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Phonologically constrained variability in L1 and L2 production and perception

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The Special Issue (SI) “Phonologically constrained variability in L1 and L2 production and perception” contains a set of papers that substantially expand upon selected oral presentations at the conference *Phonetics and Phonology in Iberia* (PaPI), held in Lisbon in 2013. The papers converge in addressing a thematically coherent topic of current theoretical interest and importance at the interface of phonetics and phonology: phonetic variability and its relation to phonological representation.

Variability and gradience are inherent features of speech production and perception. Amongst the main current issues in phonetics and phonology is the precise relation between sound variation and representation, and how it may shape speakers’ production and perception abilities. Only some segmental variations are perceived. Even fewer alternations are phonologically encoded to establish contrasts in particular languages. Sound variation may be caused by a combination of factors, which might be language internal, such as phonological, morphological or lexical, or language external, such as the indexical factors of age, gender, education, style, identity, ethnicity, or socioeconomic class. Variations in sound production and perception may also be related to the statistics of use, as in the case of word, syllable or segment frequency, probability or predictability, as well as the amount and type of language exposure, or age of acquisition, when more than one language is acquired. They can further emerge from the coexistence of linguistic systems, as in contexts of language or dialect contact, or bilingualism or multilingualism. More generally, sound variation is necessarily shaped by constraints imposed by the multifarious mechanisms involved in language learning and use.

The collection of papers included in this SI specifically bears on the interplay between variable phonetic detail and phonological representation, contributing to our understanding of major issues at the interface between phonetics and phonology. These include the conditions for the phonologization of phonetic variation, or recategorization, the mental representation of non-phonological variation, and the way phonology may constrain variation in speech production and perception. New data and analyses are brought to bear on subjects that are currently much debated, such as the nature of phonological representations, models of phonetic variation and sound change, and models of L2 acquisition (e.g. Browman and Goldstein, 1989; Ohala, 1993; Labov, 1994; Flege, 1999; Bybee, 2001; Blevins, 2004; Escudero and Boersma, 2004; Best & Tyler, 2007; Stevens and Keyser, 2010; Bosch and Ramon-Casas, 2011; Harrington, 2012).

The SI gathers work oriented in laboratory phonology (e.g. Kingston and Beckman, 1990; Goldstein, Whalen and Best, 2006; Solé, Beddor, and Ohala, 2007; Cole and Hualde, 2007; Colantoni and Steele, 2008; Fougeron, Kühnert, D’Imperio and Vallee, 2010; Ortega-Llebaria, 2010; Scott, 2011; Cohn, Fougeron and Huffman, 2012; the journal *Laboratory Phonology*, created in 2010). This is a feature common to all publications that relate to PaPI

conferences (Frota, Vigário and Freitas, 2005; Prieto, Mascaró and Solé, 2007; Vigário, Frota and Freitas, 2009; Butler, Cruz and Vigário, 2015; Romero and Riera, 2015). In this SI, a wide range of up-to-date, robust methods are applied in the analyses of speech production and perception, coming from detailed acoustic and aerodynamic measurements, 3D electromagnetic articulography, forced-choice identification tasks, or large electronic historical corpora inspection, employing appropriate statistical techniques and tackling issues of theoretical relevance. This diversity of approaches enriches the insights provided by this collection of papers that inform the core theme of the SI.

