Peak Alignment in Broad and Narrow Focus in Polish and Bulgarian. A Cross-language Study

2 authors, including:

Bistra Andreeva
Universität des Saarlandes
87 PUBLICATIONS **552** CITATIONS

Dominika Oliver and Bistra Andreeva

Institute of Phonetics, Saarland University, Saarbrücken
E-mail: {dominika, andreeva}@coli.uni-sb.de

Peak Alignment in Broad and Narrow Focus in Polish and Bulgarian. A Cross-language Study.

1. INTRODUCTION

Tonal alignment can be defined as the temporal synchronization of tones with some specific segments or prosodic locations (such as syllable onset, syllable offset or rhyme onset) and may be related to phonological and/or phonetic factors. Phonological factors are qualitative and categorical (e.g. align target with syllable X rather then syllable Y) and imply different accent patterns (H+L* vs. H*+L). Phonetic factors are gradient and can often be modelled by means of interacting quantitative parameters (e.g. align target earlier the closer it is to the next target). These factors additionally "fine-tune" the alignment of tonal targets, determining the differing phonetic realisation of the same phonological tones.

Previous studies have suggested that timing of f_0 peaks is a function of: speech tempo, durations of segments in the accented syllable, distance in syllables from the accent to the word boundary and the next stressed syllable, focal structure, as well as sentence mode (Steele & Alton, 1986, Silverman & Pierrehumbert, 1990, Prieto et al, 1995, Rietveld & Gussenhoven, 1995, Prieto, 2003, Miševa, 1991, Ladd, to appear, among others)

The purpose of this study was to produce a descriptive model of peak placement and to analyse the relationship between peak location and its segmental anchors. Questions posed further pertain to the phonetic realisation of phonologically specified peak alignment in Polish and Bulgarian as a function of the following factors: speech tempo, information structure, and position within utterance.

2. EXPERIMENTAL DESIGN

In this experiment, two tertiary-level educated female speakers of Sofia Bulgarian and two of standard Polish generated read material. The following four sentences were recorded six times per focus condition in a random order at normal and fast speech rate in a sound treated studio at the Institute of Phonetics (University of Saarland). The Bulgarian sentences are a subset of a larger dataset.

Speech material for Bulgarian:

1. *'včera 'mama 'maza 'masata.*
   yesterday mama painted the table
   'Yesterday mum painted the table.'
2. *'včera 'mama po'maga na 'Mareto.*
   yesterday mama helped to Mareto
   'Yesterday mum helped Mareto.'
3. *'včera 'mama ni po'maga po gra'matika.*
   yesterday mama us helped in grammar
   'Yesterday mum helped us in grammar.'
4. *'utre 'mama šte ni po'maga po mate'matika.*
   tomorrow mama will us help in mathematics
   'Tomorrow mum will help us in mathematics.'

Speech material for Polish:

1. *'mama 'ma te'maty.*
   mother has topics.
   'Mother has topics.'
2. *'mama wy'maga te'matu.*
   mother requires topic.
   'Mother requires a topic.'
3. *a'mator nas na'mawiał do te'matu.*
   amateur us urged to topic.
   'The amateur urged us to accept the topic.'
4. a'*mator nam niedo'magał przy Kaza'matach.*
   amateur us felt unwell in Kazamaty
   'The amateur felt unwell in Kazamaty.'

Since we are primarily interested in the contribution of the intonation, we fixed the word order to reflect the canonical one , i.e*., subject < verb < direct object < indirect object< oblique*[1]. Moreover, where possible, we designed the material to make the data easily comparable in the two languages (cf. the four sentences for Bulgarian and Polish above). In the test sentences the distance between metrically strong syllables varies from one to four unaccented syllables. In the Bulgarian material we do not analyse the very first word (*včera* 'yesterday' or *utre* 'tomorrow') but take it as a filling material preceding the stressed syllable in *mama* 'mum' or *Mareto*). The syllables we analyse are always /ma/ so that they have same segmental structure (maximally sonorant) in order to avoid micro-prosodic effects.

We used two methods for eliciting different focus types. In one, the test sentences were embedded in dialogue sequences as replies to wh-queries uttered by the instructor (a) about the entire utterance, resulting in *broad focus*, and (b) directed towards the initial or final word, resulting in a *narrow non-contrastive focus* in the respective position. In the other, *narrow contrastive focus* condition (c) we embedded the test sentences in dialogues consisting of yes/no-query uttered by the instructor towards the initial, middle or final word, and a correcting reply by the subject. Thus we span broad, narrow and narrow contrastive focus respectively, e.g.:

a) Co dzisiaj nowego? '*What's new today'?*
   [$_F$Mama ma TEMATY]

b) Co ma mama? '*What has mother got?'*
   Mama ma [$_F$TEMATY]

c) Czy mama ma streszczenia? '*Has mother got summaries?'*
   Nie, mama ma [$_F$TEMATY]

The subjects were not informed about the purpose of the study No explicit instructions were given to them. They only had the test sentences on a sheet of paper and had to read them out in a manner that most suited the instructor's query, i.e. their reaction was elicited by the way the authors presented the material.

In total there were 288 utterances per speaker for Polish and Bulgarian (6 target word per focus[2] x 4 test sentences x 2 tempi x 6 repetitions x 2 speakers).

The recordings were digitised at a sampling frequency of 16 kHz and with an amplitude resolution of 12 bits. All segments in target words in the data were manually labelled on the basis of the synchronised microphone signal and a spectrogram using xassp (Advanced Speech Signal
Processor; IPDS 1997) and slightly modified SAMPA transcription (cf. Fig. 1).

In addition to the segmental annotation, the peak position of the L(ow) and H(igh) targets was also identified and marked. To verify the labelling, each of the authors analysed random utterances from both languages and compared each other's analysis.

To sum up, the following points were labelled in each sentence:

- C0 – the beginning of the word initial consonant,

[1] Because of difficulty of constructing the stimuli for Polish (fixed stress on the penult) the word order in test sentence 3 and 4 is not the canonical one.

[2] Each focus condition had different number of target words i.e. one in broad (object), two in narrow non-contrastive (subject, object) and three in narrow contrastive (subject, verb, object), giving us six target words.

