

Crosslinguistic Segmental Durations and Prosodic Typology

Antonis Botinis¹, Robert Bannert², Marios Fourakis³ & Stamatia Pagoni-Tetlow⁴

¹Dept of Linguistics, University of Athens, Greece

²Dept of Linguistics and Philosophy, University of Umeå, Sweden

³Dept of Speech & Hearing Sciences, The Ohio State University, USA

⁴Dept of Phonetics & Linguistics, University College London, UK

Abstract

The present study is an experimental investigation of the effects of syllable position, stress, focus and tempo on segmental durations in American English, British English, Greek and Swedish. Nonsense disyllabic CVCV words were produced in a carrier sentence under different conditions of stress, focus and tempo. The results indicate that stress and tempo have a major effect on both consonant and vowel across all four languages, whereas the effects of syllable position and focus are hardly evident. Significant interactions were mostly found between syllable position and stress for the vowel.

1. Introduction

This study is an experimental investigation on the effects of the prosodic categories of syllable position, stress, focus and tempo on segmental durations in American English, British English, Greek and Swedish. The central question concerns the main effect of each prosodic category in the investigated languages; a subsequent question concerns the interactions of prosodic categories and, finally, the ultimate general question concerns crosslinguistic characteristics and prosodic typology.

Considerable knowledge has been accumulated on the effects borne by prosodic categories (foremost among which are syllable position, stress, focus and tempo (among others, cf [1], [2], [3])). However, there is still a need for crosslinguistic studies investigating the same context with identical methodology. The results of such studies would not only bring to light language-dependent as well as language-independent prosodic characteristics, but would also contribute to the development of a theory of language typology itself. On the other hand, although the main effects of the investigated prosodic categories on segmental durations are fairly known in different languages, including the ones investigated in the present study, there is still little substantial knowledge on prosodic interactions.

The duration of segments in speech production is determined by a variety of factors, which may be related to segmental (most often referred to as “intrinsic” or “microprosodic”) and prosodic effects (cf [4], [5], [6], [7]). Segmental effects may involve articulation gestures, e.g. other prosodic effects being equal, low vowels are longer than mid vowels which, in turn, are longer than high vowels. Prosodic effects, on the other hand, in addition to stress, focus and tempo investigated in this study, may involve a variety of other linguistic factors such as syllable structure, rhythmic structure, syntactic structure and discourse structure, all of which are outside the scope of this investigation.

2. Experimental procedures

The speech material of this investigation consists of a set of nonsense key words in the carrier sentence “the club {key word} plays good music” in the corresponding languages. The key words have a constant CVCV structure, where C consists of the voiceless fricative /s/ and V of the low vowel /a/, i.e. “the club sasa plays good music”.

The speakers are four female adults in each language with Ohio, London, Athens and Stockholm typical pronunciation for American English, British English, Greek and Swedish respectively. They produced the sentences, and thus the key words, with alternative stress patterns (i.e. first or second syllable stress), two tempi (i.e. normal and fast), six times each production. The key words were also pronounced in variable focus conditions, i.e. neutral-focus, pre-focus and focus. The neutral-focus productions were pronounced more or less “neutrally” i.e. the speakers had no contextual information. The alternative focus productions, on the other hand, were pronounced as a response to a question, which elicited a part of the sentence as the information required by the question. Thus, the questions “what does the club {key word} play?” and “which club plays good music?” defined the contextual frames for the pre-focus and focus productions of the key word respectively, i.e. “the club {pre-focus production of the key word} plays good music” and “the club {focus production of the key word} plays good music”.

The speech material was recorded in sound-treated room environments in Ohio (USA), London (UK), Athens (Greece) and Stockholm (Sweden) and some basic instructions were provided just before the recordings. Speakers varied the prosodic conditions, especially tempo, at an individual basis, in accordance with their speech habits. The speech analysis in all investigated languages was carried out at the Phonetics Laboratory of the University of Athens.

3. Results

The results are based on duration measurements of part of the recorded speech material, i.e. one speaker’s six productions and are thus subsequently qualitative. Statistical processing was carried out and the results are presented in two main sections: main prosodic effects and prosodic interactions with reference to syllable position, stress, focus and tempo.

3.1. Main prosodic effects on segment durations

The main prosodic effects are shown in figures 1-4.

