Articulatory settings and the dynamics of second language speech production

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1 Articulatory settings Differences in pronunciation between L1 and L2 speakers of the same language are partly due to different phoneme inventories of the different languages, in addition to realisational differences and different prosody or stress patterns. However, many studies point to existence of an additional, more global factor of language specific *articulatory settings*. It is assumed that the overall combination of the positioning of speech articulators such as the tongue, jaws and lips differs per language. The idea of a language specific articulatory setting dates back to at least the end of the 19th century (for a historical overview, see Jenner, 2001); the term *articulatory setting* itself originates from a 1964 article by Beatrice Honikman. In instructions for L2 pronunciation regular references are made to articulatory settings. But do these settings exist and can they be acquired by L2 learners?

Initial phonetic studies on articulatory settings (AS), such as that by Honikman (1964) were based on analytic listening. Later research has attempted to measure AS indirectly by linking them to acoustic quality (e.g. Laver, 1980). These indirect measurements have been questioned by others, who argue that the relationship between acoustic phenomena and the characteristics of articulatory movements can only partly be abstractly described, as individual realisations of speech sounds are subject to many varying factors (e.g. Boves, 1987). More recently, researchers have attempted to visualize movements of the articulators directly by means of scanning methods (e.g. Gick et al., 2004). However, a major disadvantage of these scanning methods is the use of sensors placed in the oral cavity during measurements. Practically all studies claim to have found evidence for the existence of language-specific AS, yet thus far none of them seems to have found unambiguous measurable evidence for language specific settings. In this paper we will report on a new attempt to measure AS acoustically and we will discuss why the settings of an L2 are so difficult to acquire.

2 An experimental study The present study examines if a new approach to acoustic analyses can be used as a method to measure AS in bilinguals, based on the assumption that acoustic analyses of natural unhampered speech provide the most suitable method to measure settings. The settings of English and Dutch were investigated by means of acoustic measurements of vowel formants in the productions of Dutch learners of English. To optimize conditions, we made within-participant comparisons of comparable vowels in interlingual homophones. Participants and stimuli were carefully selected, so as to minimize social variation and effects of coarticulation.

An auditory imitation task consisting of a Dutch and an English block was set up to examine the production of nine different vowels of advanced learners of English. The experiment had an 8*4*4 design, containing 4 tokens of 4 word types of 8 vowels each. Dutch-English homophones containing the target vowels (e.g. peak, tip, pot, bus, surf) were embedded in short sentences, which had been produced by native speakers of English and Dutch, so as to optimize language specific settings. Five female advanced learners with a very similar language background were asked to repeat the sentences which were presented to them via headphones. The vowel productions were acoustically measured using formant analyses in PRAAT at vowel midpoint. In addition, the recordings were rated by native speakers of English with knowledge of Dutch as an additional measure of pronunciation proficiency. The analyses point to significant differences between most vowel pairs for three of the five participants; these three speakers were also judged most native-like by the native speaker raters. Two dimensional plotted vowel spaces of these learners based on F1 and F2 values point to a more fronted tongue position in the English setting, which is in agreement with the descriptions others have given of English and Dutch settings (e.g. Honikman, 1964; Collins and Mees, 1999). The lower F2 values for Dutch could also be a sign of overall lip rounding. An example of the Dutch and English vowel spaces of one of the participants is given in Figure 1 below.

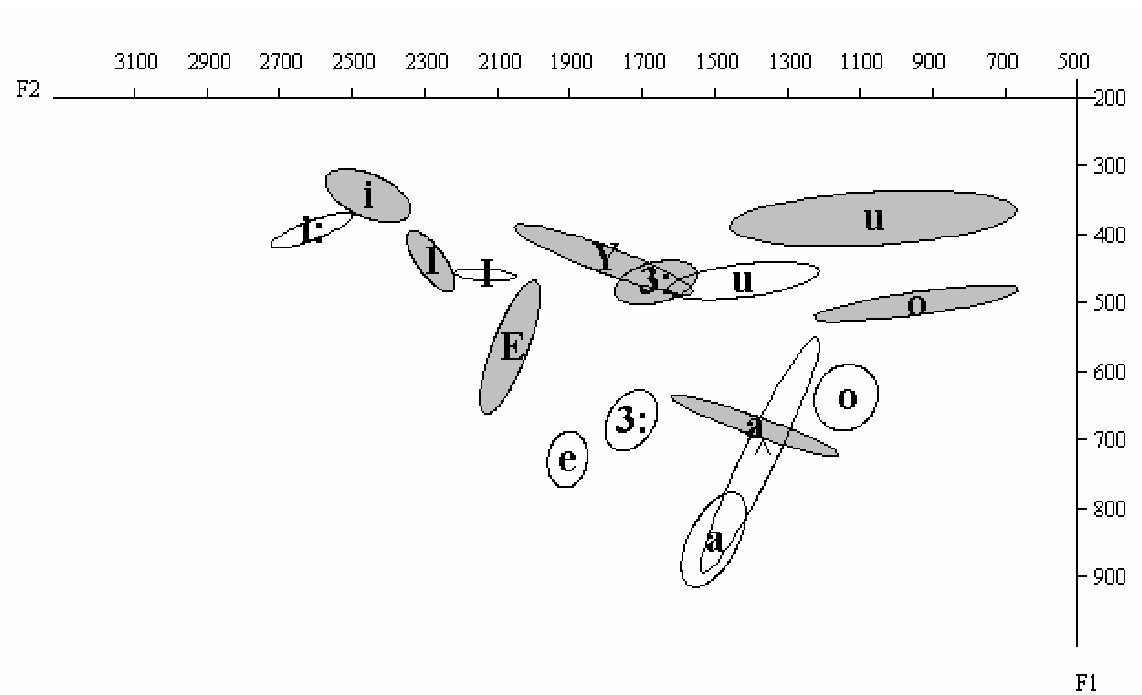

Figure 1. English (white) and Dutch (grey) vowel settings for an advanced Dutch learner of English. SAMPA symbols represent the vowels in the English words ‘surf’, ‘cast’, ‘bet’, ‘peak’, ‘tip’, ‘pot’, ‘bus’, and ‘cook’ respectively.