- V0 – the beginning of the word initial vowel,
- C1 – the beginning of the initial consonant of the target syllable,
- V1 – the beginning of the initial vowel of the target syllable,
- C2 – the beginning of the initial consonant of the syllable following the target syllable,
- V2 – the beginning of the initial vowel of the syllable following the target syllable,
- E – end of target word,
- SA – beginning of target utterance,
- SE – end of target utterance,
- H – point of f_0 maximum in the target word,
- L – point of f_0 minimum in the target word,

In all our utterances C1 = /m/, V1 = /a/, and were marked with capital letters "M" and "A" as seen in Figure 1

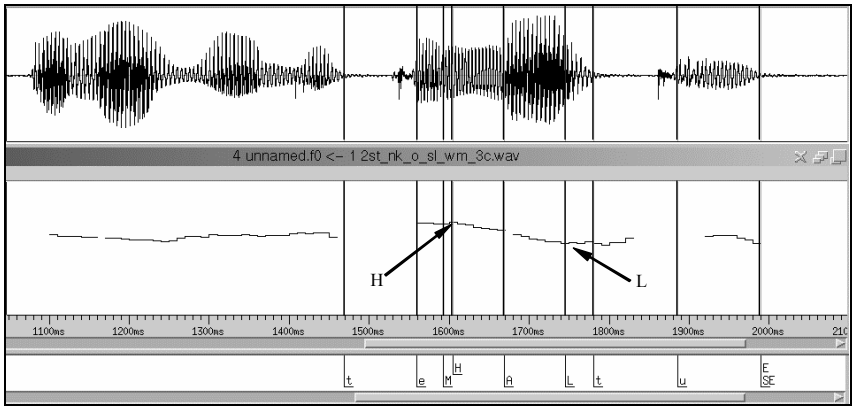

Figure 1. Example of a labelled target word *'tematu'* together with its waveform and f_0 contour .

3. MEASUREMENTS

An number of studies have indicated that the following measurements may be significant in terms of segmental anchor points for f0 peak position (Atterer and Ladd, in press, Prieto et al. 1995, Schepman et al., submitted). Thus, we calculated peak delay as a distance measure from the f0 peak to:

- syllable onset
- syllable offset
- rhyme onset

The peak delay was calculated as the absolute distance in time from the f0 peak to syllable onset (H – C1), syllable offset (H – C2) and rhyme onset (H – V1). Due to the possible effect of the varying segmental durations on peak delay, the above absolute measures were also converted to relative, taken as a proportion of syllable (C2 – C1) and rhyme duration(C2 – V1) (cf. Fig. 2). Additionally, the maximum f0 value of the pitch target was measured.

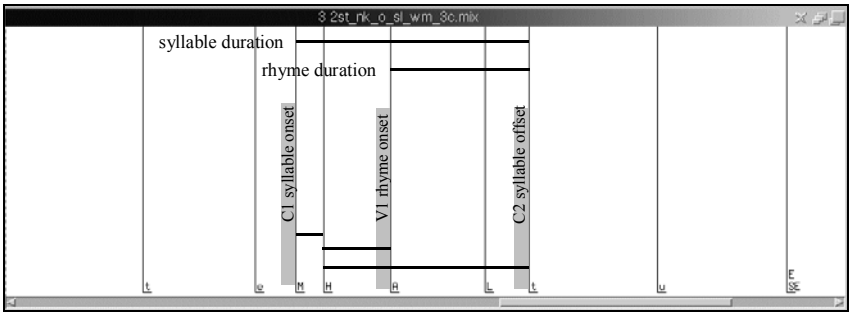

Figure 2. Example of distance measures taken.

4. RESULTS

As reported in Andreeva & Oliver (to appear) the following accent types are used in the examined focus conditions. The Bulgarian speakers use H+!H*/L*, (!)H* and L+H* whereas the Polish speakers (!)H+L*, H*+L and L+H*. For both languages they found different accent types in the same focus condition and the same accent types in different focus conditions,

To analyse the effects on peak alignment we carried out multivariate analyses of variance, with Scheffé post-hoc tests when appropriate. Since a very large number of the absolute measures and very few of the relative measures showed significant variation, statistical results are reported with reference to absolute measures. However, for better visualisation we will refer to alignment in text and in Figs. 3, 4, and 7 in terms of the relative peak position, namely the distance in percent of the syllable duration.

The results for both languages will be presented following the focus condition (broad, narrow, narrow-contrastive) and sentence position (initial, medial and final). We compare the data for Polish and Bulgarian with respect to inter- and intra-language differences.

4.1. The effect of speech tempo

4.1.1. Broad focus

In both languages statements with broad focus were mostly realised as having a falling nuclear pitch movement, i.e. a H(igh) accent followed by a L(ow). In Polish, it is represented only by a fall. Mean peak delays from the onset of accented syllable were -19.1% ((!)H+L*) and 15.7% (H*+L) for speaker WM and 44% for the speaker KA measured as a proportion of the syllable length (cf. Fig. 3). The difference in peak delay between the speakers reflects their choice of accent type: speaker KA uses exclusively H*+L whereas speaker WM prefers (!)H+L* (92% of the cases) and chooses H*+L accent in the remaining cases. Due to the different phonological peak alignment of the two accent types, (in the first case the high target occurs in the accented syllable and in the latter before the syllable onset), KA aligns her peaks much further into the syllable (3.5% into the rhyme onset) than speaker WM.

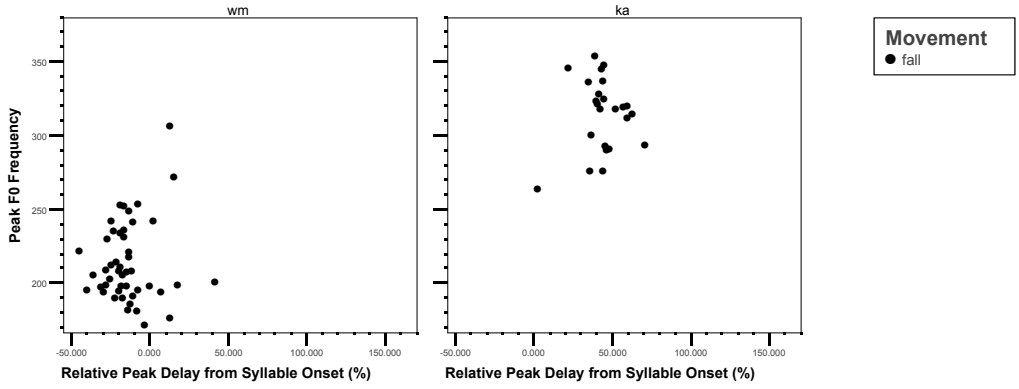

Figure 3. Polish speakers' peak height in broad focus condition

The Bulgarian speaker EK uses a pitch accent which can be analysed as either H+!H* or H+L* (because of the sentence final position and the upcoming low boundary tones L-L% it is impossible to distinguish between the two accent types). Because it was impossible to mark the position of the peak if any present, we decided to exclude the broad focus data for this

speaker. The other Bulgarian speaker, BA, uses predominantly !H* in normal speech rate and only H* in fast speech rate as well as rising pitch in four cases. Therefore, she shows a significant difference in peak alignment in two tempi (normal 3.4%, fast 42.8%). The observed positive correlation between tempo and peak alignment on one hand, and tempo and f_0 values on the other, results from the two different accent types used in this focus condition (cf. Fig. 4).