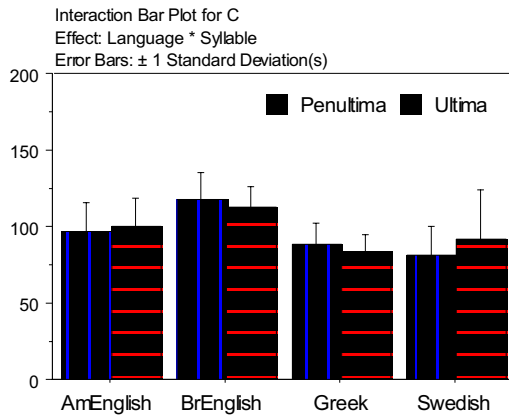


Figure 1a: Consonant duration of American English, British English, Greek and Swedish as a function of syllable position (Penultimate vs. Ultimate).

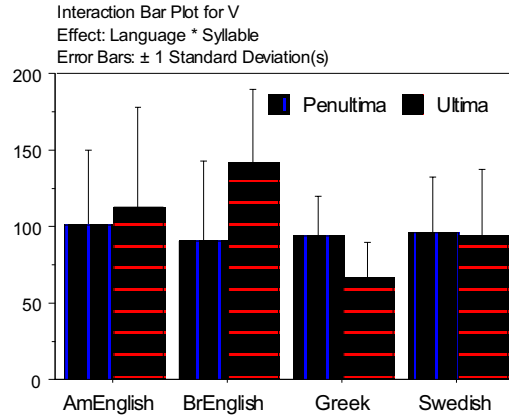


Figure 1b: Vowel duration of American English, British English, Greek and Swedish as a function of syllable position (Penultimate vs. Ultimate).

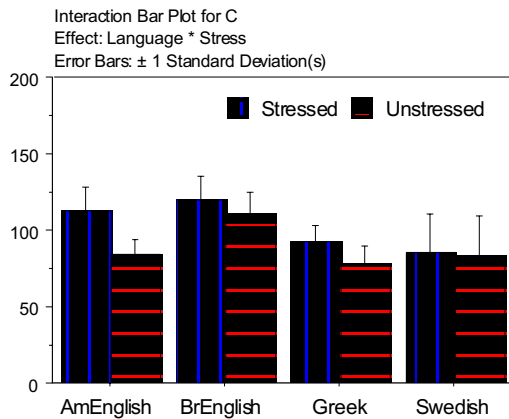


Figure 2a: Consonant duration of American English, British English, Greek and Swedish as a function of stress (Stressed vs. Unstressed).

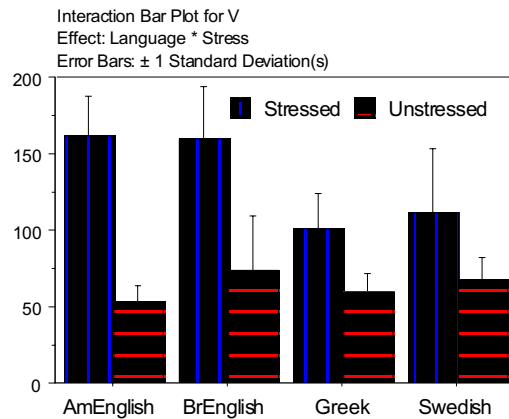


Figure 2b: Vowel duration of American English, British English, Greek and Swedish as a function of stress (Stressed vs. Unstressed).

3.1.1. Syllable position

Figures 1a-b show the effects of syllable position (*penultimate* vs. *ultimate*) on consonant and vowel segment durations. Syllable position has a significant effect on the consonant duration in British English (df 1; $F=4.8$, $p<0.02$) and Greek (df 1; $F=6.6$, $p<0.01$) but not in American English or Swedish; vowel durations also show significant differences in British English (df 1; $F=42.3$, $p<0.0001$) and Greek (df 1; $F=54.0$, $p<0.0001$) but not in American English or Swedish. British English and Greek have however a mirror image pattern in syllable position durations.

3.1.2. Stress

Figures 2a-b show the effects of stress (*stressed* vs. *unstressed*) on consonant and vowel durations. Stress has a significant effect on the consonant duration in American English (df 1; $F=226.9$, $p<0.0001$), British English (df 1; $F=13.9$, $p<0.0003$) and Greek (df 1; $F=82.5$, $p<0.0001$) but not in Swedish; vowel durations show significant differences in American English (df 1; $F=1353.9$, $p<0.0001$), British English (df 1; $F=236.0$, $p<0.0001$), Greek (df 1; $F=246.5$, $p<0.0001$) as well as Swedish (df 1; $F=26.9$, $p<0.0001$).

