

Intra-syllabic structures of articulatory gestures in Swedish prosody

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Abstract

The present PhD project uses EMA methodology, and is inspired by and related to Articulatory Phonology, in a new approach to Swedish prosody and the word accents. Roughly halfway through the project, which initially included tonal, facial and articulatory gestures, some interesting findings have lead the project slightly away from the multimodal approach, and more towards a phonological study of the intra-syllabic structures of articulatory gestures.

Index Terms: articulatory gestures, word accents, tones, EMA

1. Introduction

The present research project, initially called “Tonal, facial and articulatory gestures in Swedish prosody”, started as a project about how a comprehensive communication of speech sounds and body movements relate to each other in time. Focus was the correlation between articulatory movements, intonation and facial gestures, using an ElectroMagnetic Articulograph (EMA), which can record movements in space and time. With the EMA methodology also comes a new approach to the Swedish word accents, notable for their dialect-specific tonal timing difference, and the possibility to get data on gestures other than the speech apparatus. The project contributes to phonetic basic research, research on speech disorders, and research on human-computer interaction.

The first large data collection of the project has recently finished. The initial results show some interesting articulatory differences between the two word accents, dependent on phonotactic, phonological and prosodic structures. These findings need to be corroborated, and including visual prosody seem no longer possible within the timeframe. Hence, to reflect this change, the alternative title of the project is “Intra-syllabic structures of articulatory gestures in Swedish prosody”.

1.1. Articulatory gestures

Within the framework of Articulatory Phonology [1], and the notion of articulatory gestures as phonological units, tones have been proposed to be articulatory gestures, i.e. tone gestures, which are comparable to consonantal and vocalic gestures [2], [3]. Lexical tone gestures in Mandarin have even been proposed to compete with consonantal gestures in the onset [2]. Such an inter-competitive relationship with the vowel is the source of a phenomenon known as the *c-centre effect* (Figure 1).

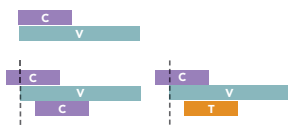


Figure 1. CV-onset (top). C-centre effect with two consonantal gestures (left), with a tone gesture (right).

1.2. Swedish word accents

In Swedish a high or a low tone can be used by listeners to access word endings [4]. That is, word stems with identical segments can carry different tones, in Swedish better known as Accent 1 and Accent 2 (henceforth A1 and A2). Traditionally A1 and A2 have been viewed as minimal pairs with a tonal timing difference. A1 is also referred to as “isolating”, with less possible continuations (such as suffixes), and A2 as “connective”, which cues more possible word endings, such as productive compounds [5].

1.3. Articulatory gestures in Swedish

In this project the findings within the Articulatory Phonology framework is combined with the phenomena of the Swedish word accents, to create an experimental design able to solve some fundamental questions regarding speech production.

The first large data collection includes 21 speakers. The initial EMA analyses on c-centre effect in CV onsets (the syllable /ma/) display tones integrating with the CV coarticulation. Results even suggest a c-centre effect difference between the accents: the consonantal gesture in A1 is 50.6 ms (mean) before the vocalic gesture; in A2 53.6 ms (Figure 2).

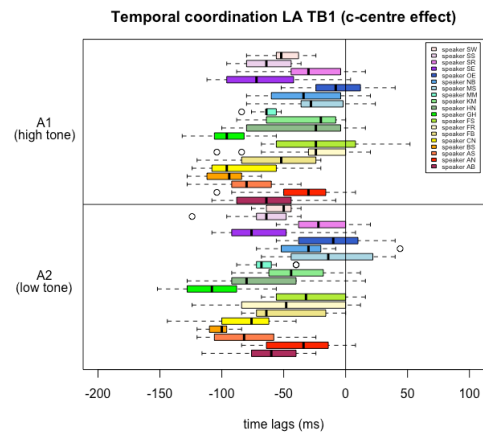


Figure 2. Time lags on consonantal gesture, LA (Lip Aperture, colored boxes), and vocalic gesture, TB (tongue body, at 0 ms).

Because of speaker variability, each speaker was tested separately; a significant difference between A1 and A2 was found for 7 speakers ($p < .05$). Additionally 9 speakers showed a tendency of a timing difference. 3 speakers showed no sign of a c-centre effect difference, however, two of them displayed significant formant differences between A1 and A2 in the acoustic analysis ($p < .05$). Hence, tones seem to affect the articulatory coordination in Swedish word accents, indicating i) possible anticipatory cues for the listener even before the tone is present, ii) tones are integrated with the segments.

2. The dissertation project plan

The initial findings on the coordination of tones with the CV-onset have raised new questions that compel the project to leave the multimodal approach, and instead lean towards a phonological study on the syllable.