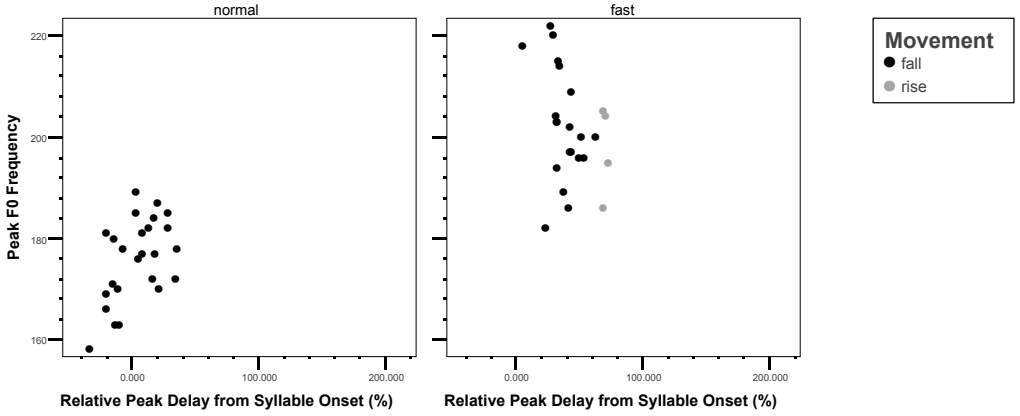

Figure 4. Speaker BA's peak frequency relative to peak position in broad focus condition (Bulgarian).

4.1.2. Narrow Non-contrastive Focus

a) Focus on subject (initial position)

When the first content word (here subject) is in narrow non-contrastive focus, pitch accents across speakers in both languages are realised as falls as well as rises. In Polish, for speaker KA, who uses only rising pitch accents (L+H*) in this condition, there is a main effect of tempo on peak alignment. The mean delay from syllable onset in normal speech rate for this speaker is 75.5% of the syllable duration, whereas in fast speech rate it occurs 26.5% later in the syllable. Additionally we observe significantly higher f_0 values in fast speech tempo for speaker KA (cf. Fig. 6). Speaker WM uses both rises (L+H*) and falls (H*+L) in this condition. The observed tendency in fast speech for this speaker is to align falls 5.5% earlier (58.5% at normal speech rate) and rises 1.7% later (85.6% at normal speech rate)(cf. Fig. 5).

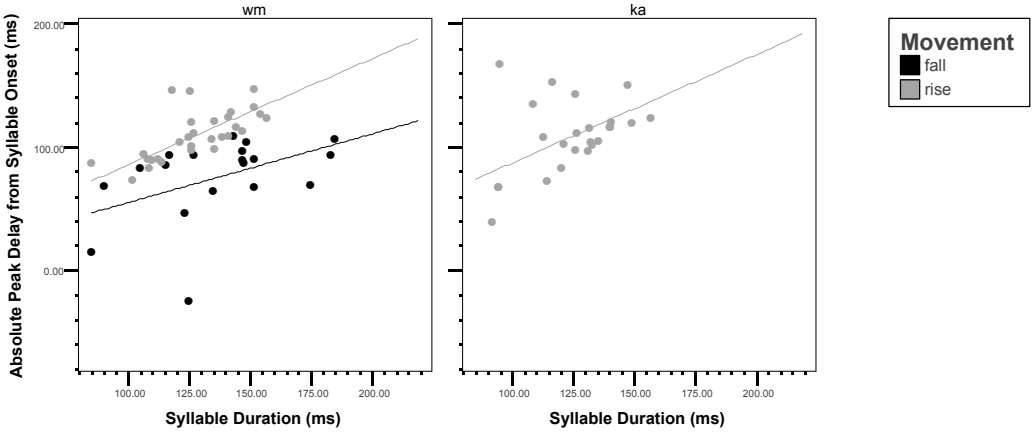

Figure 5. Polish speakers' peak positions in narrow non-contrastive focus condition

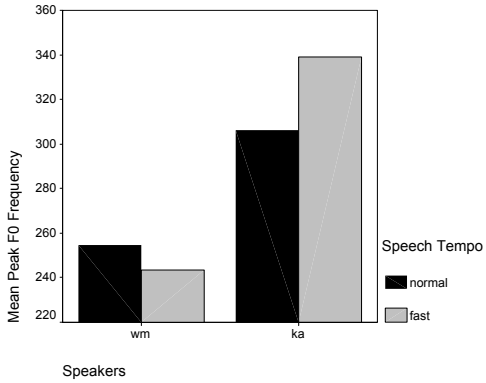

Figure 6. Speaker strategies narrow non-contrastive focus condition (Polish)

In Bulgarian, in this condition, the two speakers behave significantly differently in their alignment of falls and rises. The falling movement (H*) is realised much earlier by speaker EK (-20.6%) than by speaker BA (53.3%). On the other hand the peak of the rising movement (L+H*) for speaker EK comes later (122.1%) than speaker BA who realizes them at 85.8% (cf. Fig. 7).

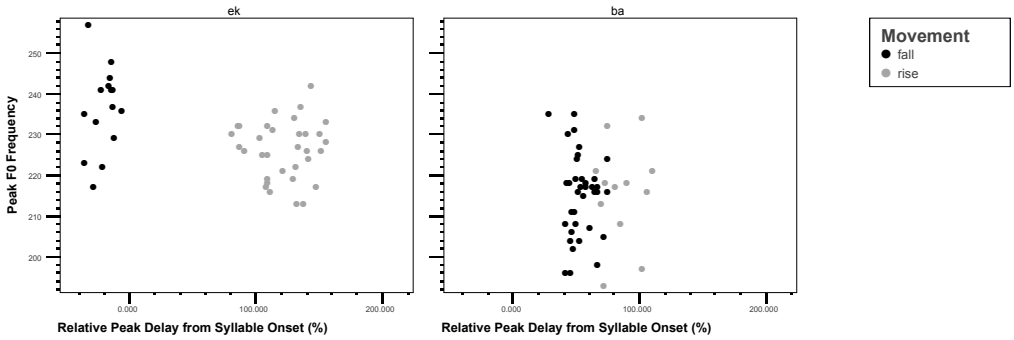

Figure 7. Bulgarian speakers' peak positions relative to pitch height in narrow non-contrastive focus condition

The analysis of the data for speaker BA shows a significant effect of speech tempo and f_0 peak height as well as f_0 peak alignment for both falls and rises in this condition. With the increase in speech tempo the f_0 peak reaches higher f_0 values. At the same time, it is produced earlier with respect to the syllable and rhyme onset for falling and with respect to rhyme onset only for rising contours (cf. Fig. 8).

