Hunyadi László: Experimental evidence for stress and accent at morphological constituent boundaries in Hungarian
Argumentum, 4 (2008), 254-265
Kossuth Egyetemi Kiadó (Debrecen)

Tanulmány

Hunyadi László

Experimental evidence for stress and accent alignment at morphological constituent boundaries in Hungarian[1]

Abstract

The study of the relation between syntax and prosody has been the focus of important research in the past decades. It has been shown that there are certain considerable mismatches between the two, essentially due to the fact that they are different kinds of structure. This paper investigates the issue of possible correlations between morphological and prosodic structure. It shows that the prosodic marking of morphological phrase boundaries is possible but it is limited to boundaries involving free morphemes only.

1 Introduction

The relation between the abstract, underlying structure of language and its manifestation in speech has long been considered as one of the central issues in the study of language. In particular, it is important to identify those cues in the flow of speech which may lead to the identification of linguistic structure, and, ultimately, to the understanding of an utterance. Within this broad issue involving phonetic/phonological, morphological, syntactic, semantic, pragmatic and cognitive aspects of language, it is straightforward to assume that the phonetic and phonological characteristics of speech play an important role. In this context it is essential to identify the phonetic and phonological structure of speech and find out to what extent it matches the abstract, in particular syntactic structure of language.

It has been shown in previous studies (cf. Selkirk 1984) that there is a special relation between syntax and prosody: both can be represented in a similar constituent structure but they differ in the possible depth of such constituency. According to Selkirk's Strict Layer Hypothesis (Selkirk 1984), the apparent relative 'flatness' of prosodic structure can be captured by the fact that, whereas syntactic constituent structure is made of recursively generated constituents, recursion is not possible in prosody. In other studies, however, it has been shown that at least to a certain degree recursion is also possible in prosody by means of stress and pause (cf. Ladd's Compound Prosodic Domains, cf. Ladd 1996). Finally, it was also shown that intonation, i.e. pitch variation plays an important role in reflecting both

[1] This paper is based on a talk given at the Alignment workshop at IDS Mannheim, Germany, November 20-21, 2008. Research this article is based on was partially supported by Grant OTKA 69042.

Hunyadi László: Experimental evidence for stress and accent at morphological constituent boundaries in Hungarian
Argumentum, 4 (2008), 254-265
Kossuth Egyetemi Kiadó (Debrecen)

syntactic constituency and logical scope across languages (cf. Hunyadi 1995, 2002) even overriding linear word order constraints.

Constituency is not the sole property of syntax, though. It is the essential characteristics of structure in general and thus it can be found at other structural levels as well, including morphology and phonology. Since we may expect certain interaction between the various levels of linguistic structure, it interesting to find out if there are any prosodic clues of lower level, non-syntactic constituency. The present paper investigates the issue of the role of prosody in marking constituency inside morphology, in particular, at morpheme boundaries at two levels: involving free as well as bound morphemes.

2 Problems of prosodic constituency

In order to find out what role prosody plays in marking morphological boundaries, let us first identify the main means of denoting prosodic structure in general.

2.1 Prosodic phrases: cues to prosodic structure

The primary function of prosody is to divide the stream of speech into chunks. These chunks are not arbitrary: only those are structurally meaningful which delimit the given stream of speech into phrases. Given the fact that phrases are the underlying building blocks of an utterance, we need to assume that the number of types of prosodic phrases is necessarily limited. The means of denoting phrase boundaries similarly needs to be limited. Accordingly, these boundary markers are restricted to just a few: (a) a clear pause accompanied by a local F0 fall or rise, (b) a subtle local slowing and (c) a local pitch change. (For the study of various prosodic phrase markers cf. Liberman & Prince 1977, Cooper & Sorensen 1981, Hayes 1984, Clifton et al. 2002).

It is important to note that, given the physical nature of speech, prosodic phrase boundaries must be audible, i.e., these phonological properties of prosodic structure always require some marked phonetic realization. Due to this obvious interdependence between phonology and phonetics in prosodic phrasing, i.e. due to the fact that a prosodic phrase needs to be physically (phonetically) marked in speech, the realization of phrase boundaries is relative to both linear and long-distance relations. Accordingly, whether a given pause in the flow of speech represents a boundary is quantitatively relative to other pauses either preceding or following the given pause. Similarly, a subtle local slowing can only be considered as a phrase marker in relation to other changes of tempo across longer stretches of speech. All this suggests that prosodic phrase boundaries are often hard to identify and hard to locate unambiguously (false positives and false negatives may equally occur).

