
Acoustic properties and functions of phrase-final rises in Polish task-oriented dialogues

Własności akustyczne i funkcja końcowej melodii wznoszącej frazy intonacyjnej w polskich dialogach zadaniowych

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ABSTRACT

The present work is an exploratory study of the form and function of final rises in Polish task-oriented dialogues. Ten dialogue sessions were selected from the DiaGest2 corpus and analysed for the occurrence and realisation of phrase-final rises. They are tagged for dialogue act category and basic contextual properties (overlap, turn position) and analysed for the basic acoustic parameters. The results support and enhance findings of earlier works for the Polish language and, while showing some tendencies in terms of form-function correlation, they also confirm the complexity of intonational mechanisms in task-oriented dialogues.

STRESZCZENIE

Niniejsze badania poświęcono eksploracji formy i funkcji końcowej melodii wznoszącej frazy intonacyjnej w polskich dialogach zadaniowych. Z korpusu DiaGest2 wybrano dziesięć sesji dialogowych i przeanalizowano je pod kątem występowania oraz sposobu realizacji końcowej melodii wznoszącej. Zawierające ją frazy otagowano pod względem realizowanych w nich aktów dialogowych oraz ich elementarnych własności kontekstowych (nałożenia, lokalizacja w kolejce dialogowej). Przeanalizowano podstawowe parametry akustyczne końcowej melodii wznoszącej. Wyniki badań potwierdzają i rozszerzają spostrzeżenia dokonane we wcześniejszych pracach dotyczących tego zagadnienia w języku polskim. Pokazują one pewne korelacje między formą i funkcją końcowej melodii wznoszącej, jednocześnie dowodząc wielkiej złożoności mechanizmów intonacyjnych w dialogach zadaniowych.

1. Intonation and its functions in dialogue

Although “intonation has traditionally been regarded as a problem” [1], current studies seem to face an extremely demanding challenge. First of all, the study of intonation should take into account the context of communication, with its entire complexity and many extralinguistic, interactive and attitudinal factors. Secondly, the perception-oriented approach should be more widely implemented as the difference between what can be measured and what is actually perceived is often significant. And while traditional acoustic analyses are still necessary for speech technology applications, one should take auditory perception properties into account in order to obtain results which are valid for regular interpersonal communication settings. In both cases, it is

of special importance to pay attention to the level and frame of analysis as pointed out by Hirst and Espesser [2] and further elaborated by Jassem [3].

There is a tendency to view intonation as comprising two components, linguistic and non-linguistic [4], although this distinction is extremely difficult to judge and implement precisely in the study of spontaneous speech and it may actually lead us back to the fundamental questions of our understanding and definition of language and its boundaries.

Intonation is commonly agreed to contribute to the meaning of utterances at a number of levels and in a number of ways. Among the most often listed functions of intonation, there are (a) attitudinal function, (b) accentual function, (c) grammatical function, (d) discourse function, (e) psychological function and (f) indexical function [1, 5, 6]. Some functions may be encoded in the same stretch of pitch contour and their influences on its shape may be extremely difficult or impossible to distinguish. Nevertheless, typically, sections (or components) of the pitch contour tend to differ in at least some of their potential functions. Pierrehumbert and Hirschberg [7] claim that pitch accents convey information about the status of the individual discourse referents as well as their relative importance (from the speaker's perspective). Phrase accents (i.e., boundary tones in intermediate phrases) are used to express the way in which intermediate phrases are related to preceding or succeeding intermediate phrases. Finally, boundary tones (at the boundaries of an intonational phrase) contribute information about the intonational phrase as a whole, and also about relationships among subsequent intonational phrases.

Dialogue is said to be the primary and most natural setting for language use and development. Therefore, it may be also considered as an optimum setting for the study of intonation in use. In dialogues or multilogues, intonation is employed to realise specific functions related to the communicative interaction and less or more immediate communicative goals. It may express an intent to hold the floor, to signal readiness to leave it to other speakers, but also to fight for it [8]. In the context of interaction, coherence-related functions of intonation may be also more peculiar as intonation can also be used to build coherence not only within turns [9–11] but also between them by stressing their mutual relations. While having additional functions in dialogue, intonation is also influenced by additional factors resulting from the dynamics and interactivity of the process of communication. The necessity of more or less immediate reaction to an interlocutor's turn may yield more disfluent or disrupted utterances. Accidental overlaps, fighting for the floor, changes of attitude, are just some examples. Cultural and attitudinal factors may also come into play. In monologues, attitudes and emotional states rarely evolve as dynamically as they do in dialogues. One may also notice that various factors may have different importance at various stages of dialogue. Again, the dynamics and unpredictability of dialogue make these issues even more challenging.