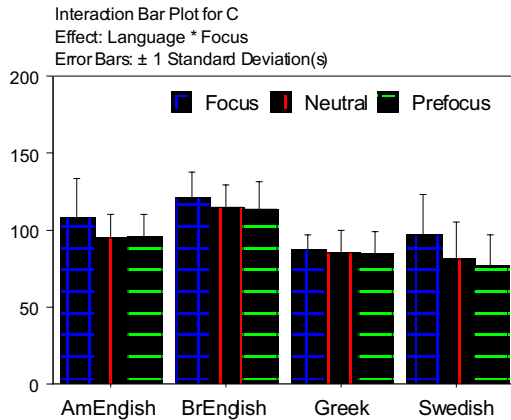


Figure 3a: Consonant duration of American English, British English, Greek and Swedish as a function of focus (Focus vs. Neutral vs. Prefocus).

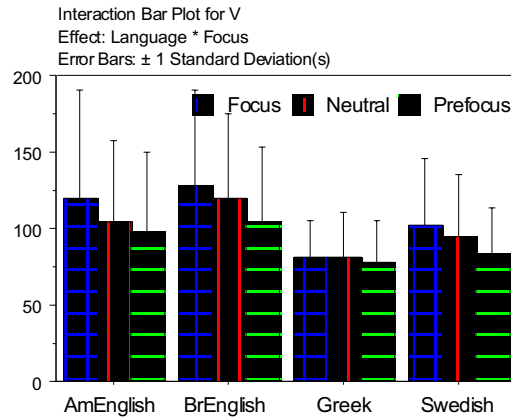


Figure 3b: Vowel duration of American English, British English, Greek and Swedish as a function of focus (Focus vs. Neutral vs. Prefocus).

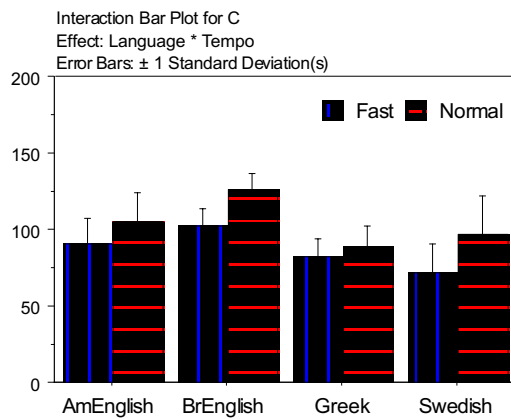


Figure 4a: Consonant duration of American English, British English, Greek and Swedish as a function of tempo (Fast vs. Normal).

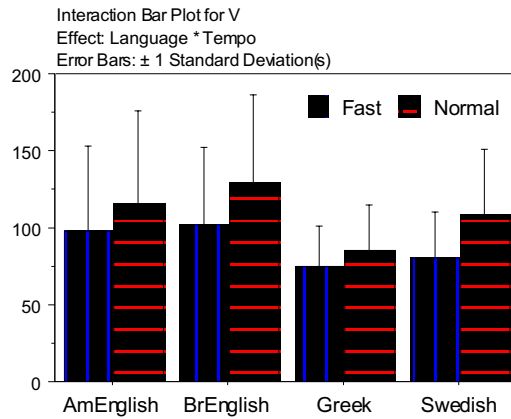


Figure 4b: Vowel duration of American English, British English, Greek and Swedish as a function of tempo (Fast vs. Normal).

3.1.3. Focus

Figures 3a-b show the effects of focus (*focus vs. neutral vs. prefocus*) on consonant and vowel durations. Focus has a significant effect on the consonant duration in American English (df 2; $F=10.0$, $p<0.0001$); Scheffe's post-hoc test showed significance for focus vs. neutral ($p<0.0001$) as well as focus vs. prefocus (0.004) but not for neutral vs. prefocus. No significant differences for focus was found in British English, Greek or Swedish. Vowel durations did not show significant differences in any of the four languages.

3.1.4. Tempo

Figures 4a-b show the effects of tempo (*normal vs. fast*) on consonant and vowel durations. Tempo has a significant effect on the consonant duration in American English (df 1; $F=34.6$, $p<0.0001$), British English (df 1; $F=182.1$, $p<0.0001$), Greek (df 1; $F=13.4$, $p<0.0003$) and Swedish (df 1; $F=20.2$, $p<0.0001$); vowel durations show significant differences in American English (df 1; $F=4.5$, $p<0.03$), British English (df 1; $F=9.8$, $p<0.002$), Greek (df 1; $F=6.2$, $p<0.01$) and Swedish (df 1; $F=9.3$, $p<0.003$).

3.2. Prosodic interactions on segment durations

3.2.1. Interactions with syllable position.

The interactions between syllable position and stress were not significant for the consonant in any language but did reach a significant level for the vowel in American English (df 1; $F=31.1$, $p<0.0001$), British English (df 1; $F=10.0$, $p<0.001$), Greek (df 1; $F=9.4$, $p<0.002$) and, marginally, Swedish (df 1; $F=3.8$, $p<0.05$).