Each paper adds to our understanding of particularly challenging questions concerning phonetic variation and how it relates to the phonological system from various different angles. These questions are currently attracting the attention of researchers from the fields of phonetics and phonology, and, more generally, of language and cognition. Among these are the following four issues. First, what are the factors that may lead to or constrain sound variation and how do these factors interact in language production and perception? All papers bear on these issues. For instance, in their paper Scarpace et al. show that a number of language internal and language external factors play a role in the variable realization of /j/ in Peninsular Spanish, some with greater influence in the observed patterns than others; and Canalis provides new insights on the phonological conditioning of intervocalic plosive voicing in Old Tuscan, which deviates from the voicing processes found in other Romance languages. Second, what may create irregular sound change, or incomplete phonological recategorization? How can incomplete phonological recategorization be distinguished from non-native sound patterns introduced by more or less massive isolated borrowings in historical data? Canalis' paper provides an interesting contribution to the understanding of the particular case of incomplete sound change in Old Tuscan, offering convincing evidence for distinguishing incomplete sound change from isolated borrowing, and assigning a key role to perception in the cases where recategorization took place. Third, what is the phonological status of phonetic variations, such as various kinds of vowel deletion phenomena? Do they result from categorical, phonological processes? What is the role of articulation and perceptual constraints in phonetic reductions and in the phonologization of the process? Do specific words show variable rates of reduction and if so, how is this type of variation represented in the speakers mind? The research by Meneses and Albano and by Cunha tap into these matters. Looking at different types of vowel deletion phenomena in two varieties of Portuguese, the authors conclude that distinct variable phonetic processes operate in each variety, creating the perceptual conditions for phonological recategorization, which may be in progress, but is not yet complete; furthermore in the case of the European variety of Portuguese, the absence of vowel in some individual words may have been lexicalized. Fourth, what are the exact details of the effects that the L1 phonological system exerts on the acquisition of a second language, and what is the best model to account for the specific effects of factors such as age of acquisition, order of acquisition and amount of language exposure? The contributions by Rallo Fabra and Casillas specifically address these questions, looking at groups of Spanish-English bilinguals with different profiles of acquisition of L1 and L2, and from the perspective of production and perception. Results indicate that phonological properties of the L1 impact speakers' production and perception of the L2 with variations that are interpretable in terms of deeper phonological knowledge versus more superficial, phonetic knowledge of the L2. All these topics are currently widely debated in the specialized literature, making this SI of *Phonetica* a very timely collection of papers.

The first four articles of this SI concentrate on the phonological status and conditioning factors of gradual phonetic processes creating segmental variability in the L1, and bear on the

conditions for phonological recategorization and sound change. The last two papers investigate the effects of L1 phonological categories, and their phonetic exponents, in the production and perception of L2 segmental properties.

In the paper “Allophony of /j/ in Peninsular Spanish”, Daniel Scarpace, David Beery and José I. Hualde conduct a corpus-based acoustic study on /j/’s realization in Peninsular Spanish. Because of its wide range of variable realizations, the phonological status of this segment is difficult to establish (represented here as /j/). The authors investigate the contextual factors that may condition the realization of /j/, namely, preceding segment, pause, stress, and word position. The role of style is also considered. Results show that both preceding context and stress are relevant factors: the segment is often realized with more constriction after consonants and pauses, and in the onset of stressed syllables. An effect of style is also observed, with more constriction in more formal styles. Additionally, /j/ is more occluded in word-initial position than when it is word-medial, although this is the weakest of the factors with a significant effect on the realization of /j/. The hypothesis is raised that more occlusion in the latter case may be explained by the strengthening effect of a higher prosodic boundary (Fougeron and Keating, 1997). In addition to confirming previous impressionistic descriptions, the paper shows that the realization of this consonant varies along a continuum of degree of constriction, and it is extremely variable and affected by both language internal and language external factors. Importantly, this research shows that the traditional view assuming distinct allophones cannot be maintained, and raises the question of how (much of) the phonetic variation documented is mentally represented (e.g. Bybee, 2001; Pierrehumbert, 2001).