The studies of the role of intonation in discourse became more serious only late in the eighties, with works by Hirschberg and Litman [12], Hockey and others. Kowtko and her colleagues [13, 14] gave a more precise picture of the role of intonation in dialogues by analysing the intonational realisations of dialogue moves and studying the role of intonation in the framework of dialogue games. Their studies were followed by many similar analyses carried out for other native languages and various types of dialogue tasks.

2. The aims of the study: phrase-final tone

The present study is an exploration into the form and function of final rises in the context of task-oriented dialogues. It is meant as an extension to the ideas and results presented in [11] but it is based on different, newly tagged material from a multimodal corpus and on more recent software tools, and it offers additional analyses. The work is focused on phrase-final rises in major intonational phrases and the realisation of rises in various dialogue contexts as well as in various dialogue acts.

Pierrehumbert and Hirschberg [7] propose a general discourse function for boundary tones: “Boundary tones convey information about the directionality of interpretation for the current intonational phrase—whether it is ‘forward-looking’ or not.” Von Heusinger [6] points to the fact that “besides the signalling of the phrase boundary, the shape of the tones carries an additional function, which is assumed to have scope over the whole phrase.” Further von Heusinger, among three main aspects of intonational meaning, mentions the role of boundary tones which “indicate the relation of the phrase they are assigned to other parts of the discourse”.

Considering the entire potential of boundary tones, relatively few researchers have focused on their form and function. Few studies contain more detailed exploration of the boundary tones in Polish. The major studies of Polish intonation have been based on quite different theoretical and methodological approaches and their results are not always easy to compare. Early works by Steffen-Batogowa [15] followed her own methodological framework and a system for the representation of speech melody. The works by Jassem as well as those influenced by his approach and the British School [11, 16] were based on a model of intonational phrase that is focused on the pitch movement around the nuclear syllable. Few authors have made attempts to introduce a Polish version of ToBI [7] and to apply the Metrical-Autosegmental (AM) approach to the Polish language. But even in this framework, the analysis of boundary tones was rather limited [17]. In a recent work by Mejnartowicz [18], final boundary tones in Polish are analysed in more detail but only for questions.

As the present study is not based on the AM framework, does not involve a Polish ToBI, and it is focused on the phrase final melody only, the term ‘phrase final tone’ (*PFT*) be used to refer to the last perceivable pitch movement bounded to the ‘major intonational phrase closing boundary’. The *PFT* may be difficult to isolate as an ‘independent’ pitch movement as it remains under the influence of the neighbouring pitch accents and other prosodic phenomena. As shown in, e.g., [11], phrase closing melody in Polish may be flat or at least perceived as such and not provide cues to the boundary (which may possibly be found in the rhythm and energy domain).

3. PFR in Polish task-oriented dialogues

3.1. Recordings

The study is based on ten task-oriented ‘origami’ dialogue recordings from DiaGest2 corpus [19], where interlocutors stood facing each other in a distance of ca. three meters from each other. One of the parties (Instruction Giver, IG) gave instructions to the other (Instruction Follower, IF) how to re-construct a figure made of paper and some other

artefacts. The figure was visible to the IG but not to the IF. Each recording is approximately five minutes long but the density of turns and the actual amount of speech varies. In total, there were 15 female (10 IFs and 5 IGs) and 5 male speakers (only IGs). Although the sound quality was generally satisfactory as the recording was taken using two large membrane condenser microphones and a professional grade audio interface, the noise made by participants (especially IFs manipulating their objects) left many portions of the recordings unusable for pitch extraction or even perception-based pitch evaluation.

It must be noted that the task itself as well as the setting (standing face to face behind tables) certainly influenced the flow of dialogue and its prosodic properties. It is different from ‘casual’ dialogues with no obligatory or even leading topic. It is strongly collaborative. Overlaps are relatively rare and fighting for turn almost does not happen – at least not to the degree observed in regular ‘everyday’ conversations. Nevertheless, speech is spontaneous in the sense that the participants are not prepared for the task or even for being recorded and, due to the pressure of time and the engaging character of the task, they seemingly do not pay attention to the recording procedure or forgot that they were being recorded (some taboo words occur, the authors of the recordings are mentioned, etc.). Another important fact is that the choice of this particular type of dialogue resulted in a specific proportion of dialogue acts that occurred. Instructions and various instances of feedback dominated the material under study.