In addition to the existence of distinct boundary markers as phrase delimiters, prosodic phrases are frequently assumed to have their own specific, characteristic internal prosodic structure: they differ in their intonational tune as well as DTE (Designated Terminal Element). Accordingly, prosodic phrases included between the same pair of boundary markers can differ depending on their internal structure. As such, in order to identify a prosodic phrase one needs to identify both the external boundary markers (phrase delimiters) and the internal prosodic structure within these markers. It may well be the case, that even

Hunyadi László: Experimental evidence for stress and accent at morphological constituent boundaries in Hungarian
Argumentum, 4 (2008), 254-265
Kossuth Egyetemi Kiadó (Debrecen)

though the boundary markers are present, no prosodic phrase can still be identified, since these markers do not include any well-formed intonational pattern (tune in general).

When describing prosodic phrase boundaries in these terms, through physically relevant, phonetic objects (such as a pause, slowing down etc.) we refer to certain abstract, functional prosodic objects, similarly to the way sounds refer to phonemes. Accordingly, we assume that at the level of phonology prosody has an invariant structure that is built from a limited number of primitives, such as pause, F0-change, slowing down and intonational tune, and this invariant structure is realized by the physical objects of phonetics.

2.2 Mismatches between syntactic and prosodic structure

That prosodic structure cannot directly derive from syntax (and that it has its own characteristic structure) was shown by Chomsky and Halle (1968). As their example shows there is a clear mismatch between syntactic and phrase boundaries, presented in (1) – [and] mark syntactic, || mark prosodic phrase boundaries:

(1) [|| This is [the dog || that chased [the cat || that killed [the rat || that ate [the malt || that lay in [the house that Jack built ||]]]]]]

This example shows that the closing prosodic phrase boundaries (denoted by || and marked by a pause) always follow the corresponding syntactic phrase boundary and the two do not coincide. Chomsky and Halle's account for this obvious kind of mismatch is that it is the result of attempting to match one kind of structure unto another.

2.3 Structural hierarchy vs. linearity of elements[2]

Selkirk (1984) observes that these two kinds of structure are different in the sense that whereas syntactic structure can have an indefinite depth, prosodic structure, due to the flow of words being linear in essence, cannot. Her Strict Layer Hypothesis (SLH) formulates this difference as follows:

> SLH: In a prosodic tree, any domain at a given level of hierarchy consists exclusively of domains at the next lower level of the hierarchy. It follows from this that, whereas syntactic structure is recursive, prosodic structure is not recursive.

3 Prosodic boundaries between phonological phrases

Boundary markers, as we saw above, are essentially characterized by the primitives of pause (duration), slowing down (tempo) and F0-change (intonation). Since these primitives have physical, phonetic realization and their identification is relative to other, local and non-local factors, their success of identification may vary according to the phonetic signal. Our earlier experiments, however, show that in case of abstract, non-linguistic objects, the phrasing (grouping) of such objects can be unambiguously realized by duration, i.e. temporal variation (cf. Hunyadi 2006). Accordingly, a clear durational phrase boundary (pause) can be identified

[2] For a detailed overview of previous work cf. Truckenbrodt (1999, 2007).

at the boundary of two phrases, whereas, if two objects make a single group, the boundary (if any) between these two objects is significantly shorter than if there were a phrase boundary between the two.

Tonal variation is found similarly important in both abstract, non-linguistic phrases as well as linguistic utterances. The belonging of two tonal chunks to one and the same intonation phrase is either denoted by an uninterrupted, continuous tonal contour (if the two chunks are adjacent) or by their virtual tonal continuity (if the two chunks are non-adjacent – in case of embedding and insertion).

In summary, we can find that there are clear pausal and tonal means of denoting prosodic structure in general. What we wish to find out is whether the possibilities of these means also extend to the denotation of morphological phrase boundaries as well. Within morphology, we would expect duration, especially pause not to play such a role: it follows from the nature of morphology that a phonological word should be realized as a single prosodic unit undivided by a pause: namely, constituents of a compound word are not expected to be delimited by a pause following the definition of the phonological word. Similarly, apart from tonal languages, we do not expect morphological constituents of a single word to have a distinct tonal contour at constituent boundaries. However, what we may wish to further investigate is the role of accent/stress at morphological boundaries, especially involving free morphemes. Following the fact that any word can have an underlying accent of its own, we may suggest that free morphemes can be assigned their own accent. We may also suggest that, since bound morphemes do not have an underlying accent of their own, we do not necessarily expect an affixed word to have separate accents for each of the their morphological constituents.