3 A dynamic perspective Superficially, these findings point to the existence of language specific articulatory settings, though only for the most successful Dutch learners of English in the experiment. For these learners, clear differences were found between Dutch and English F1 and F2 values for similar vowels in interlingual homophones. However, these findings cannot be generalised across participants and are limited to the context of the specific task and context of the experiment. If the settings can only be found at the individual level and cannot be generalised, can we still say that there is a set of AS for a particular language or language variety? The answer to this question must be found in the dynamic nature of articulation.

Sounds that we perceive are not necessarily the result of a unique combination of articulatory movements, but can be the produced in many different ways. As Levelt (1993) noted, speech produced by a speaker with a pipe in his mouth hardly differs from unhampered speech, which illustrates the dynamic adaptability of the speech organs. A powerful theory to account for the dynamic nature of articulation is dynamic systems theory (DST). The most important characteristic of a Dynamic System is that it defines a system as a set of dynamically interacting subsystems. Each following stage of the development of the system follows from its previous stage, leading to relatively unpredictable nonlinear self-organisation. Although the organisation of the system is relatively unpredictable, each system has *attractors* following from, for instance, physical constraints, and the availability of resources or specific intentions. A clear example of a dynamic system is the behaviour of a flock of birds (see Port and Van Gelder 1995). The application of DST to speech production (see, for instance, van Lieshout, 2004) is based on the framework of task dynamics. In this framework, speech production is not described in terms movements of the individual articulators, but in terms of the coordinated actions of all articulators involved in making a particular constriction (*tract variables*). An example of a tract variable is lip protrusion, which involves several coordinated articulators (upper lip, lower lip, jaw). The combined use of several tract variables is referred to as a *gesture*, which can be seen as the dynamic equivalent of a phoneme. The dynamical specification of a gesture includes a spatial goal that can be related to the point attractor in a dynamic system (Goldstein et al., 2003)

The global approach to speech production in terms of articulatory settings fits in the holistic approach of the DST theorem, as it centres on coordination of articulators rather than on the traditional linguistic units of static segments. From this perspective it is not surprising that the variable nature of the speech system cannot be captured by measurements of individual articulators. Rather than specifically defined positions of articulators, articulatory settings must be regarded as attractor points of a system, which can be reached in various ways at different moments in speech production. Since acoustic measurements do not attempt to establish the way in which articulatory settings are realised, but focus on the eventual output, the results of the experiment reported here are completely in agreement with this line of thinking. Acoustic measurements may give insight into the attractor points of one individual speaker at one moment in time, in strongly controlled conditions, but will probably not allow for generalisations for a speech community.

4 Conclusion The history of research into language specific articulatory settings has shown numerous attempts to define AS in terms of overall positions of the individual articulators. Although this paper has demonstrated that an individual's AS can be measured relatively accurately by acoustic correlates, we have argued that AS must be seen in the context of the dynamic nature of speech production. This approach cannot only account for the observed difficulty of determining a fixed set of articulatory settings from measurements of individual articulators, but the can also account for the failure of most adult L2 learners to acquire these settings.

5 References

Boves, L. (1987). Acoustical Analysis and Physiological Parameters. In H.F.M. Peters & W. Hulstijn (Eds.), *Speech Motor Dynamics in Stuttering* (pp. 97-115). Wien: Springer-Verlag.

Collins, B. & Mees, I. M. (1999). *The Phonetics of English and Dutch*. (4th ed.) Leiden: Brill.

Gick, B., Wilson, I., Koch, K., & Cook, C. (2004). Language-specific articulatory settings: Evidence from inter-utterance rest position. *Phonetica, 61,* 220-233.

Goldstein, L., Byrd, D., & Saltzman, E. (2006). The role of vocal tract gestural action units in understanding the evolution of phonology. In M.A.Arbib (Ed.), *Action to Language via the Mirror Neuron System* (Cambridge: Cambridge UP.

Honikman, B. (1964). Articulatory Settings. In D. Abercrombie, D.B. Fry, P.A.D. MacCarthy, N.C. Scott, & J.L.M. Trim (Eds.), *In Honour of Daniel Jones: Papers contributed on the occasion of his eightieth birthday 12 September 1961* (pp. 73-84). London: Longmans, Green & Co. Ltd.

Jenner, B. (2001). 'Articulatory setting', genealogies of an idea. *Historiographia Linguistica, 28,* 121-141.

Laver, J. (1980). *The phonetic description of voice quality*. Cambridge: Cambridge University Press.

Levelt, W. J. M. (1993). The architecture of normal spoken language use. In G.Blanken, J. Dittmann, H. Grimm, J.C. Marshall, & C.W. Wallesch (Eds.), *Linguistic disorders and pathologies: An international handbook* (pp. 1-15). Berlin: Walter de Gruyter.

Port, R. & van Gelder, T. (1995) *Mind as motion: Explorations in the dynamics of cognition* (1995). Cambridge, Mass.: MIT Press.

Van Lieshout, P. (2004). Dynamical systems theory and its application in speech. In B. Maasen, R. Kent, H.F.M. Peters, P. Van Lieshout, & W. Hulstijn (Eds.), *Speech Motor Control In Normal And Disordered Speech* (pp. 51-82). Oxford: Oxford UP.