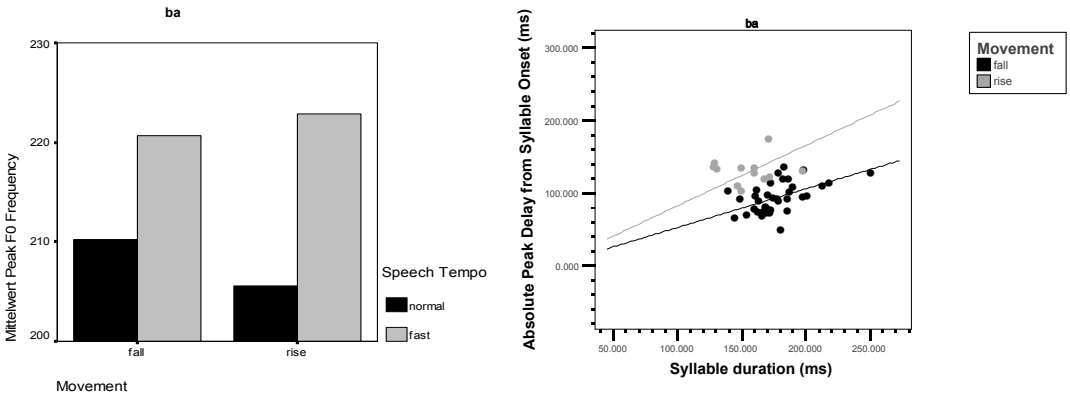

Figure 8. Bulgarian speaker BA's peak height and position in narrow non-contrastive focus condition

b) Focus on object (final position)

In this condition both Polish speakers produce falling pitch accents. Speaker WM uses H*+L as well as (!)H+L* whereas speaker KA uses exclusively H*+L. The analysis of peak alignment for the same accent type (H*+L) reveals significant speaker and tempo differences in that speaker WM puts her peak at 16% and 7.9% from the syllable onset in normal and fast speech tempo respectively (cf. Fig. 9 left panel), whereas speaker KA realises her peaks later (40.9%) without significant difference across tempo.

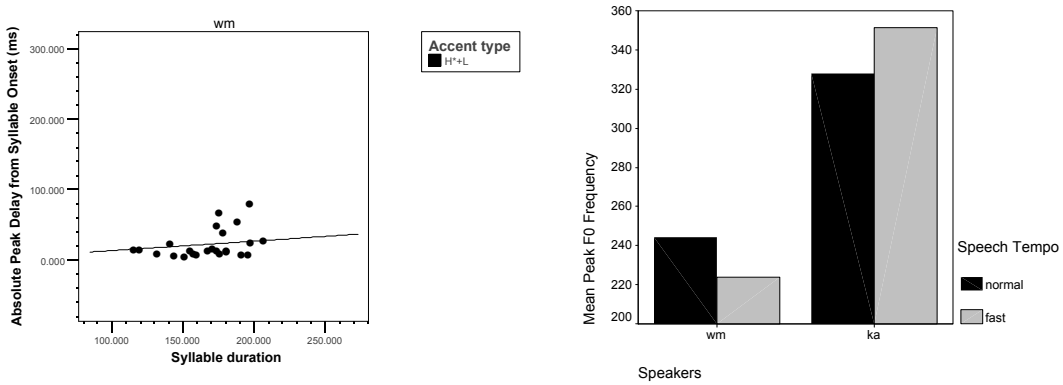

Figure 9. Polish speakers' peak alignment and height in narrow non-contrastive focus condition

For both speakers we observe a significant effect of speech tempo on f_0 peak values. However, they show contrasting behaviour: with increasing speech tempo, f_0 values decrease for speaker WM and rise for speaker KA (cf. Fig. 9 right panel).

In Bulgarian, whereas speaker EK uses only rising pitch accents (L+H*), speaker BA prefers H* accents (only four cases of L+H* accents are found). The position of peaks with respect to the syllable onset reflects the different pitch movement choices, for speaker EK at 100.8% (rises), and speaker BA at 33.8% (falls), and at 72.2% (rises). As expected, we found a significant main effect of tempo on peak alignment values for both speakers (cf. Fig. 10), and on f_0 peak height in the case of speaker BA only, i.e. a higher peak in fast speech.

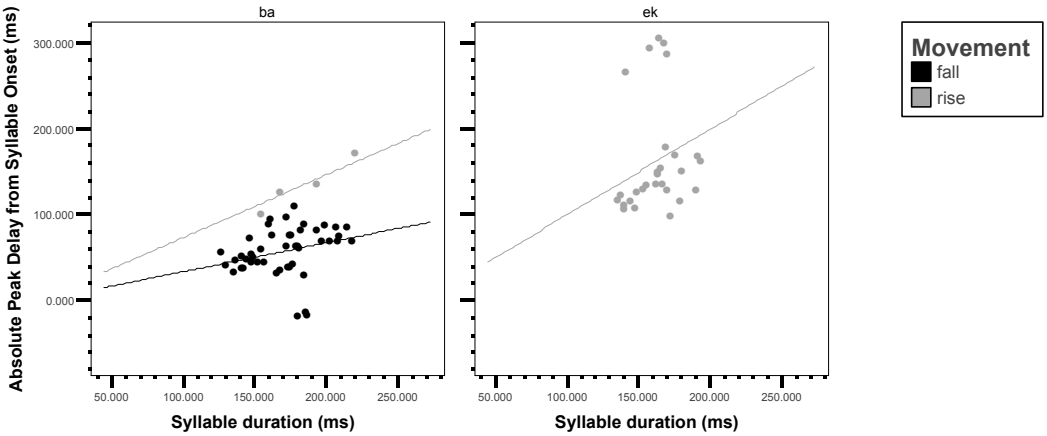

Figure 10. Bulgarian speakers' peak alignment in narrow non-contrastive focus condition

4.1.3. Narrow Contrastive Focus

a) Focus on subject (initial position)

In Polish, in narrow contrastive focus the accented syllable of the subject is realised with a rising pitch (L+H*) and the peak delay is placed either towards the end of the syllable rhyme or after the syllable offset. In normal speech tempo, speakers WM and KA align the peak at

85.6% and 96.5% of the syllable duration respectively. In fast speech tempo, we observe peak alignment at 81.4% for speaker WM and 105.6% for speaker KA. Speaker WM aligns the peak earlier in fast speech as expected (cf. Fig. 11 right panel). The opposite behaviour found for speaker KA is not significant. Contrasting behaviour for the two speakers was also found with respect to the effect of speech tempo. The effect was significant for both speakers; WM lowered f_0 with increasing tempo, whereas speaker KA showed higher f_0 with increasing speech tempo (cf. Fig 11).