In order to test these assumptions, first we have to specify the phonetic properties of accent/stress. In the following, we will assume that accent and stress have similar phonetic properties with the distinction that accents are found at the word level and stress is the property of a whole utterance, beyond the word level. In other words, accent marks the prominence of a syllable over other syllables in the same phonological word, whereas stress represents the prominence of a phonological word (marked by its accent) over other phonological words in the utterance.

4 The phonetic properties of accent/stress: PET

The phonetic cues of accent/stress have been widely studied (for a comprehensive classical overview of this issue cf. Fónagy 1958). The possible candidates are the parameters intensity/energy appearing as loudness in perception, pitch measured as a value of F0, and duration. It is also worth to note that these parameters of speech do not normally participate in the marking of accent/stress in free variation, instead, they appear in combination: an increase of intensity is often accompanied by a change of F0, or an increase of duration may combine with intensity or F0-change. Although they normally appear in combination, we can still assume that they can be treated as independent variables. In order to capture the complex nature of this cue while preserving each of these parameters as independent variables, we will follow the approach in Hunyadi 1995).

Hunyadi (1995) assumes that all three major parameters of speech, i.e. pitch (measured as F0), energy (measured as intensity) and duration (measured as time) participate in the marking of accent/stress, even though at varying degrees. The phonetic cue of accent/stress

Hunyadi László: Experimental evidence for stress and accent at morphological constituent boundaries in Hungarian
Argumentum, 4 (2008), 254-265
Kossuth Egyetemi Kiadó (Debrecen)

appears in perception as a varying relation between these parameters. Accordingly, if all three parameters have the same share in the flow of speech, then there is no perception of accent/stress, but if, at a point in the flow of speech, one of the parameters has a relative prominence (e.g. there is more F0-change than intensity change), this "imbalance" among the parameters creates a cue to accent/stress. This relative relation of the three major phonetic parameters is formulated as follows:

(2) PET = Pitch and Energy over Time
$\text{Pitch}_{norm\ t1} - \text{Energy}_{norm\ t1}$, $\text{Pitch}_{norm\ t1+1} - \text{Energy}_{norm\ t1+1}$, ... $\text{Pitch}_{norm\ tn} - \text{Energy}_{norm\ tn}$

Namely, after normalization, we calculate the difference between pitch and energy measured at each of the sample times *t1, t2,...tn*. Whereas each of the parameters takes the form of a series of values across time and can be represented as a usual waveform of its own, this calculation of PET results in a single waveform combining all three parameters yielding a single value at each sample time. Accordingly, any difference between pitch and energy at a given sample time will result in a value other than 0: if at a given sample time pitch has relative prominence over energy, this value will be greater than 0, if it is energy that has prominence, this value will be smaller than 0. A series of these relative values over time will take the form of a wave representing the change in relative prominence of pitch and energy. Some changes are the effect of local phonetic processes, such as the combination of a plosive consonant and a vowel. These changes only extend to that particular combination and are shown as an effect with a very short duration. However, typical instances of accent/stress represent a change with a much longer duration, and, as a result, instancs of accent/stress can be well differentiated from local changes as a function of time. As a result, PET offers a means to capture the relative prominence of phonetic parameters as a cue of accent/stress by calculating the difference of pitch and energy over time.

The following pair of graphs shows how the stress difference between (3) and (4) can be represented as a function of PET (stressed words are capitalized):

(3) VALAMENNYIEN eljöttek.
all/some of them came
'All of them came.'