Interactions between syllable position and focus did not reach a significant level for either consonant or vowel in any of the four languages.

Interactions between syllable position and tempo, did not reach a significant level for either consonant or vowel in any of the four languages.

3.2.2. Interactions with stress

The interaction between stress and focus did reach a significant level for both consonant (df 1; $F=11.9$, $p<0.0001$) and vowel (df 1; $F=16.3$, $p<0.0001$) in American English but not in any other language.

The interaction between stress and tempo did not reach a significant level for either consonant or vowel durations in any of the four languages.

3.2.3. Interactions with focus

The interaction between focus and tempo did not reach a significant level for either consonant or vowel in any of the four languages.

4. Discussion

In summary, stress and tempo had a considerable effect across the investigated languages whereas the effects of syllable position and focus were hardly evident. On the other hand, significant interactions were mainly observed between syllable position and stress and, partly (in American English), between stress and focus.

The results of the present investigation certainly reflect aspects of prosodic reality but may also be biased with reference to experimental conditions, mainly the quantity of data, the speech material and the acoustic measurements. First, the quantity of data is restricted to six productions by one speaker and has thus statistical shortcomings (further work is on the way). Second, the key material consisted of nonsense rather than real words. The advantage of this choice was the direct comparison of the results in the four languages. An obvious disadvantage was the production of the key words which, irrespective of the guidelines, were produced rather distinctively and often not in good accordance with the focus conditions, especially in American English, British English and Swedish. Third, the acoustic measurements of the vowels, especially the ultimate syllable ones, were carried out with reference to the formant rather than the voicing extinction. In conclusion, the experimental methodology of the present investigation may display a certain degree of interference regarding the effects of syllable position and focus.

Syllable position may have a lengthening effect on segment durations, according to which final segments at word, phrase and utterance levels may be longer than non-final counterparts and this has often been reported in the

international literature (e.g. [1]). In the present study, however, although the ultimate syllable was the boundary of a noun phrase, the final lengthening effect was only evident in British English. Interestingly enough – and in accordance to results from earlier studies – Greek not only displayed no evidence of a lengthening effect in this environment, but in fact showed clear evidence of the opposite tendency.

Stress has a considerable effect on segmental duration, according to which segments in stressed syllables were longer than segments in unstressed syllables – a widely known fact in prosodic research (cf. [1] for a review). This effect has been corroborated for all four languages in the present study.

Focus has also been repeatedly reported as a prosodic category with duration correlates ([7]) but no widespread effect was observed in the investigated languages. This is in line with earlier studies in Greek where no substantial effect of focus application was found ([5]).

Tempo had a considerable effect on the segmental durations of both consonants and vowels and this is in accordance with reports in the international literature ([3]).

In short, stress, followed by tempo, had the most substantial effect whereas the effects of syllable position and focus were not evident. On the other hand, prosodic interactions were hardly noticed whereas stress and tempo has shown significant interactions in earlier studies in Greek ([5]).

5. Conclusions

In the present investigation the following conclusions have been drawn: First, stress and tempo have a constant effect of segmental durations across all four investigated languages. Second, the results of final vs. non-final syllable position are not conclusive. Third, the results of focus are not conclusive either and further research is needed, especially with reference to the distribution of focus as well as its duration correlates. Forth, although minimal prosodic interactions were observed in the present investigation, further research in this area is clearly urgently needed.

6. References

- [1] Klatt, D.H. 1976. Linguistic uses of segmental duration in English: Acoustic and perceptual evidence. *J. Acoust. Soc. Amer.* 59, 1208-1221.
- [2] Crystal, T.H, House, A.S. 1988. The durations of American English vowels: An overview. *J. Phon.* 16, 263-284.
- [3] Gopal, H. S. 1996: Generalizability of current models of vowel duration. *Phonetica* 53, 1-32.
- [4] Di Cristo, A.; Hirst, D.J., 1986. Modelling French micromelody: Analysis and synthesis. *Phonetica* 43, 11-30.
- [5] Fourakis, M., Botinis, A., Katsaiti, M. 1999. Acoustic characteristics of Greek vowels. *Phonetica*, 56, 28-43.
- [6] Turk, A. E. and White, L. 1999. Structural influences on accentual lengthening in English. *J. Phon.* 27, 171-206.
- [7] Fant, G., Kruckenberg, A. and Liljencrants, J. 2000. Acoustic-phonetic Analysis of Prominence in Swedish. In *Intonation: Analysis, Modelling and Technology*, Botinis, A., ed., Dordrecht: Kluwer, 55-86.