2.1. Method and material

The primary data collection was recorded during the spring of 2017 with an EMA, the Carstens AG501, in the Humanities Laboratory at Lund University. 21 speakers of South Swedish read target words in carrier sentences on a screen. The material consists of different syllabic and phonotactic structures, however all have the same word onset /ma/. The articulatory data, which consists of close to 3000 observations, has been collected from sensors on the upper lip, the lower lip, the jaw, the tongue tip, and two sensors were placed on the front and on the back of the tongue body. Acoustic data was recorded simultaneously.

2.2. The dissertation project studies outlined

2.2.1. Pilot study.

Early recordings were made in 2014 with two speakers of South Swedish, presented at ICPHS 2015, and at Fonetik 2015 (a national Swedish conference) [6]. A new take on the EMA material is being presented at Interspeech 2017, together with acoustic material from a different project [7].

2.2.2. Study 1. Tones and the coarticulation in CV onsets.

Study 1 has already been mentioned (cf. 1.3 and 2.1): open syllables /ma/ (different word accents and word endings) in pre-nuclear position are compared (603 observations). Here it will be argued that tones integrate with the segments, since the tone gestures do appear to affect the articulatory coordination in a different manner in A1 as compared to A2. This study will also argue that since the stem tones that help listeners predict possible word stem continuations affect the coordination of the articulatory gestures, it might result in additional anticipatory cues being available to the listener even before the tone has been perceived. A poster has been presented at Speech Motor Control 2017 [8], but the intention is to develop the ideas into a journal article, possibly accompanied by a perception study.

2.2.3. Study 2. Internal juncture in South Swedish.

This study follows up on a result from Study 1 that for 17 of 19 speakers showed an effect of word endings on the coarticulation in CV onsets ($p < .05$). That is, the c-centre effect in /ma/-syllables that was followed by a liquid /l/ was greater than the ones followed by a nasal velar /n/. Hence, the hypothesis is that phonotactics and type of internal juncture affect the coordination of gestures in word onset, which seems plausible since that would present the listener with even more cues as early on as possible, facilitating speech processing. The same data is used (cf. 2.1), with the plan to write a journal article.

2.2.4. Study 3. Formant analysis on articulatory data.

Some speakers in Study 1 did not display c-centre effect differences between the two word accents, but instead formant differences, hence the tones were indeed integrated but not just in timing. This study focuses on the connection between the formant patterns and the spatio-temporal coordination of

gestures, motivated by the already mentioned perceptual cues that could possibly allow listeners to anticipate the nature of the upcoming tone. The data need to be completed with acoustic recordings, and developed into a journal article, possibly in collaboration with co-authors (i.e. my supervisor).

2.2.5. Study 4. Tone gestures in Swedish.

This study is still on a planning stage, but will try to map the nature of the tone gestures in the two Swedish word accents, in accordance with Articulatory Phonology, and possibly compare it to other languages, such as Mandarin. EMA material is yet to be recorded. Much work needs to be done on planning for the right elicitation by the speakers, in order to get the tone gesture onsets of both word accents. It is planned to be developed into an article co-authored by one or two leading experts in the field.

2.2.6. Study 5. Tonal prominence within the syllable.

The recorded data (cf. 1.3) has indicated an effect of information structure on the articulatory coordination. This study plans to use the material recorded in Study 4, and theories on information structure and the work by Gösta Bruce and likes. The study will include articulatory and acoustic data, possibly also visual gestures. This might be a collaboration within an already existing research project, led by one of my supervisors.

2.2.7. Study 6. The mora in South Swedish.

This is the imagined theoretical backbone of the project, yet there are no plans on how to address this question just yet. Still, it is included here. The idea is that the tone gestures of South Swedish is a key as to how the articulatory gestures are coordinated in the syllable. If we argue that the mora is the TBU, and tones are integrated with the segments, the segments in turn, or the consonantal and vocalic gestures, are connected to the mora as well. This is work in progress.

2.3. Planning ahead

Because of the workload it is not realistic to finish all studies within the dissertation project, and therefore they need to be narrowed down. What might be more fruitful as a postdoc-project? Which studies work better together?

What makes it intriguing to shift from a multimodal project, and towards a project on the intra-syllabic structure, is the nature of the syllable: its form does not correlate well to its function. While many phonologies recognize the MOP and the syllable onset as an important factor, the maximizing effect of the word onset is seldom fully recognized. Moreover, the outcome of the project will contribute to the growing research field on articulatory integration of tones with segments, with the possible outcome of loosening the traditional division of segmental and supra-segmental. Hence, at the moment it seems like a good idea to keep working on the recent research findings within the project, and focus on the studies that specifically deal with the syllable as a form and less as a function.

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