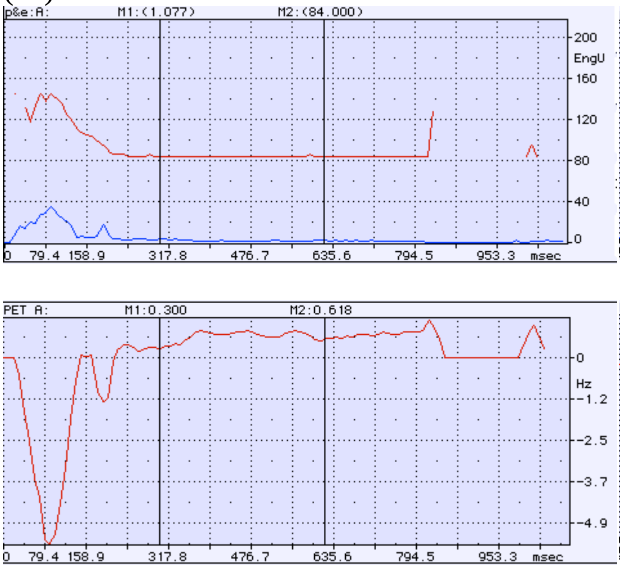
(4) Valamennyien ELJÖTTEK.
all/some of them came
'Some of them came.'

This pair of examples shows that the same quantifier word is used both for universal (3) and existential (4) quantification. The difference between the two kinds of quantification is denoted by a difference in stress: the stressed quantifier denotes universal, the unstressed one denotes existential quantification. As the examples show the presence or absence of stress is the only indication of the given kind of quantification. Accordingly, stress has an important logical function.

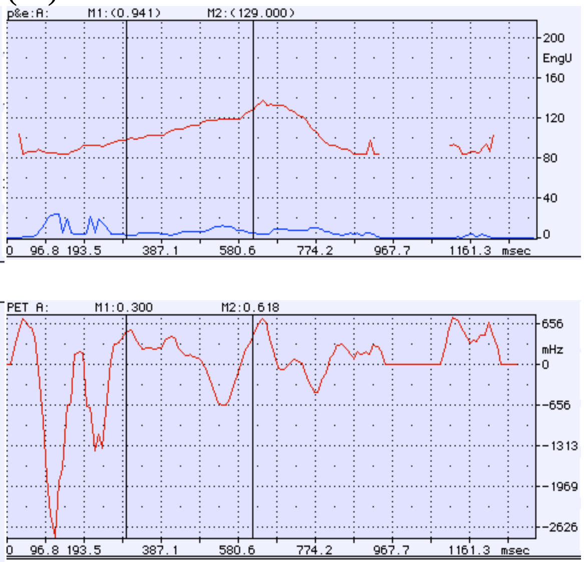
Compare the following pairs of graphs. The upper graph in each pair shows the pitch and energy contour of the given utterance separately, whereas the lower graph displays the respective combined PET-form of each of the utterances; cf. (3a) and (4a):

Hunyadi László: Experimental evidence for stress and accent at morphological constituent boundaries in Hungarian
Argumentum, 4 (2008), 254-265
Kossuth Egyetemi Kiadó (Debrecen)

(3a)



(4a)



Valamennyien eljöttek   Valamennyien eljöttek

The comparison of the lower PET-graphs shows the following: both in the stressed (3a) and the unstressed (4a) variants there is a considerable emphasis on the initial syllable (the curve clearly falls under 0). However, in the case of (3a) this is the only clear emphasis (a deep valley with a significant duration), so it can be considered the phonetic cue to stress. In (4a) the emphasis on the initial syllable is not the only one (and not the longest one), it is rather due to the utterance-initial position of the given syllable. The second vertical bar indicates the position of the stressed syllable *eljöttek* ‘came’. Compared to the same phonological word in the same linear position in (3a) similarly denoted by the second vertical bar, this excursion is really significant. Whereas in (3a) there is a continuous decrease of both pitch and energy (with a slight prominence of pitch with PET-values greater than 0) after the initial stressed syllable, this continuous decrease of the values of the same parameters cannot be observed in (4a). Instead, the new valley with its relatively long duration indicates the location of stress in the utterance.

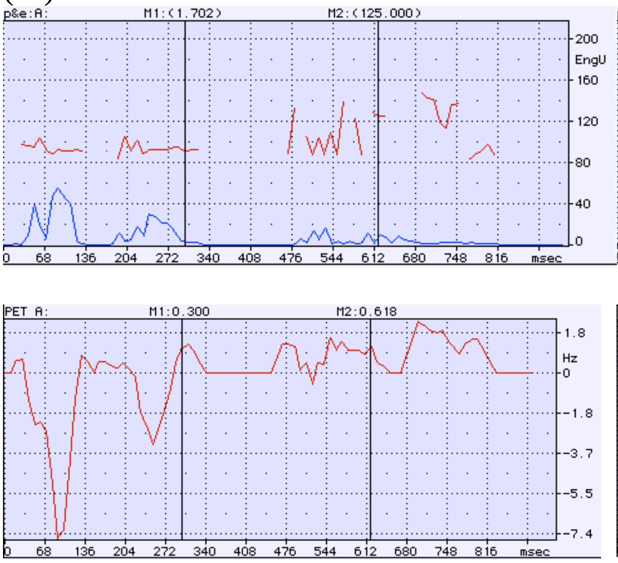
The next pair of examples indicate yet another instance where stress has its clear logical function, the expression of specificity; cf. (5) and (6):

(5) AKARSZ valamit?
you want something
‘Do you want anything?’