Stefano Canalis (“Variable phonological rules and ‘quantal’ perception as a source of probabilistic sound change: The case of intervocalic voicing in Old Tuscan”) is also concerned with a variable phonological process, specifically the origin of voicing that affected only some intervocalic voiceless stops in Old Tuscan. Against previous claims, he argues that stop voicing was not due to isolated borrowings, but rather was caused by a variable, allophonic voicing rule whose output was only partially subject to phonological recategorization. The author observes that the forms that exhibit voicing reflect phonological conditioning, with properties unattested in voicing varieties of Romance. Canalis further shows that the probability of change correlates in a non-linear way with a number of phonological factors found to play a role in voicing. In particular, it is shown that voicing was more likely next to low vowels and stressed vowels and in velar stops. A perceptual explanation is offered for the irregular, sporadic sound changes in recategorization, compatible with Stevens’ (1989) Quantal Theory of Speech: voicing was generally phonologized in environments that favored voicing mostly because in these cases partial voicing was strong enough to cause perceptual uncertainty and be reinterpreted as full voicing. Besides adding to the understanding of how sound change occurs, and how gradual and variable phonological processes can cause discrete sound changes that alter the lexical representation of words, this paper also offers a more general contribution to the understanding of the mechanisms that can determine differential sound change.

In “From reduction to apocope: final poststressed vowel devoicing in Brazilian Portuguese”, Francisco Meneses and Eleonora Albano carry out a series of production and perception experiments aiming to determine whether a categorical deletion process (apocope) or a variable phenomenon (varying degrees of reduction, devoicing, lenition) accounts for the realization of high vowels in word final position preceded by /s/ in Brazilian Portuguese

(BP). It is most commonly assumed in the literature that stressless high vowels undergo categorical deletion in this position, but variable realizations have been reported more recently. In two production experiments, acoustic and aerodynamic measures were extracted from the final stretch of target words embedded in carrier sentences, ending in /a/, /i/, or /u/ preceded by /s/. The acoustic measures included the /s/ noise centroid and the durations of the target syllable, noise, and vowel. For the aerodynamic analysis, oral airflow peaks were considered. The aim was to identify the presence/absence of (traces of) the production of the vowel, and hence evidence for gradual versus categorical vowel deletion. In a perception experiment participants were engaged in a forced choice task, containing triads of words such as ['fas], ['fa.si] and ['fa.su]. (Only) if apocope is categorical, a perceptual confusion between the three word forms would be expected. Results from the three experiments converge in showing that these high vowels are not subject to a categorical phonological rule in BP, but rather to a gradual ongoing lenition process. Approaching the data from the perspective of Articulatory Phonology (Browman and Goldstein, 1989), the authors posit that the process first involves reduction of gestural magnitude, followed by increased gestural overlap, and eventual deletion. All these steps of reduction coexist synchronically, yielding variation. Along the lines of Ohala (1981, 1993), perception is argued to play a crucial role in phonologization: where there is complete overlap, devoiced vowels may trigger a listener-based process of apocope, which may then become phonological. The role of perception in phonological change is also highlighted in the papers by Stefano Canalis and Conceição Cunha.

In the paper “Portuguese lexical clusters and CVC sequences in speech perception and production”, Conceição Cunha revisits a major topic in European Portuguese (EP) phonology also within the framework of Articulatory Phonology. Specifically, Cunha investigates the deletion of stressless vowels that creates (surface) consonant clusters in EP. A systematic assessment is made of the similarity between basic consonant clusters and consonant clusters that result from the deletion of an unstressed vowel (CVC→CC; referred to here as “non-basic” clusters). A perception experiment shows that the difference between the two types of consonant clusters is partially neutralized: listeners perceived both consonant clusters and CVC sequences as clusters, but were also able to identify some of the lexical intervocalic vowels of the CVC sequences. A physiological study using 3D electromagnetic articulography (EMA) further reveals that non-basic consonant clusters exhibit less overlap of consonantal gestures than basic consonant clusters in EP, but this difference is gradual, not categorical. The analyzed data could suggest that an EP sound change is in progress since at least some of the lexical contrasts are neutralized at the level of realization, and are no longer perceived. The results add to the characterization of the variable process of reduced vowel deletion in EP, with impact in areas such as the acquisition of the phonological system, syllable structure and linguistic rhythm, and it contributes, more generally, to the understanding of the constraints on sound change.

The effect of speakers’ native phonological system on L2 performance is at the core of the last two papers, where the production and/or perception of L2 English vowels is examined in bilingual speakers with different ages of acquisition and language dominance.