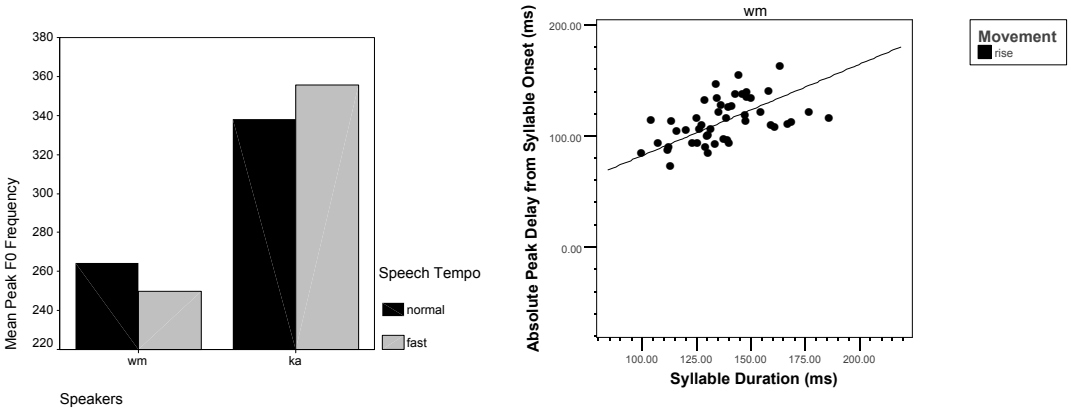

Figure 11. Polish speakers' peak alignment and height in narrow contrastive focus condition

In Bulgarian there are main effects of tempo and speaker on peak alignment. As in 4.2.2. speaker EK uses only rising movements (L+H*), whereas speaker BA uses both movement types (L+H* and H*). At a normal speech rate this speaker uses predominantly L+H*, whereas at a fast speech rate L+H* as well as H* are found. Both speakers align f_0 peak earlier with increasing tempo in rising as well as in falling movements if present (cf. Fig. 12).

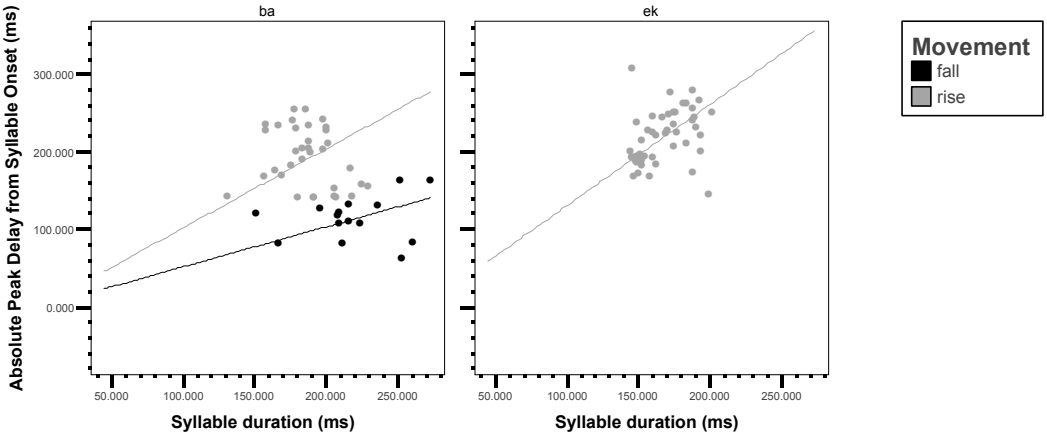

Figure 12. Bulgarian speakers' peak alignment in narrow contrastive focus condition

There is an opposite tendency between the speakers with respect to f_0 peak height in the rising movement in two tempo conditions. Speaker BA reaches higher f_0 values in fast speech tempo, while speaker EK reduces her f_0 peak values with increasing speech rate. There is no main effect of tempo on peak height in the falling movements of speaker BA (cf. Fig. 13).

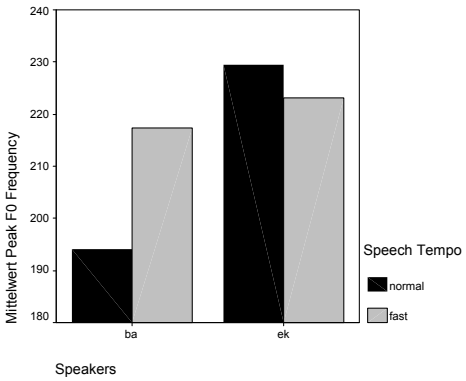

Figure 13. Bulgarian speakers' peak height in narrow contrastive focus condition

b) Focus on verb (medial position)

In Polish, in medial position, there were significant speaker differences. Speaker KA uses exclusively rises (L+H*), aligning them at 66.4% into the syllable. Speaker WM produces predominantly H*+L (there are only three cases of rising pitch accents). For this speaker f_0 peak delay is located at half the length of the syllable for falls (51.3%) and at 86.7% for rises. The alignment analysis shows main effect of speech tempo for both speakers, whereby peak occurs earlier in fast speech (cf. Fig. 14).

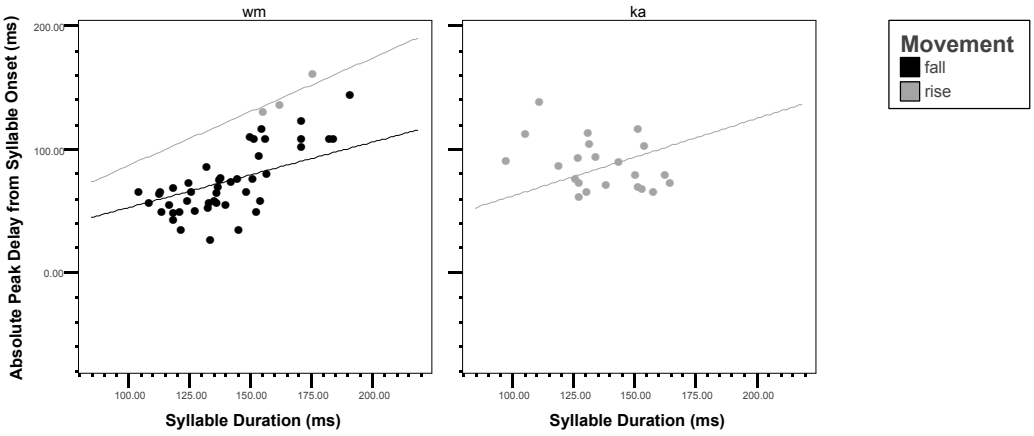

Figure 14. Polish speakers' peak alignment in narrow contrastive focus condition

The falls produced by speaker WM are significantly lower in fast vs. normal speech rate. Again, the opposite is true for rising contours used by speaker KA (cf. Fig. 15).