(6) AKARSZ VALAMIT?
you want something
‘Do you want something?’

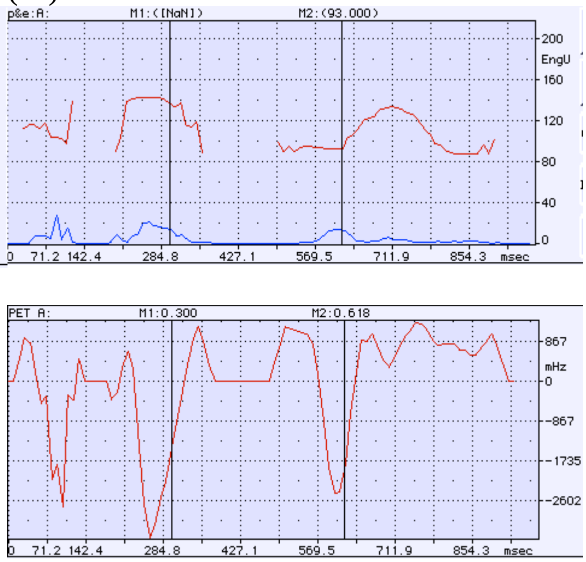
In (5) the absence of stress indicates non-specificity, whereas in (6) the presence of stress indicates specificity. This important logical difference delivered by stress alone can be manifested in the PET-representation of the respective utterances; cf. (5a) and (6a):

(5a)



Akarsz valamit

(6a)



Akarsz valamit

The comparison of the above pairs of graphs clearly demonstrates the presence of a second stress in (6) on the quantifier *valamit*: there is a significant excursion of the curve starting at the stressed syllable of the quantifier as compared to its non-stressed counterpart in (5).

These examples shed light on two important issues related to prosody: first, prosody, stress in particular, can in our perception indicate important logical differences by itself, and second, the perceived stress has clear phonetic representation that can be captured in terms of PET, i.e. the relative prominence of pitch or energy over time.

In the next section we are going to find out if the phonetic correlates of stress can also be found as accent at morphological constituent boundaries.

5 Accent/stress at morphological constituent boundaries

Let us consider if PET can indicate accent/stress in phonological words. Compare the following pair of sentences:

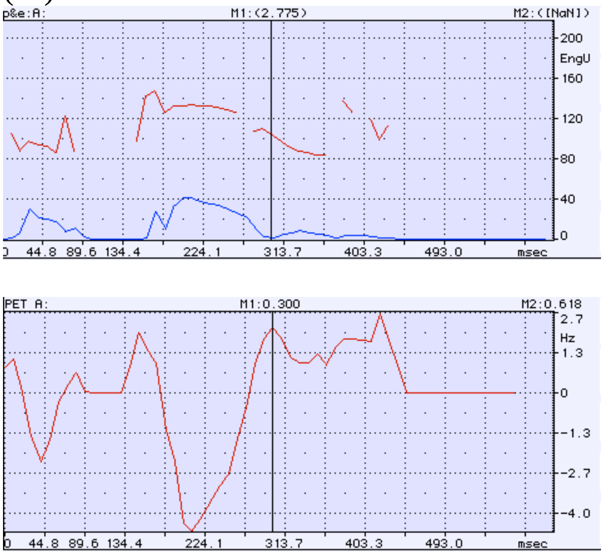
(7) a karom
the my-arm
'my arm'

(8) Akarom?
do I want
'Do I want it?'

