased tonal space between subsequent pitch accents to cope with the tonal span of the intonation unit or utterance, thus confirming the existence of the look-ahead strategy of the speaker [7]. At the same time, there is clear evidence of the individual strategies in scaling pitch level of successive accents particularly in IPs containing more than 5 PWs: for speakers with narrow individual range the pitch level at the beginning of the IP is sustained until the last two pitch accents before the nucleus when down-stepping of the pitch accents is resumed to reach the pre-planned F0 target end level. For other speakers increased length of the IP results in lowering the pitch level of the final accent. Thus pitch range adjustment also depends on the length of the intonational unit, but it may take various forms depending on the speaker's individual preferences.

The actual placement of this adjustment within the IP seems to be governed by many factors: apart from the intention of the speaker to cover the tonal span and reach the preplanned F0 "bottom" level, there are also semantic—resetting at prominent words [19] and pragmatic reasons.

On the basis of the results of the present investigation based on large data of the corpus of professionally read speech it is possible to draw the conclusion that presence or absence of declination is used in Russian to distinguish sentence types—declarative versus interrogative, and different rate of declination alone may contribute to the contrast between non-final declaratives which end with a continuation rise and general questions proper. Similar data was reported for Danish [15] and Dutch [4]: the use of different rates of declination for different sentence types; non-final statements in Danish are characterized by a more gradual declination. Moreover, declination is claimed to be absent from Danish and Dutch questions, which means that "not only to declination reset, but also to declination, a communicative function can be attributed" [3].

It is worth mentioning here, that the use of different rates of declination as opposed to local pitch movements to distinguish sentence types was found to be a typological parameter differentiating between Danish and Dutch [2]. Thus "the natural tendency for F0 to decline has been integrated into the linguistic code, in the form of controlling or entirely suppressing the F0 decline" [17].

Figure 8: F0 declination in case of accent shift

tional unit: "classical", in which the length of the intonational unit "sets" the end frequency level for the speaker (constant slope); "proportional", within a fixed range: when pitch accents are almost regularly spaced out and the pitch level of each successive accent is defined by the length of the intonational unit in prosodic words; "obligatory" (induced), when downstepping involves the last 2 pitch accents in the IP.

The relationship between F0 slope and the utterance length—the shorter the utterance the steeper the slope—confirm the possibility of planning the declination.

Thus, pitch scaling is also the function of the ut-

6. REFERENCES

[1] Anderson, S. W., Cooper, W. E. 1986. Fundamental frequency patterns during spontaneous picture description. *J. Acoust. Soc. Am.* 79(4), 1172–1174.

[2] Gooskens, R. H. J. M., Heuven, V. J. J. P. v. 1995. Declination in dutch and danish : global versus local pitch movements in the perceptual characterisation of sentence types. *13th International Congress of Phonetic Sciences* Stockholm. 374–377.

[3] Hart, J. T., Collier, R., Cohen, A. 1990. *A Perceptual Study of Intonation: An Experimental-Phonetic Approach to Speech Melody*. Cambridge University Press.

[4] Heuven, V. J. v., Haan, J. 2000. Phonetic correlates of statement versus question intonation in dutch. In: Botinis, A., (ed), *Intonation: Analysis, Modelling and Technology* number 15 in Text, Speech and Language Technology. Kluwer Academic Publishers 119–143.

[5] Hirst D., A., Di Cristo 1998. *Intonation systems: a survey of twenty languages*. Cambridge University Press.

[6] Ladd, R. D. 1986. Intonational phrasing: the case for recursive prosodic structure. *Phonology* 3(01), 311–340.

[7] Levelt, W. J. M. 1989. *Speaking: From Intention to Articulation*. MIT Press.

[8] Ode, C. 1989. *Russian Intonation A Perceptual Description*. Amsterdam: Rodopi Bv Editions.

[9] Pierrehumbert, J. 1979. The perception of fundamental frequency declination. *J. Acoust. Soc. Am.* 66(2), 363–369.

[10] Pike, K. L. 1945. *The intonation of American English*. Publications in Linguistics 1. Ann Arbor: University of Michigan Press.

[11] Shi, C. 2000. Language-independent prosodic features. In: Botinis, A., (ed), *Intonation: Analysis, Modelling and Technology*. Kluwer Academic Publishers 243–263.

[12] Skrelin, P., Volskaya, N., Kocharov, D., Evgrafova, K., Glotova, O., Evdokimova, V. 2010. Corpres - corpus of russian professionally read speech. Sojka, P., Horák, A., Kopeček, I., Pala, K., (eds), *13th International Conference on Text, Speech and Dialogue* number 6231 in Lecture Notes in Computer Science. Springer Berlin Heidelberg 392–399.

[13] Svetozarova, N. D. 1975. The inner structure of intonation contours in russian. In: Tatham, M. A. A., Fant, G., (eds), *Auditory Analysis and Perception of Speech*. Academic Press 499–510.

[14] Swerts, M., Strangert, E., Heldner, M. 1996. F0 declination in read-aloud and spontaneous speech. volume 3 Philadelphia, USA. 1501–1504.

[15] Thorsen, N. G. 1980. A study of perception of sentence intonation–evidence from danish. *J. Acoust. Soc. Am.* 67(3), 1014–1030.

[16] Umeda, N. 1982. F0 declination is situation dependent. *J. of Phonetics* (10), 279–290.

[17] Vaissière, J. 1983. Language-independent prosodic features. In: Cutler, A., Ladd, D. R., (eds), *Prosody: Models and Measurements*. Heidelberg: Springer Verlag 53–65.

[18] Volskaya, N. 2000. Declination in intonation modeling for speech synthesis. Kaunas. 194–199.

[19] Volskaya, N., Vorobyova, S. 2010. Declination reset as a means for providing prominence. St. Petersburg. SPIIRAS 64–71.

[20] Yuan, J., Liberman, M. 2014. F0 declination in english and mandarin broadcast news speech. *Speech Communication* 65, 67–74.