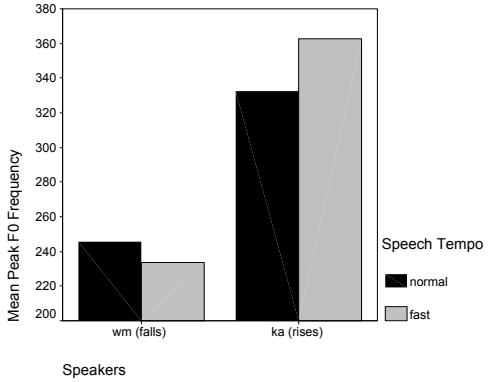

Figure 15. Speaker strategies in narrow contrastive focus condition (Polish)

In the majority of cases in the Bulgarian data, both speakers produce rising pitch accents (L+H*). There is a strong effect of speech tempo on peak location in the rising movements

(cf. Fig. 16). The peak f_0 value in the rising movements of the speaker BA increases strongly with speech rate (cf. Fig. 17). The falls (H*) are present in normal speech rate for speaker EK (2 cases) and fast speech rate for speaker BA (7 cases). Speaker EK realises the peak at 64.9% for falls and 124.6% for rises, whereas speaker BA at 95.7% for rises in normal speech rate. In the fast speech condition speaker EK reaches the peak at 107.5% for rising accents and BA at 44.4% for falls and 82.2% for rises.

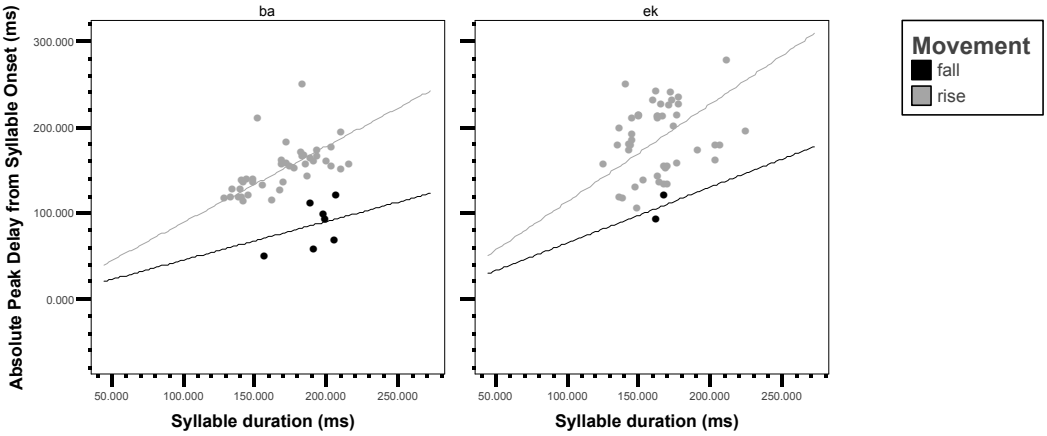

Figure 16. Bulgarian speakers' peak alignment in narrow contrastive focus condition

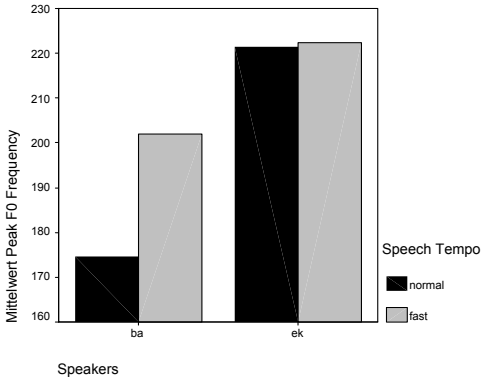

Figure 17. Bulgarian speakers' peak height in narrow contrastive focus condition

c) Focus on object (final position)

In Polish, in terms of peak alignment this condition is realised exclusively by H*+L by both speaker KA and WM. For speaker WM the mean peak delay values are 16.6% from syllable onset, and the peak is placed before the rhyme onset. Speaker KA, on the other hand, aligns the peak later, at 44.1 % of the syllable duration, and at 4.9% of the rhyme duration. Both speakers show significant peak alignment differences in two tempo conditions as noted for other conditions with falling pitch accents: we observe earlier peak alignment with increased speech rate (cf. Fig. 18).

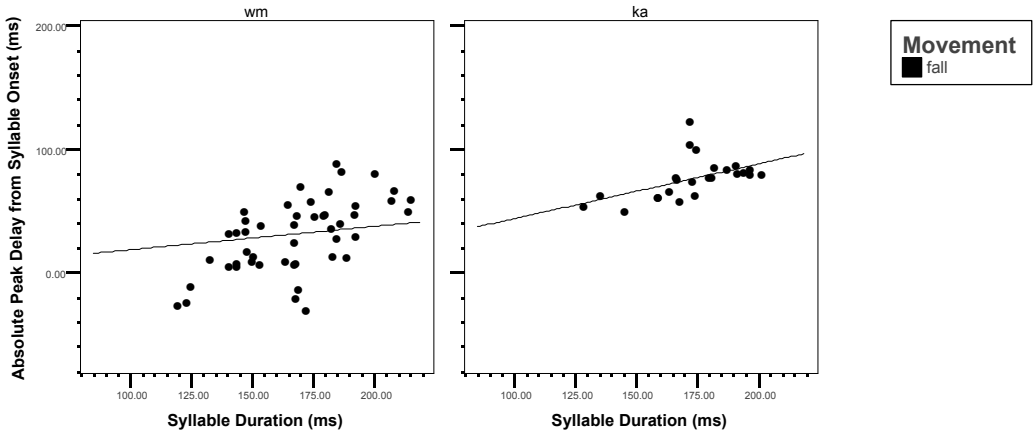

Figure 18. Polish speakers' peak alignment in narrow contrastive focus condition

In Bulgarian there is effect of speaker and tempo on peak alignment in this condition. H* is only produced by speaker BA and only at a fast speech rate (peak alignment at 37.3%). In rising pitch accents (L+H*) speaker EK aligns the peak on average later (at 95%) than speaker BA (at 82%). We found a main effect of tempo on peak alignment for this type of movement (cf. Fig. 19). Speaker BA also changes f_0 range with tempo change, i.e. the faster the speech rate the higher f_0 values, which was found to be significant (cf. Fig. 20).