The two phonological words are identical with respect to their phonological material. The difference is morphological: the initial phoneme /a/ represents the definite pronoun *a* in (7), whereas the same phoneme in (8) does not have a morphological status of its own. Phonetically, the definite pronoun is unstressed in (7), whereas the initial /a/ in (8) is stressed due to its being the word-initial syllable. The pairs of graphs show this difference in terms of PET as well; cf. (7a) and (8a), respectively:

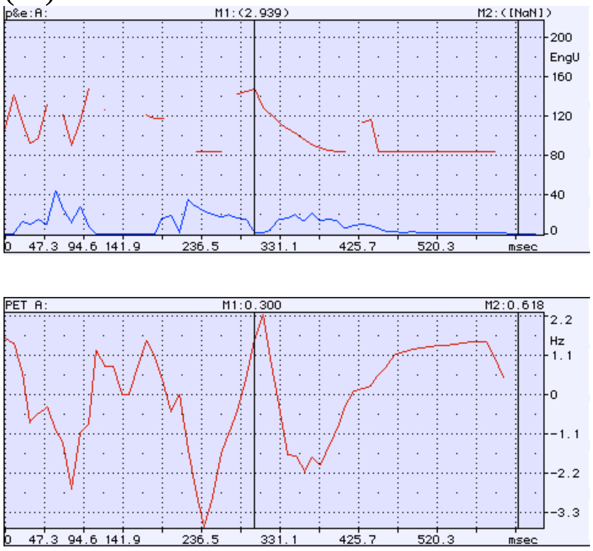
Hunyadi László: Experimental evidence for stress and accent at morphological constituent boundaries in Hungarian
Argumentum, 4 (2008), 254-265
Kossuth Egyetemi Kiadó (Debrecen)

(7a)



a ka- rom

(8a)



a- ka- rom

The comparison of the two lower graphs (PET for (7a) and (8a), respectively, shows clearly that, as expected, there is only one significant accent in (7a), on the initial syllable of the word *karom*. In contrast, in (8a) we see almost identical three accents in the word *akarom*. The first accent is on the initial syllable, as required by Hungarian morpho-phonology. The second accent falls on the second syllable of *akarom* due to the fact that, (8) being a yes-no interrogative sentence, it is this penultimate syllable where a characteristic rise of pitch must fall – accompanied, as we can see, by a similar and relatively even more significant increase of energy. The presence of an accent on the third syllable is not an extra one, rather, it is the consequence of the fact that the accent on the second syllable is not eradicating, i.e. it is not a focus accent.

Let is now compare two utterances in which the sequence of phonemes is the same, but the morphological structure of the sequence is different; cf. (9) and (10):

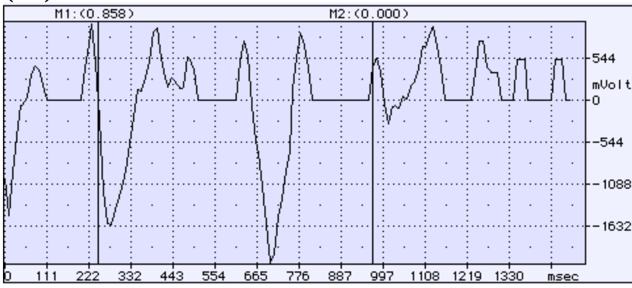
(9) Amit mondottál, teljesen igaz.
what you said fully true
'What you said is absolutely true.'

(10) A mondott tál felborult.
the said bowl turned over
'The said bowl turned over.'

Let us see if there is any prosodic difference in the realization of *mondottál* 'you said' and *a mondott tál* 'the said bowl'; cf. (9a) and (10a), respectively:

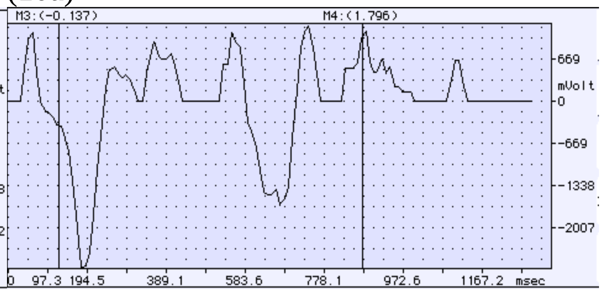
Hunyadi László: Experimental evidence for stress and accent at morphological constituent boundaries in Hungarian
Argumentum, 4 (2008), 254-265
Kossuth Egyetemi Kiadó (Debrecen)

(9a)



Amit mondottál teljesen igaz

(10a)