Lucrecia Rallo Fabra’s paper, “Can non-native speakers reduce English vowels in a native-like fashion? Evidence from L1-Spanish L2-English bilinguals”, investigates the realization of English reduced vowels by L1-Spanish L2-English bilinguals. Important phonetic and phonological properties are known to differ in English and Spanish unstressed vowel systems (the former but not the latter exhibits vowel reduction). This makes it a good testing ground

for theories such as the Feature Hypothesis in L2 learning (McAllister, Flege and Piske, 2002), according to which the acquisition of L2 phonetic features depends on their respective phonological status in L1. Laboratory speech was recorded from three groups of speakers: early bilinguals, late bilinguals, and English speaking monolinguals. Vowel reduction was assessed through the inspection of vowel duration, intensity and formant frequency measures. In terms of vowel quality, the early bilinguals were found to reduce unstressed vowels similarly to native speakers, suggesting that vowel reduction may be operating at a phonological level, in contrast with the late bilinguals. Late bilinguals demonstrated more context dependent patterns, which suggests that vowel reduction is operating at a lower phonetic level. Both groups of bilinguals show fewer differences in duration and intensity between stressed and unstressed vowels than the native control group. Results support the Feature Hypothesis for the late bilinguals in particular. Late bilinguals show difficulties in reducing vowels in a native-like manner. This suggests that the phonological status of phonetic features in the L1 has influenced L2 production. The paper contributes towards our understanding of L2 speech learning in terms of the acquisition of the integration of segmental and suprasegmental information, specifically the phonetic features of L2 unstressed reduced vowels.

Joseph V. Casillas (“Production and perception of the /i/-/ɪ/ vowel contrast: The case of L2-dominant early learners of English”) also looks at an English vowel contrast in English-Spanish bilinguals. The impact of the L1 on L2 performance is investigated by taking into account age of acquisition and language dominance. L2 dominant early learners of Southwestern American English who no longer fluently speak their L1 (Spanish) were tested on a production and a perception task, and compared with two control groups, native English speakers and L1-Spanish late-onset learners of English. A series of experiments were carried out examining the /i/-/ɪ/ vowel contrast in American English: namely, a production experiment followed by acoustic analysis, and a forced-choice perceptual identification task. The production experiment looked at duration, spectral centroids and trajectory length. Results revealed that the early L2 learners produced this contrast in a native-like manner, although their vowels showed less dynamic movement than those of native controls. The perception experiment demonstrated that early L2 learners differ from both control groups in how the /i/-/ɪ/ continua are categorized based on spectrum and duration, and the extent to which they rely on the two cues. Overall, results corroborate that age of L2 acquisition is a predictor of native-like perception and production (Flege, 1999), but they also show that early exposure is not sufficient for native-like performance (as also shown by Pallier, Bosch and Sebastián-Gallés, 1997; Sebastián-Gallés and Soto-Faraco, 1999). The research adds to the understanding of much debated issues on sequential effects in language learning, and how L1 system, linguistic experience and age of acquisition can impact L2 behavior.

The oral presentations at PaPI, which provided the basis for the published articles of this Special Issue, were selected through a strict peer-review process, whereby each submission was reviewed by three members of the conference scientific committee. The papers selected to be included in this SI have been subject to a new round of peer-review process, and have each been assessed by two other specialists as well as the guest editors. We take the opportunity to gratefully acknowledge all the reviewers for their contribution to this final result.

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We conclude by noting that this Special Issue of *Phonetica* closes the lineage of publications originating from *PaPI – Phonetics and Phonology in Iberia* conferences. The conference has now widened its geographic span and, in harmony with this change, it was renamed *PaPE – Phonetics and Phonology in Europe*, meaning that from 2015 onwards these renewed scientific meetings will take place not just in Iberia, but in other places within Europe, such as Cambridge, UK, where the first edition of *PaPE* took place, in June 2015.

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