3.2. Extraction of the material for analyses

The recordings were manually segmented into words, syllables, minor- and major intonational phrases using Praat [20]. The total size of the recordings measured in syllables was over eight thousand for IGs and almost four thousand for IFs. *PFTs* were categorized on the basis of perceptual decision into three categories (rise, flat, fall). Many units were tagged as ‘unfinished phrases’, presumably intended to be produced as regular phrases but clearly abandoned somewhere in the middle. There were also cases where the *PFT* was impossible or too difficult to be reliably judged on the basis of close listening or instrumentally (e.g., whisper, creaky voice, low energy, overlaps). Non-lexical fillers were excluded from further analysis although some of them had a distinctive melody. The set initial set of 748 rising *PFT* phrases was finally narrowed down to 617 signals appropriate for instrumental analysis due to recording or voice quality issues found in the material (general low signal-to-noise ratio, overlapping speech, noise coming from object manipulation, hitting microphones, voiceless or creaky voice, etc.).

Although both minor and major phrases were tagged for the final pitch change direction, further analyses apply only to the major phrases (*MaPs*). As it is shown in Table 1, the proportion of the final rises was significantly higher in the utterances produced by IFs. The number of phrases closed with a flat melody was relatively low in both IGs and IFs and the proportion of unfinished phrases was significantly higher in the utterances produced by Igs.

3.3. Phrase-final rises and dialogue act categories

Although intonation is rarely the only or the decisive cue to the category of dialogue act realised in a given utterance, it often provides relevant information and often contributes to the identification of the dialogue act category to a meaningful degree [11, 21, 22]. In the material under study, the phrases with rising final melody were

Table 1. Four categories of the final pitch direction tagged in the recordings

Pitch direction	IG	IF	phrase count (IG + IF)
final rise	28%	47%	748
final fall	52%	39%	959
final flat	6%	6%	121
unfinished	14%	8%	244
Totals:	100%	100%	2072

tagged for their dialogue act category, following the general framework of DIT++ [23]. However, only the dominant function [24] of each utterance was tagged (with an additional comment where necessary).

Most of the functions are Information Transfer Functions (including questions and answers) and Action Discussion Functions (mostly instructions) from the subset of the General Purpose Communicative Functions, as well as various types of Feedback from the subset of the Dimension-Specific Communicative Functions. All in all, a number of very different dialogue acts was realised used with final rises. In Table 2, the proportions of the most frequent dialogue acts in the set of phrase-final rise utterances are shown.

Table 2. Major classes of dialogue acts in the set of 617 MaPs.

Major class of DAs	Proportion (617 phrases)
Question (all types)	30%
Feedback (all types)	26%
Instruction (and elaborations)	21%
Statement (incl. evaluative)	12%
Dialogue Flow Management	5%
Other categories	6%
Total:	100%

The proportions refer to the content of the set under analysis (617 final rise *MaPs*) but are not very different from those in the entire initial set of the final rise *MaPs* (748 *MaPs*). Nevertheless, they are strongly determined by the type of dialogue and they can hardly be extended to, e.g., a leisure conversation or a political debate. Major classes of acts are formed by summing up all the sub-classes (e.g., questions include all kinds of questions, e.g., check question, propositional question, choice question).

3.4. Phrase-final rises: pitch contour realisations

As mentioned above, the initial set of 783 final-rise *MaPs* was reduced to 617 tokens in order to ensure reliability of instrumental analyses and to avoid errors that might be caused by acoustic artefacts. In the algorithm for finding pitch maxima and minima in F0, jump detection and smoothing functions were activated. The analysis was limited to the ultimate or the penultimate and ultimate syllables (chosen manually at the stage of annotation, depending on the placement of the last prominence and the temporal range of the final tone). Fundamental frequency was measured in Hz and semitones relative to 1 Hz.

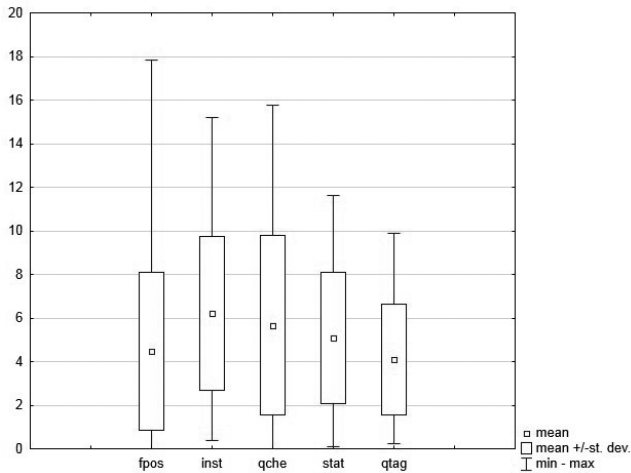


Figure 1: Pitch frequency rise range (semitones) in the five most numerous categories of dialogue acts (fpos – positive feedback, inst – instruction, qche – check question, qtag – question tag, stat – statement).