A mondott tál felborult

The two vertical bars represent the start of the second and third syllable of *mondottál* and *mondott tál*, respectively. As the PET-graphs show we can identify an accent on each of these two syllables in both cases with the only difference that in (10a) *mondott tál* the accent on the third syllable (the second significant valley) is not so deep as in the same position in (9a). This fact can be accounted straightforwardly: the fact that this valley is not so deep in (10a) indicates that, although the accent is present, energy has relatively less prominence than in (9a) – due to the fact that there is an absolute increase of F0 on this syllable. This increase of F0 is an indication of a morphological boundary as compared to (9a). It suggests that a boundary between phonological words (*mondott* 'said' and *tál* 'bowl' in this case) may require to be marked prosodically more than between a stem and a bound morpheme. It is the consequence of the characteristics of intonation spreading over an utterance: in non-tonal languages an intonation contour does not specifically change within a phonological word, instead, it changes (if at all) at phonological word boundaries. Accordingly, it changes on the word 'tál' in (10a) and this change is represented by an absolute increase of pitch on that word – resulting in the relative prominence of pitch on the third syllable of (10a), shown by a lesser degree of valley on 'tál' in (10a) than on '-tál' in (9a).

Let us consider one more example with the same sequence of phonemes but different morphological structure; cf. (11) and (12):

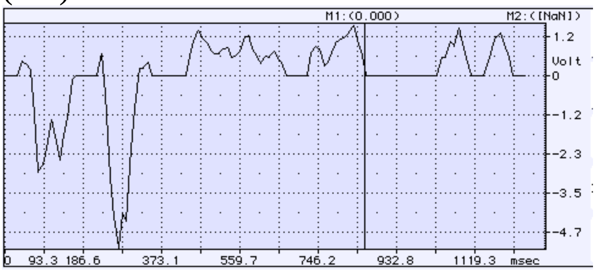
(11) Ez a háza szép.
this the his-house nice
'This house of his is nice.'

(12) Ez a ház a szép.
this the house nice
'This house is the nice (one).'

The difference between the two sentences is that the word stem *ház* is followed by '-a' as a possessive affix in (11) whereas in (12) it is followed by *a* as a definite article. Let us see if PET can show any prosodic difference corresponding to this morphological difference; cf. (11a) and (12a), respectively:

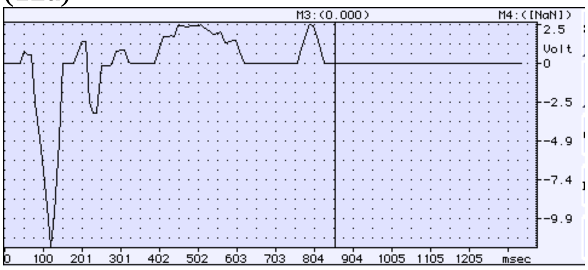
Argumentum, 4 (2008), 254-265
Kossuth Egyetemi Kiadó (Debrecen)

(11a)



Ez a há- za szép

(12a)



Ez a ház a szép

The comparison shows a very slight difference: the continuous line at 0 before the second vertical bar in (12a) suggests a pause produced by the speaker before *a szép*, whereas there is no pause before '-a', a bound morpheme in (11a).

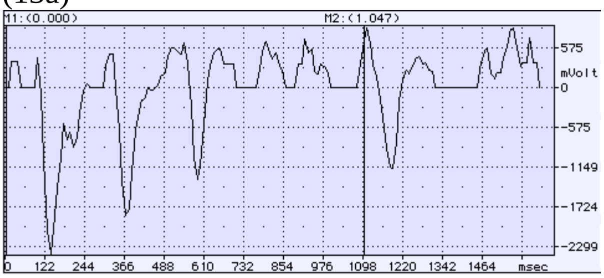
The reason for the fact that beyond a difference in duration (pause) we cannot see any role of pitch or energy manipulation here is that both the bound morpheme '-a' and the definite article *a* are unstressed by default. Accordingly, no change can be expected in these parameters. Finally, let us now see an example where a bound morpheme is contrasted to a free morpheme with the same phonemic sequence. It is expected that pitch and/or energy variation is at place here; cf. (13) and (14):

(13) Száguldozhatok nélküled.
I can drive madly without you
'I can drive madly without you.'

(14) Száguldozhat ok nélkül.
He can drive madly reason without
'He can drive madly without reason.'