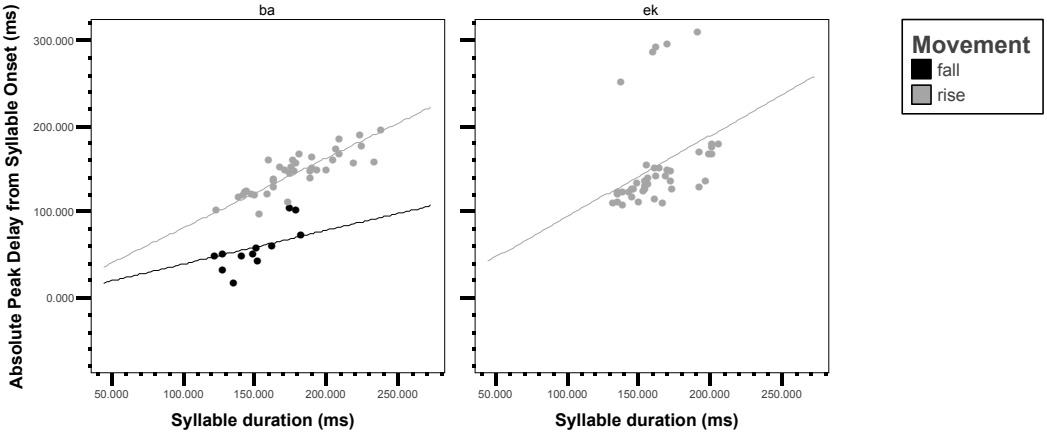

Figure 19. Bulgarian speakers' peak alignment in narrow contrastive focus condition

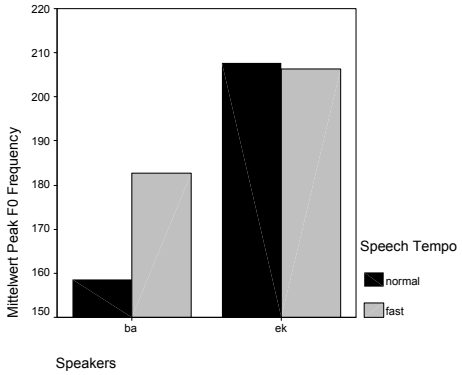

Figure 20. Bulgarian speakers' peak height in narrow contrastive focus condition (Bulgarian)

4.2. The effect of position in sentence

Another main effect in the analysis is the relationship between the pitch alignment and the structure of the utterance. With respect to the position of the focused item in the utterance we

find the following tendency across focus conditions: the later the focused item in the utterance the earlier the peak alignment.

4.2.1. Non-contrastive focus

The analysis shows that in the non-contrastive focus condition within the same movement (falling or rising) the f_0 peak is aligned later in sentence initial position than in sentence final. In Polish, in the case of speaker WM, it is linked to different accent types used in the two positions, i.e. in the initial position we observe H*+L, whereas in the final (object) position this speaker additionally uses (!)H+L* and H+L*. The statistical analysis reveals, as expected, a significantly later peak alignment in the initial position (55.6%) than in the final (shown here as a proportion of the syllable length). The alignment measures are not significantly different for the sentence final position between narrow non-contrastive and broad object for this speaker (-15.9% vs. -16.1%, 12.6% vs. 15.7% respectively), which reflects the fact that WM makes use of the same accent types (H*+L and H+L*) in both conditions. As speaker KA chooses to use different movement types in initial and final position (rise vs. fall, respectively), the comparison is limited to the object in final position in the broad and narrow non-contrastive condition. Here, speaker KA uses same accent type (H*+L) and aligns f_0 peaks similarly for object in narrow non-contrastive and broad focus (43.3% vs. 43.9%).

In Bulgarian, the pattern is the same; for speaker BA within falling contours ((!)H*), the f_0 peak in initial position is aligned significantly later than in the final one (53.3%). In final position, the peak for the object in broad focus is situated significantly earlier than for the object in narrow non-contrastive condition in normal tempo (3.4% vs. 27.2%, respectively). That is due to the fact that in normal speech tempo condition speaker BA uses !H* in broad and H* in narrow focus. The fact that, in fast tempo, this speaker uses mostly H* accent type explains a non-significantly different peak alignment in this condition. The other Bulgarian speaker (EK), using rising contours (L+H*), aligns her peaks significantly later in initial than in the final position at a fast speech tempo (131.3% vs. 92.8%).

tempo	**normal**		**fast**	
speaker	**rise**	**fall**	**rise**	**fall**
BA		subj > obj > broad		subj > obj = broad
EK	subj = obj		subj > obj	
WM		subj > obj = broad		subj > obj = broad
KA		obj = broad		obj = broad

Table 1. The effect of position in a sentence on peak alignment across focus and speakers in non-contrastive focus.

4.2.2. Contrastive focus

Within the contrastive focus condition, three sentence positions are compared: initial, medial and final. Polish speaker WM uses a rising accent type (L+H*) in initial and falling accent type (H*+L) in medial and final positions. With the falling movement, the f_0 peak is aligned significantly later in medial than in the final sentence position (51.3% vs. 16.6% respectively). In the data from speaker KA, we observe a significantly later positioned f_0 peak in initial versus medial position for the accent type L+H* (101% vs. 66.3%).

The Bulgarian speaker BA aligns f_0 peaks of the rising movements significantly later in the initial position than in the medial one (118.6% vs. 95.7%) in normal speech. The f_0 peak on the verb (sentence medial position) is in turn situated at a similar distance from the syllable onset as the peak in the sentence final position (object) in both tempi (e.g. in fast speech 82.2% vs. 81.9% respectively). Both falling and rising accents used by speaker BA have

peaks positioned significantly later in the initial than in the final position (e.g. falling movement in fast tempo 53.6% vs. 37%). When the focus is placed in sentence medial position, the f_0 peak can either align at the same place as the subject or the object e.g. in L+H* in fast speech the verb aligns at 82.2%, whereas the object at 81.9%.

In the same focus condition, speaker EK, who uses rising contours (L+H*), places the sentence initial f_0 peak either later than in the medial position in fast speech (124.2% vs. 107.5%), or at a non-significantly different position at a normal speech tempo. In comparison with the final position, this speaker aligns the f_0 peak sentence medially significantly later in both tempo conditions (115% vs. 95%) (cf. Table 2).

tempo	**normal**		**fast**	
speaker	**rise**	**fall**	**rise**	**fall**
BA	subj > verb = obj		(subj = verb) > (verb = obj)	(subj = verb) > (verb = obj)
EK	subj = verb > obj		subj > verb > obj	
WM		verb > obj		verb > obj
KA	subj > verb		subj > verb	

Table 2. The effect of position in a sentence on peak alignment across focus and speakers in-contrastive focus.