In Figure 1, the mean values of pitch rise in the realisations of the five most frequent categories of dialogue acts are presented. As dialogue acts of the question tag category (which can be defined as a specific question for confirmation) are normally realised as two *MaPs*, the pitch was measured for the second component, corresponding to ‘isn’t it’, ‘aren’t they’, etc., in English, but realised in Polish using simple words like ‘tak’, ‘nie’ and some others. In Figure 2, the mean values of the pitch rise rate are presented for the same set of dialogue acts. This measure does not account for any minute changes of F0 as it is calculated as $(F0_{max} - F0_{min}) / (t_{F0max} - t_{F0min})$.

The mean values of pitch rise produced in one- and two-syllable signals (3.76ST and 5.82ST, respectively) turned out to be significantly different at $p = 0.05$. This may reflect the fact that the speaker had more time to produce a higher rise over a two-syllable ending.

There was no statistically significant difference between the relative pitch rise values in overlapping and non-overlapping phrases. Potentially, they might have been observed as, e.g., an element of fighting for the floor. Nevertheless, as mentioned earlier, in this kind of dialogue turn taking tends to be fluent and easy as there is no need to fight for the floor. Phrases tagged as turn-final also turned out not to differ significantly in their mean final pitch rise from those marked as non-final. However, in this case, a significant proportion of tags was marked as problematic. Feedback is usually not meant to interrupt the interlocutor’s turn but sometimes the feedback phrase may be long or prominent enough to disrupt the melodic continuity of the concurrent utterance.

Some of the above calculations were carried out separately for the most numerous categories of dialogue acts. In the overlapping and non-overlapping realisations of positive feedback, the mean values of pitch rise were obtained as 6.4ST and 4.2ST, respectively, a significant difference, $p = 0.05$. For instructions, the difference between the means in overlapping and non-overlapping utterances seemed to be neglectable even though, due to the limited number of overlapping utterances in the set,

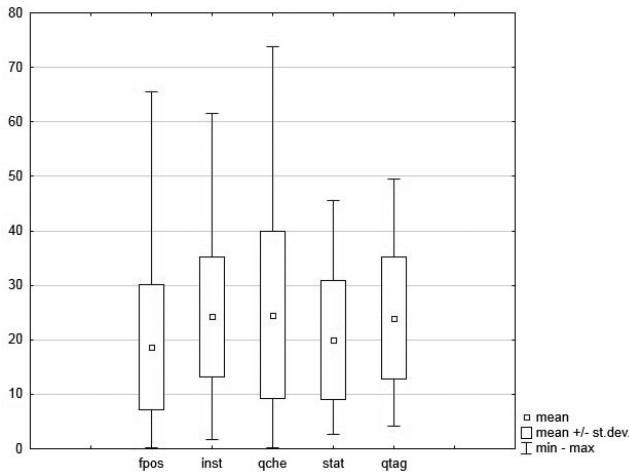


Figure 2: Pitch frequency change (semitones per second) in the five most numerous categories of dialogue acts.

statistical testing was impracticable. Similar calculations were carried out for the subset of questions (excluding question tags), and the difference between the mean pitch rise in overlapping and non-overlapping phrases (5.35ST and 5.5ST) turned out to be statistically not significant again. Further, it was shown that the difference in the values of the mean final pitch rise in turn-final and non-turn-final realisations of instructions was statistically significant (7.4ST and 5.6ST, respectively). However, it was not significant for the values of mean pitch of positive feedback nor for questions in these two conditions (turn-final vs. non-turn-final).

In order to analyse and categorise the shapes of *PFTs* Prosogram (ver. 2.8) [25] was used. Prosogram produces stylisations of intonational contours based on a perception modelling approach. It detects whether a given portion of pitch trace is perceived as ‘flat’ (static) or ‘dynamic’ (rising or falling), depending on the glissando threshold value provided by the user, here the default value ($G = 0.32/T^2$; tested for Polish in, e.g., [11, 18]). Intuitively, it might be hypothesized that the two-tone step-like intonation contours will be more often present in two-syllable than in one syllable signals. However, the proportions of such realisations were not significantly different. In one-syllable signals, 73% of the final rises were step-like, while in the two-syllable signals, 70% of rises were realised in that way (see Figure 3 for details). As it could be expected, in the case of the two-syllable signals, there was much more variety in the proportion of the dynamic section of the modelled contour as it was more probable to find both dynamic and static stretches of F_0 .

