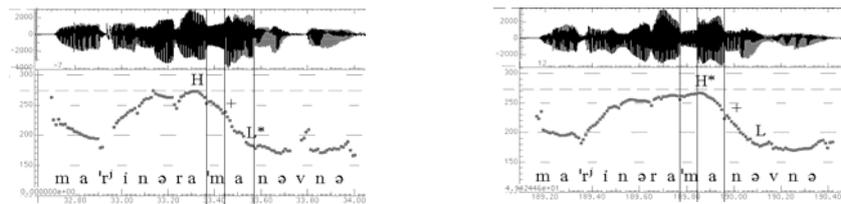


## How many falling intonation patterns in Russian?: categories of F0 alignment

In a number of works on Russian intonation, it has been recognized that there exists a "falling pattern" [1], [7]. The phenomenon relevant to the present study is that the alignment of the F0 fall relative to the stressed syllable can show significant variations. The variants of the falling pattern are illustrated in Figure 1. In the contour to the left, the F0 peak at the beginning of the fall is aligned just before the onset of the stressed syllable (-*má*-), whereas in the contour to the right, it is aligned just after the vowel onset of the syllable.

For these alignment variations, following two interpretations would be possible, and the latter one is assumed to be correct in the present study: 1) F0 alignment varies along a continuous dimension and two contours in Figure 1 are merely gradient variations of a single intonation pattern, 2) F0 alignment functions as a binary distinction and the two contours are two categorically distinct types of falling pattern.

The aim of this study is to experimentally investigate whether F0 alignment functions as a binary distinction in Russian and there are two types of falling pattern which differ in how the F0 fall is aligned relative to the stressed syllable.



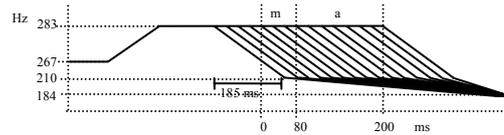
**Figure1:** Two variants of falling patterns. The utterance is *Marína Románovna* (a name and patronymic of a Russian woman). Vertical lines indicate the onset of the initial consonant, the vowel onset and the vowel offset of the stressed syllable -*má*-.

In the traditional framework [1], the existence of two types of falling pattern in Russian was recognized. The feature that differentiates these two patterns, however, was defined in impressionistic terms, and thus it remained unclear. Odé investigated Russian intonation in the realm of perception and found that Russian subjects could differentiate two types of falling pattern, whose distinctive feature is the F0 alignment [3]. Furthermore, Odé found that in most cases the difference between two falling patterns in the traditional work could be attributed to the alignment difference [4].

In a preliminary descriptive framework of Russian intonation, which I proposed elsewhere [2], I assumed that in Russian there were two types of falling pattern which differ in the F0 alignment. In this work, the two contours in Figure 1 were interpreted as two categorically distinct types of falling pattern, consisting of contrastive types of pitch accents, H+L\* and H\*+L, respectively. This representation is a sort proposed by Pierrehumbert [5], in which H and L mean phonological level tones, High and Low, which characterize the stressed syllable. An asterisk or "star" indicates alignment difference of the HL tonal sequence: a starred tone is aligned with the stressed syllable, while an unstarred tone leads or trails it. In this study, however, I offered no substantial grounds for this formulation.

Thus, this study can be regarded to some extent as a replication, based on a different methodology, of the work by Odé [3], [4], and as an attempt to provide empirical evidence for the formulation in my previous study [2].

Igarashi, Yosuke (2005) How many falling intonation patterns in Russian?: categories of F0 alignment. [in English]. *Programme & Book of Abstracts: Between and Stress and Tone*: 32-33. The Between Stress and Tone (BeST). (June 18, 2005, The International Institute for Asian Studies, Leiden, Netherlands)

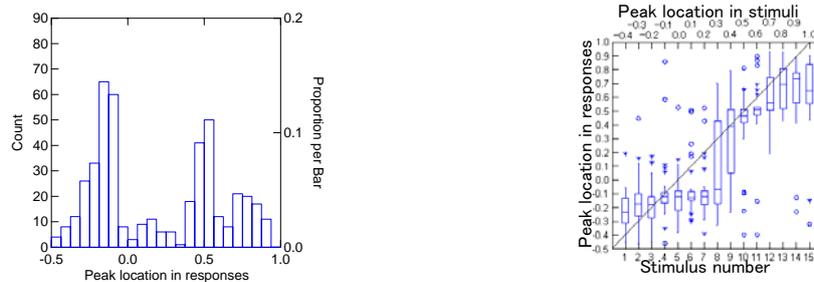


**Figure 2** F0 contour for all 15 stimuli used. Vertical dotted lines indicate the onset of initial consonant, the onset and the offset of the vowel of the stressed syllable *-má-*, respectively.

In the experiment, I adopted the method developed by Pierrehumbert and Steel in their study of the English intonation [6]. The method can be summarized as follows: 1) resynthesis was used to construct a set of stimuli in which the alignment of the F0 fall varied in small steps (Figure 2), 2) subjects heard the stimuli in randomized order and imitated what they heard, 3) the location of F0 peak relative to the onset of the stressed syllable was measured in each response. If the experimental results show continuous peak locations in responses, then subjects should have perceived continuum. If, on the other hand, the results show the responses clustering into discrete groups, then they should have perceived categories and the assumption in this study would be supported.

The results showed that responses to stimuli with continuous peak location clustered into two discrete groups, and supported the assumption of the present study. Figure 3 shows plots of data for one of our subjects. A histogram for the peak location in all of the data (left) is obviously bimodal, indicating the existence of two categories of alignment. In a box-plot of median peak location for responses to each stimulus plotted against peak location in the stimulus itself (right), there are clearly substantial deviations between the stimuli and the responses, and they are in the direction of the assumption of this study, with two plateaus for each category and a sloping region for ambiguous stimuli. Examination of these plots indicates that the boundary between the two categories lies in the vicinity of stimuli 8 and 9, i.e. around the vowel onset. Other subjects showed similar results.

The results of the experiment replicated those in Odé [3], showing that in Russian F0 alignment acts as a binary distinction. The results also provided empirical evidence supporting the phonological framework [2], in which two types of Russian falling pattern, consisting of contrastive pitch accents,  $H+L^*$  and  $H^*+L$ , are identified.



**Figure 3:** An overall histogram (left) and median box-plot (right) for one of our subjects. "Peak location" here was calculated by measuring the temporal distance between the onset of the stressed syllable and the F0 peak divided by the duration of the syllable.

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