

## 1 Introduction

"Purely segmental descriptions fail to capture all the richness of the timevarying informational structure of speech."

The present study aims to illuminate the syllabic status of word initial clusters on the basis of gestural coordination patterns. In the Articulatory Phonology framework (Browman and Goldstein, 1986, 1988, 1992a, 2000), it is assumed that syllable structure is reflected in the coordination of articulatory gestures. A number of studies have shown that word initial consonant clusters which form complex onsets show a different coordination pattern from those which do not. These studies have investigated a range of languages which are independently known to have complex onsets (Browman and Goldstein, 1988 and Marin and Pouplier, 2010 for American English; (Goldstein et al., 2007 for Georgian; Marin, 2011 for Romanian) or only simple onsets (Goldstein et al., 2007 and Hermes et al., 2011 for Tashlhiyt Berber; Shaw et al., 2009 for Moroccan Arabic).

The work here is focused on word initial clusters in Italian. In the phonology of this language, clusters such as  $/\mathrm{pr}/$  and  $/\mathrm{tr}/$  are uncontroversially analysed as complex onsets (e.g.  $<\mathrm{prima}>$  - 'first',  $<\mathrm{tre}>$  - 'three'). By contrast, the status of clusters containing a sibilant ( $/\mathrm{s}/$  or  $/\mathrm{z}/$  among others) is highly controversial (e.g.  $<\mathrm{spina}>$  - 'thorn',  $<\mathrm{sfila}>$  - 's/he unthreads'). The sibilant in these clusters is referred to as 'impure s'. There is morphological evidence for this analysis. For instance, the definite article is 'lo' when a sibilant cluster follows (<lo studente> - 'the student') but not otherwise (single sibilant: <il sale> - 'the salt', non-sibilant cluster: <il prato> - 'the lawn').

Furthermore, many sibilant clusters, but not all, violate the Sonority Sequencing principle (e.g. <spina> -'thorn', with /s/ being more sonorous than /p/, but <snella> - 'slim'). Nonetheless, researchers continue to disagree on the syllabic status of the sibilant: whereas some still take it to be part of a complex onset, others interpret it as extrasyllabic, as an unsyllabified element or even as a coda consonant (Chierchia, 1986;

<sup>1</sup> Louis Goldstein's talk: Roots and prospects of an articulatory phonology at "Speaker Series: The Haskins Legacy - The Science of the Spoken and Written Word" (30th June 2011).

Davis, 1990; Bertinetto, 1999a; Wiltshire and Maranzana, 1999; Boyd, 2006; Goad, 2010). The present study looks at this question from a kinematic point of view, investigating gestural coordination patterns of both non-sibilant and sibilant clusters to shed light on the syllabification of the initial consonant in these clusters. To this aim, the work reported on here is based on articulatory data for several speakers. This data has been acquired by means of an electromagnetic midsagittal articulograph (EMMA), a device which captures movements of the articulators, in particular those of the tongue tip, tongue blade, tongue body, the lips and the jaw.

Studies employing an articulograph on American English and Romanian (Browman and Goldstein, 1988; Marin and Pouplier, 2010; Marin, 2011) have provided evidence that in these languages sibilant clusters function as complex syllable onsets. The goal of the present study is to investigate how the 'impure s' in Italian differs from /s/ in the languages analysed to date where it is considered to be part of a complex onset. Results will be discussed in terms of (a) universal syllabification of sibilant clusters (Boyd, 2006) and (b) whether it is possible for speakers of a language to have two different phonological representations for word initial clusters, depending on which consonants are involved.

First indications that word initial sibilant clusters in Italian are syllabified differently from e.g. English or Romanian have are reported in our published study involving two subjects (Hermes et al., 2008, 2012). This thesis reports on the earlier study and extends the corpus used in that study by including two further subjects. Furthermore, a larger number of consonant clusters and conditioning factors are investigated here. Although this study focuses mainly on articulatory coordination, the acoustic domain is also investigated, so as to ascertain whether an acoustic consequence of the gestural patterns found can be identified and used as the basis for analysis involving a larger number of informants. A major goal of this thesis is to account for the distinct coordination patterns within a coupled oscillator model, implemented in the framework of Articulatory Phonology.

The theoretical background for this thesis is introduced in the following chapter. A review of recent research on the syllable in various phonological frameworks, along with phonological and phonetic evidence for the syllable and its subsyllabic constituents is provided.

The controversial case of word initial sibilant clusters is outlined in section 2.2, focussing on Italian, in particular on the article allomorphy before words beginning with these clusters. The theoretical background includes an introduction to the Articulatory Phonology framework. The coupling hypothesis of syllable structure with its proposed measurements for syllable structure is reviewed and illustrated using examples from several studies that have been carried out within this framework on American English, Georgian and Romanian - languages allowing complex onsets - and on Tashlhiyt Berber and Moroccan Arabic - languages disallowing complex onsets.

The empirical study is presented in detail in the chapter three which includes information on the articulatory and acoustic recordings made, the speech material used, and on the annotation and analysis carried out.

Chapter four includes the results for the gestural coordination in nonsibilant and sibilant clusters, analysing the proposed variables. The focus of the analysis is on the adjustment of consonantal gestures in word initial position, a mechanism used as an indicator for syllabic constituency.

Acoustic analyses have been carried out to pave the way for acoustic follow-up studies involving more speakers. To this aim, chapter five deals with the segmental duration of the vowel following and preceding both non-sibilant and sibilant clusters and explores the reliability of duration as and indicator of syllabic constituency.

Chapter six proposes a model of coupled oscillators for Italian word onsets based on the findings on gestural coordination and segmental duration. The main aim is to present the differences between the coordination of the different types of clusters.

The findings of this study together with their implications for further research (see chapter seven) are summarised in the concluding chapter.