5. SUMMARY AND CONCLUSION

The goal of this study was to investigate the phonetic details of peak alignment in phonologically specified accent types across different focus conditions (broad and narrow contrastive vs. non-contrastive focus) in Polish and Bulgarian. The relationship between peak location and segmental structure was explored for different speech rates (normal vs. fast) and positions within the utterance (final vs. non-final).

In the production experiment we observed different alignment patterns in Polish and Bulgarian. The statistical analysis of the data showed that apart from accent type itself, speaker, speech tempo, focus type and position in the sentence as well as the interaction between them influence peak alignment at the 5% significance level. Additionally, the peak f_0 frequency was significantly influenced by the following factors: focus, speaker and accent type in both languages, whereby in Bulgarian there was also a main effect of speech rate and position in the sentence.

The results showed main speech tempo effects on temporal alignment of f_0 targets and peak f_0 height. The observed correlation between tempo and peak alignment is positive in the two languages. With increasing speech tempo, speakers align their peaks significantly earlier. The f_0 targets are conditioned by the accent type used and therefore we observe speaker specific strategies: either increasing or lowering f_0 values with tempo changes. The fact that the absolute but not the relative measures for peak alignment differ significantly with changing speech rate clearly lends support to the claim that speakers control the peak alignment in a consistent way relative to the course of the syllable. This confirms the hypothesis about the existence of well-defined targets. However, in our data, they do not appear to be aligned relative to "segmental anchor points" to which the tones would be aligned as defined by Arvaniti et al. (1998), and Atterer and Ladd (in press). The results demonstrate that the target is sensitive to syllable onset, rhyme onset and syllable offset for Bulgarian, and syllable onset and offset for Polish. The alignment pattern found here emerged clearly due to the use of only one syllable type (/ma/) for all conditions. However, further investigations for these two languages need to be carried out with the variety of syllable structures in order to assess the extent to which the

target is aligned relative to onset and offset of the syllable or the beginning and end of the sonorant portion.

The following accent types were found to be used by the Bulgarian speakers: H+!H*/L*, !H*, H* and L+H*. Polish speakers use H+L*, !H+L*, H*+L and L+H*. For both languages, we found different accent types in the same focus condition and the same accent types in different focus conditions. This is reflected in the alignment measures where the following patterns are observed.

First, in non-contrastive focus f_0 targets are aligned significantly earlier than in contrastive focus in both languages. This is mainly due to the fact that, the speakers tend to use rising accents in contrastive and falling accents in non-contrastive focus conditions. Additionally, alignment of f_0 events in both languages varies with respect to the position of the focused items in an utterance. Within each focus type utterance initial focused items (subject) are aligned significantly later than utterance medial (verb) and utterance final items in focus (object). A possible explanation is the phenomenon of "tonal repulsion". The proximity of the intonation phrase boundary tones leads to temporal readjustments of peak location (Silverman and Pierrehumbert, 1990).

Finally, the details of alignment for the H(igh) targets highlight the differences in the phonetic realisation of phonologically specified accent types in the two languages. These findings suggest that Bulgarian speakers align their f_0 peaks later than the Polish speakers and confirm general claims in literature (Arvaniti et al, 2000) that these H target points are language specific in nature. However, the experimental findings demonstrated a cross-language pattern, namely, that in all focus type conditions, speakers controlled the position of the f_0 peak such that accented items positioned later in the utterance received an earlier f_0 peak alignment than those in sentence medial and initial position. It is not clear how much this pattern is a result of what may be a universal tendency or whether it is partly a reflection of the choice of a different falling accent types used in different sentence positions.

The above study sheds light on the description of temporal alignment of f_0 events in Polish and Bulgarian across focus conditions. Nevertheless, as already stated above, further analysis is needed before the above claims and descriptions can be extended to a more general model of alignment in the two languages studied.

6. ACKNOWLEDGEMENTS

The first author is funded by the International Post-Graduate College "Language Technology and Cognitive Systems". Both authors would like to thank Prof. William Barry for his invaluable comments and ideas.

7. REFERENCES

Arvaniti, A, D. R. Ladd and I. Mennen (1998). "Stability of tonal alignment: the case of Greek prenuclear accents". Journal of Phonetics 26, 2-25.

Arvaniti, A., D. R. Ladd and I. Mennen (2000). "What is a starred tone? Evidence from Greek." In M. Broe & J. Pierrehumbert (eds.), Papers in Laboratory Phonology V: Acquisition and the Lexicon. Cambridge University Press, 119-131.

Atterer, M. and D. R. Ladd (in press). "On the phonetics and phonology of "segmental anchoring" of F0: evidence from German". To appear in Journal of Phonetics.

Avgustinova, T. and B. Andreeva (1999). Thematic Intonational Patterns in Bulgarian Clitic Replication. In: Proceedings of the XIVth International Congress of Phonetic Sciences, San Francisco. 1501-1504.

Caspers, J. and V. van Heuven (1993). "Effects of time pressure on the phonetic realization of the Dutch accent-lending pitch rise and fall.", Phonetica 50, 161-171

IPDS (1997). xassp (Advanced Speech Signal Processor under the X Window System) - User's Manual. Version 1.2.15. AIPUK 32, 31-115.

Ladd, D.R. (1996). Intonational Phonology. Cambridge University Press.

Miševa, A. (1991). Intonacionna sistema na bâlgarskija ezik, Sofija: BAN

Pierrehumbert, J. (1980). The Phonology and Phonetics of English Intonation. PhD thesis, MIT, published 1988 by IULC.

Prieto, P., J., van Santen and J. Hirschberg (1995). "Tonal Alignment Patterns in Spanish", Journal of Phonetics 23, 429-451

Schepman, A., Lickley, R. and Ladd, D.R. (submitted). Effects of vowel length and "right context" on the alignment of Dutch nuclear accents.

Silverman, K. and J. Pierrehumbert (1990). "The timing of prenuclear high accents in English", in J. Kingston & M. E. Beckman (eds.), Papers in Laboratory Phonology I, Cambridge: CUP, 72-106

Steele, S. (1986). “Nuclear accent F0 peak location: effect of rate, vowel, and number of syllables.”, Journal of the Acoustical Society of America Supplement 1, 80, s51.

Vallduví, E., and E. Engdahl (1995). Information Packaging and Grammar Architecture. In: J. N. Beckman Proceedings of North East Linguistic Society 25. 1. University of Pennsylvania. 519-533.

Vallduví, E., and E. Engdahl (1996). The Linguistic Realisation of Information Packaging. In: Linguistics 34, S. 459-519.