

# Stress and accent: acoustic correlates of metrical prominence in Catalan

Lluïsa Astruc<sup>1</sup>, Pilar Prieto<sup>2</sup>

<sup>1</sup>Associate Lecturer, Faculty of Education and Languages, The Open University, UK

<sup>2</sup>Researcher and Lecturer, ICREA-Universitat Autònoma de Barcelona, Spain

## Abstract

This study examines the phonetic correlates of stress and accent in Catalan, analyzing syllable duration, spectral balance, vowel quality, and overall intensity in two stress [stressed, unstressed] and in two accent conditions [accented, unaccented]. Catalan reveals systematic phonetic differences between accent and stress, consistent with previous work on Dutch, English, and Spanish (Slujter & van Heuven 1996a, 1996b; Campbell & Beckman 1997, Ortega-Llebaría & Prieto 2006). Duration, spectral balance, and vowel quality are reliable acoustic correlates of stress, while accent is acoustically marked by overall intensity and pitch. Duration, at least in Catalan, is not a reliable indicator of accent since accentual lengthening was found only in speakers who produced some accents with a wider pitch range.

## Introduction

The search for consistent acoustic correlates of metrical prominence is complicated by the fact that stress and accent interact, since only stressed syllables can be accented. Some studies claim that stress does not have any phonetic reality and that only knowledge of the language allows listeners to distinguish minimal pairs such as ‘pérmít’ and ‘permít’. According to this view (Bolinger 1958, Fry 1958), the main correlate of stress is pitch movement and, in the absence of pitch, nothing in the speech signal indicates where stress is. According to the alternative view (Halliday 1967, Vanderslice & Ladefoged 1972), metrical prominence consists of two categories with two conditions each, which ranked from lower to higher yield the following hierarchy: [-stressed, -accented] > [+stressed, -accented] > [+stressed, +accented]. Stress would then have separate phonetic correlates, although they strongly interact with those of accent. Recent experimental work on stress and accent has had contradictory results. Slujter & van Heuven (1996a, 1996b) modelled metrical prominence as a two-dimensional scale with two categories in each dimension (accent and stress). They found that differences in duration (stressed syllables are longer) and in spectral balance (stressed syllables show an increase in intensity that affects

the higher regions of the spectrum), were strong correlates of stress, while overall intensity was a cue of accent rather than of stress. Their results were confirmed in American and British English (Turk & Sawusch 1997, Turk & White 1999), and in Spanish (Ortega-Llebaría & Prieto 2006). However, Turk and collaborators (1997, 1999) also found that duration interacted strongly with accent. On the other hand, Beckman & Campbell (1997) modelled prominence as a one-dimensional scale with three categories: stressed-accented, stressed, and unstressed. They did not find consistent phonetic correlates of stress in American English. They concluded that the apparent phonetic correlates of stress were only a side-effect of vowel reduction and when full vowels are examined, no correlates of stress are found. Our research question is whether different levels of prominence are indeed cued by a separate set of phonetic correlates in Catalan, a weakly stressed-timed language with lexical stress and phonemic vowel reduction as Dutch and English.

## Methodology

The corpus is formed by 576 target sentences, read by six female native speakers of Central Catalan. The experimental design has four experimental conditions: [+accent, +stress], [+accent, -stress], [-accent, +stress], and [-accent, -stress]. We have three vowels, two unreduced vowels, [u] and [i], and [a], reduced in unstressed position. Eight minimal pairs with CVCV structure and with ultimate and penultimate stress (Mimi-Mimí, Lulu-Lulú, mama-mamà, Mila-Milà, Milu-Milú, Vila-Vilà, mula-muler, Mula-Mulà) provide the stress conditions. The accent conditions are provided by minimal pairs of appositive and right-dislocated noun phrases (described respectively as accented and deaccented. See Astruc 2005, for a review). The intended interpretation (apposition or right-dislocation) is elicited with a question. Target syllables are word-initial in segmentally identical words in postfocal contexts, which allow us to control for position effects, for polysyllabic shortening, and for focal lengthening. Table 1 shows the four experimental conditions.

Table 1. Target syllable mi (in bold) in four accent and stress conditions

	[+ accent] apposition	[-accent] right-dislocation
[+stress]	M'agrada la protagonista, la <b>Mimi</b> 'I like the protagonist, Mimi'	Vol ser la protagonista, la <b>Mimi</b> 'She wants to be the protagonist, Mimi'
[-stress]	M'agrada la protagonista, la <b>Mimí</b>	Vol ser la protagonista, la <b>Mimí</b>

### Procedure

Six female native speakers of Central Catalan were recorded at 44.1 kHz directly onto a computer in a studio. They were instructed to read the target sentences naturally at an average voice level using a Shure SM10A head-worn microphone to keep constant mouth-microphone distance. Some target utterances did not receive the intended interpretation and they had to be repeated. Some speakers produced some pitch accents in a wide pitch range. Acoustic and instrumental analyses were performed using Praat (4.3.09). Segmentation and labelling were done by hand, marking CV boundaries and the highest and lowest F0 point in both vowels. Measurements of duration (ms), pitch (Hz), frequency of the formants (F1, F2, F3, in Hz), spectral balance (in four bands: B1: 0-500Hz, B2: 500-1000Hz, B3: 1000-2000Hz, B4: 2000-4000Hz), and intensity (dB) were taken automatically at the peak of intensity of both syllables.