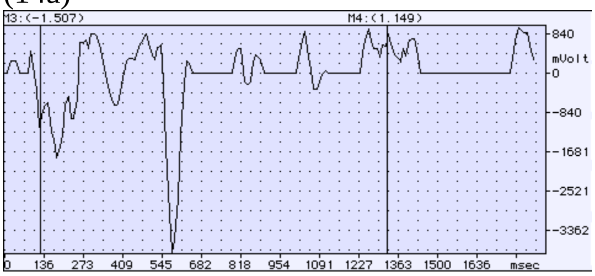
In (13), '-ok' is a bound morpheme (first person singular), i.e. it cannot be accented, whereas *ok* in (14) is a free morpheme 'reason' which, followed by the postposition *nélkü*l should be accented. This is what we can see from their respective PET-graphs:

(13a)



Száguldozhatok nélküled

(14a)



Száguldozhat ok nélkül

As (13a) shows, there is no accent on the last syllable '-ok' of *száguldozhatok* 'I can drive madly', instead, there is a significant accent on *nélküled* 'without you'. In contrast, in (14a) we see a certain relative accent on *ok* 'reason' such that it is, as expected, followed by the unaccented postposition *nélkül* 'without'. Accordingly, the prosody of the two sentences follows their morphological difference: at morphological boundaries involving at least one free morpheme, we can identify a prosodic delimitation; at other boundaries such a prosodic segmentation is not apparent.

6 Summary and conclusions

In this article we have investigated the relation between different modalities of linguistic structure, i.e. syntax, semantics and prosody. We pointed out that these modalities have different means of denoting structural relations. As for syntax, it is obvious that by the application of recursion an indefinite depth of structure can be generated, whereas, due to its relative flatness, recursive generation of prosodic structure is limited but such structures are not excluded. Accordingly, no direct matching between syntactic and prosodic structure needs to be expected.

It was shown that the denotation of prosodic structure has phonetic cues, including the basic parameters of the flow of speech, such as duration, the change of pitch and the change of energy. It was shown that the perceptual object of accent/stress can be captured as a complex relation of the above three phonetic parameters and this relation can be reduced to and described by the function PET (Pitch and Energy over Time).

It was shown that graphs produced by the function PET are suitable for capturing the perceptual object of accent/stress both in utterances and smaller chunks of speech involving sequences of morphemes. We found that prosody is, in principle, suitable for the marking of morphological boundaries. However, such boundaries must involve free morphemes for the following reason. Accent and stress involve a change in pitch and energy. In a non-tonal language these parameters only change across phonological word boundaries. Accordingly, we can only expect a certain prosodic cue to morphological phrase boundaries if this condition is met. Our examples and analyses have given support for this generalization.

References

Chomsky, N. & Halle, M. (1968): *The Sound Pattern of English.* New York: Harper and Row.

Cooper, W.E. & Sorensen, J.M. (1981): *Fundamental frequency in sentence production.* New York & Berlin: Springer.

Clifton, C.Jr., Carlson, K. & Frazier, L. (2002): Informative prosodic boundaries. *Language and Speech* 45.2, 87-114.

Fónagy, I. (1958): *A hangsúlyról. Nyelvtudományi Értekezések* 18. Budapest: Akadémiai Kiadó.

Hayes, B. (1984): The phonology of rhythm in English. *Linguistic Inquiry* 15, 3-74.

Hunyadi, L. (1995): Mondathangsúly a magyarban. In: Gósy, M. (ed.): *Beszédkutatás 1995*. Budapest: MTA Nyelvtudományi Intézete, 32-45.

Hunyadi, L. (2002): *Hungarian Sentence Prosody and Universal Grammar*. Frankfurt am Main: Peter Lang.

Hunyadi, L. (2006): Grouping, the cognitive basis of recursion in language. *Argumentum* 2(2006), 67-114.

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

Liberman, M. & Prince, A. (1977): On stress and linguistic rhythm. *Linguistic Inquiry* 8, 249-336.

Hunyadi László: Experimental evidence for stress and accent at morphological constituent boundaries in Hungarian
Argumentum, 4 (2008), 254-265
Kossuth Egyetemi Kiadó (Debrecen)

Selkirk, E. (1984): *Phonology and Syntax: the relation between sound and structure.* Cambridge: MIT Press.

Truckenbrodt, H. (1999): On the relation between syntactic phrases and phonological phrases. *Linguistic Inquiry* 30, 219-255.

Truckenbrodt, H. (2007): The syntax-phonology interface. In: de Lacy, P. (ed.): *The Cambridge Handbook of Phonology*. Cambridge: Cambridge University Press, 435-456.