Most of the stylised rising contours followed one of these patterns: (a) plain rise – entire contour represented as a single rising stretch; (b) complex rise – entire contour rising but represented as two stretches having different slope; (c) flat section + plain rise section; (d) plain fall + plain rise; (e) plain rise section + flat section (plateau), (f) step rise – a rising contour represented as two horizontal stretches. There were few examples of multi-step rises and more elaborated complex rises. This categorisation is based solely

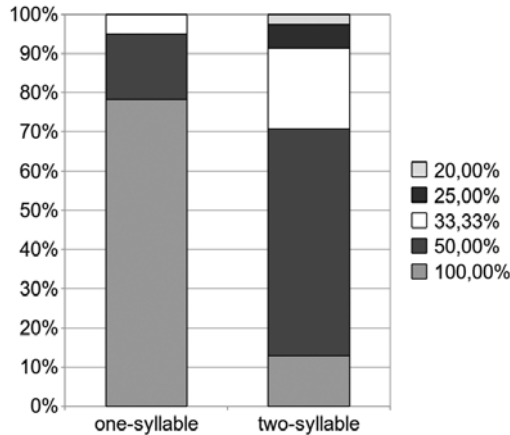


Figure 3: Proportion of dynamic part of pitch contour in one- and two-syllable final rises (five percentage categories from Prosogram).

on the directions of pitch change and does not take into account possible categorical differences between pitch levels (e.g., low, mid, high). It is also determined, to a certain extent, by the parameters used by Prosogram (including the glissando threshold). The categories mentioned above may provide a starting point for further perception-based studies on the final rises in Polish.

4. Discussion, conclusion and further work

Intonational phrases featuring final rises make for a significant proportion of the phrases occurring in the Polish task-oriented dialogues. Phrase final rises are found in a range of dialogue act categories, including instructions, statements, all kinds of feedback (allo- and auto-, positive and negative), in all types of questions, in some types of answers as well as in dialogue flow control acts. The function of the final rise seems to need further exploration in order to go beyond the traditional ‘openness’ or ‘expected continuation’ framework [5]. In fact, many of the phrases under study that featured final rises were tagged as turn-final on the basis of their content and context. Still, one cannot exclude that there existed an ‘intention to continue’, especially in the IG who might feel obliged to proceed with the dialogue because of her/his assumed role. Producing ‘open phrases’ can be considered as a potential strategy for achieving this goal.

The proportion of the final rises was significantly higher in the utterances produced by IFs. This can be explained by the fact that it was mostly the IF who produced feedback, and various kinds of feedback (but mostly positive allofeedback, co-occurring with dialogue flow control) were found to feature final rises.

The proportion of unfinished phrases was significantly higher in the utterances produced by IGs which is also not surprising as their role was to provide instructions, which were frequently complex utterances that – additionally – were produced by a speaker whose cognitive resources were already partially consumed by the efforts related to the strategy and technique of conveying information to the IF.

Another finding is that, among the three most numerously represented dialogue act categories, only for positive feedback was there a statistically significant difference between the mean value of pitch rise in overlapping and non-overlapping realisations.

Similarly, only instructions were found to feature a significantly different pitch rise in the turn-final and non-final condition (7.4ST and 5.6ST, respectively). This result may be also somewhat surprising if a rise is to be considered as a cue to the intention of continuation. However, one may hypothesize that if it is really strong (even exaggerated), it may actually serve as a phrase closure marker.

The number of factors that can influence the realisation of the *PFT* is overwhelming and their influences may be dynamic, i.e. change over time due to some other, external or internal factors. The results may be influenced by attitudinal factors that are quite difficult to capture. Most of the studies concerned with the boundary melody are focused on certain aspects or realisations in certain contexts or dialogue acts [26, 27] and rarely produce directly comparable results.

Although some difficulties are reported in the perception-oriented intonation studies [28] and there are few attempts of going beyond the rise vs. fall contrast [1, 5], further work is planned in order to perform perception tests and perception-based categorisation of the contours found in the presented material. Data mining techniques will be used to look for simultaneous effects of various factors as traditional statistics may fail to provide reliable results due to relatively small data sets and a large number of variables.

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