### Results

The experimental paradigm worked well: appositions were consistently accented and right-dislocations were consistently deaccented. A one-way ANOVA ( $F(1)=147.534$ ;  $p<.05$ ) confirmed significant effects of accent on pitch range. Figure 1 shows mean results for pitch, duration, intensity, vowel quality, and spectral balance of the target syllable.

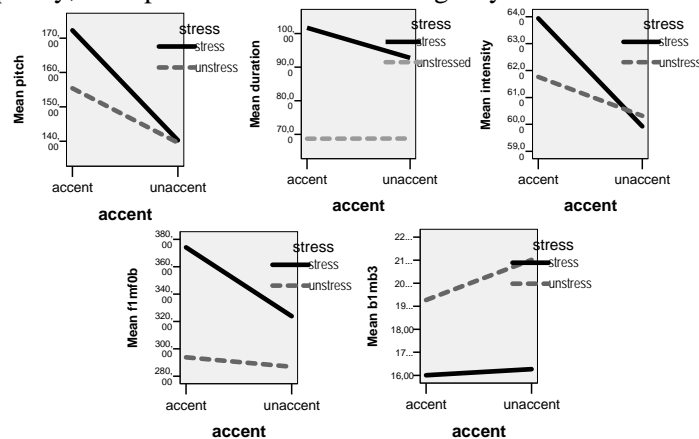


Figure 1. First row: pitch, duration, vowel quality, and intensity of V1 for all speakers. Second row: vowel quality and spectral balance of [a] for all speakers.

Repeated measures ANOVAs show significant effects of stress on the vowel quality of [a] ( $F1-F0$ , multivariate  $F(1,5)=12.003$ ,  $p<.05$ , partial Eta squared=.706), and on the spectral balance (B3-B1) of [a] ( $F(1,5)=7.756$ ,  $p<.05$ , partial Eta squared=.608) and [u] ( $F(1,5)=23.039$ ,  $p<.05$ , partial Eta

squared=.882), and on the duration (multivariate  $F(1,5)=265.77$ ,  $p<.05$ , partial Eta squared=.982) of all three vowels. Accent also has a strong effect on duration, but less stronger than that of stress (multivariate  $F(1,5)=11.320$ ,  $p<.05$ , partial Eta squared=.694). A speaker-by-speaker analysis reveals that only half of the speakers showed accentual lengthening, and these were the speakers who also used pitch accents with wider pitch excursions. Syllables were plausibly lengthened to accommodate these wider pitch movements. In conclusion, we controlled for focal and positional effects and for vowel reduction and found that stress differences are cued by systematic acoustic correlates, thus supporting the hypothesis that different levels of prominence are signalled by separate sets of acoustic cues.

## Acknowledgements

Thanks to our informants (A. Abella, E. Bonet, T. Cabré, A. Gavarró, M. Mata, M. Llinàs, P. Prieto) and to E. Ferragne and M. Ortega-Llebaria for their Praat scripts.

## References

- Astruc, L. 2004. The intonation of extra-sentential elements. Doctoral dissertation. University of Cambridge. Available from [www.astruc.info](http://www.astruc.info).
- Bolinger, D.L. 1958. A theory of pitch accent in English. *Word* 14, 109-149.
- Campbell, N. and Beckman, M. 1997. Stress, prominence and spectral tilt. In Botinis, A.; Kouroupetroglou, G; and G. Crayiannis (eds.), *Intonation: theory, models and applications*. Proc. of and ESCA Workshop, Athens, Greece.
- Fry, D.B. 1958. Experiments in the perception of stress. *Language and Speech* 1, 126-152.
- Halliday, M.A.K. 1967. *Intonation and grammar in British English*. Mouton.
- Sluijter, A. and van Heuven, V. 1996a. Spectral balance as an acoustic correlate of linguistic stress. *Journal of the Acoustical Society of America* 100 (4). 2471-2485.
- Sluijter, A. and van Heuven, V. 1996b. Acoustic correlates of linguistic stress and accent in Dutch and American English. Proc. of ICSL, 96. Philadelphia: Applied Science and Engineering Laboratories, Alfred I duPont Institute, 630-633.
- Turk, A.E. and Sawush, J.R. 1997. The domain of accentual lengthening in American English. *Journal of Phonetics* 25, 25-41.
- Turk, A.E. and White, L. 1999. Structural influences on accentual lengthening. *Journal of Phonetics* 27, 171-206.
- Ortega-Llebaria, M. and Prieto, P. 2006. Stress and accent in Catalan and Spanish: patterns of duration, vowel quality, overall intensity, and spectral balance. Proc. *Speech Prosody*. Dresden, Germany. 337-340.
- Vanderslice, R. and Ladefoged, P. 1972. Binary suprasegmental features and transformational word-accentuation rules. *Language*. 48: 819-38.