

## Consonant coordination and perception in Portuguese stop clusters and CVC-sequences

The focus of this research is on consonant clusters coordination and perception in two varieties of Portuguese, Brazilian (BP) and European (EP) and more specifically on whether there are timing and overlap differences in the production of CVC-sequences and consonant clusters and how they are perceived by native speakers.

Preliminary auditory studies have suggested that there is a greater tendency in Brazilian (BP) than in European Portuguese (EP) for a vowel to intervene between two consonants of a stop cluster (Bisol, 1999; Mateus & d'Andrade 2000). Thus BP and EP differ in the production of *captar* ('to catch'), which is sometimes transcribed as /kapɪtar/ in BP but /kaptar/ in EP. EP unstressed high vowels [i,u] are mostly deleted in connected speech. Consequently there are post-lexically many clusters that are similar to L clusters resulting in near homophones (e.g. PL /(t)ɐptar/, *tapetar* "to wallpaper" and L /(k)ɐptar/, *captar* "to catch"). In a nutshell, previous studies showed that BP tends to realize stop clusters and CVC-sequences with an intermediate vowel, while EP tends to realize both as a consonant cluster.

This intervening vowel in the lexical representation of the cluster (Mateus & d'Andrade 2000) is a popular explanation, but another equally plausible way of representing such differences may be in terms of timing differences in a model of articulatory phonology (Browman & Goldstein, 2002), that could be expressed by phase differences between the consonants. Thus, in BP, C<sub>2</sub> is timed to occur later than C<sub>1</sub> in a /C<sub>1</sub>C<sub>2</sub>/ cluster and this gives rise to the perception of an intervening short vowel without one actually being included in the word's lexical representation. If consonants of a cluster are timed to occur closer together in EP than in BP, then listeners should also be more inclined to (mis)perceive a cluster as a singleton consonant in EP. For other languages previous studies have shown that the contrast between pairs differing in the presence or absence of a pretonic unstressed vowel were not completely neutralized (e.g., *beret/bray*; *police/please*) and that the difference between the words was maintained phonetically because of the longer distance between the two consonants in the words with lexically unstressed vowels (Browman & Goldstein, 1990; 1992; Geng et al., 2010). Consequently, the aims of this study were to test, if consonants overlap more in EP than in BP, more in CVC-sequences than in cluster and whether these different lexical stimuli can be discriminated in perception.

In order to test these hypotheses, movement data were recorded using a 5D electromagnetic articulograph (Carstens AG500) from five EP first language speakers and two BP L1-speakers. The stimuli consisted of lexical words containing /pt/, /pit/, /put/, /kt/, /kit/, /kut/ in medial position. For the intergestural timing we measured a) the time interval between the end of the constriction plateau of C<sub>1</sub> and the beginning of the constriction plateau of C<sub>2</sub> (Chitoran et al 2002; Kühnert et al 2006), b) the distance between both constriction plateaus, and the duration of both consonants. For the intragestural timing of tongue tip (/t/) we compute the magnitude, the time to peak velocity and the swiftness of the raising gesture (Harrington 2010:155). The results showed more overlap in the EP than in the BP data, however, in both data sets clusters showed more overlap than the corresponding CVC-sequences. These differences were quite small but consistent over the data for the EP stimuli. The distance between plateaus and the consonant duration were also smaller for clusters than CVC-sequences.

In the perception experiment twenty-one L1 EP and 19 L1 BP speakers participated with a forced choice task in which they judged whether medial /Ct/ or /CVt/ stimuli (C<sub>1</sub> = /p, t/) excised from real words had been produced as a CVC, a cluster or reduced to a singleton /t/. In the BP stimuli EP listeners performed the task less well but both groups were able to distinguish between CC and CVC. In the European stimuli both groups of listeners perceived clusters, independently of the word intended in the production.

Overall, this study showed that consistent differences still present in the production but not in the perception of European clusters and CVC-sequences.