THE HISTORY OF THE CLASSICAL VOWEL ARTICULATION MODEL: A REPLY TO CATFORD AND FISCHER-JØRGENSEN

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ABSTRACT

This paper is devoted to a discussion of Catford's (1) and Fischer-Jørgensen's (2,3) defence of the classical vowel articulation model. Objections to the model are not directed at Bell's personality, but at the theoretical structure of his model: critical functions of the model are contradicted by empirical data and by acoustical theory. Nor are the objections only relevant for amendments introduced by Jones. That argument is contradicted by the chronology of the debate.

BACKGROUND

The classical vowel model, originally introduced by Bell in 1867 (4) and modified into various versions by other authors, is characterized by the class of central vowels. The model was designed around the single resonance theory, according to which the upper surface of the tongue narrows the mouth channel locally in order to delimit the buccal cavity and tune its natural resonance. Bell postulated a configurative aperture that "may be shifted to any part of the back or front of the palatal arch" (p. 71). He held that the horizontal and vertical position of the tongue arch relative to the roof of the mouth set the size and location of this aperture, so that the natural resonance of the mouth cavity would rise progressively as the tongue moved from low to high at the back, central and front locations in turn.

Much of Bell's terminology was soon changed. Sweet substituted raised for the higher modification of tongue height. Ellis replaced inner and outer by retracted and advanced. The I.P.A. adopted the French tradition of four degrees of opening. Jespersen preferred three degrees, Jones followed the I.P.A. The I.P.A. and Jones retained Bell's term mixed until the 1920s, when central was substituted. The dynamic periods in the evolution of the model and the progress of the debate are the 1880s, and the years around 1915 and 1930, when authors undertook major revisions of their textbooks in response to Bell's original proposal, and to the negative data reported by Meyer in 1910 (5) and by Russell in 1928 (6).

The classical vowel model rapidly superseded the ancient throat-tongue-lip model. It was adopted by the neogrammarians and the I.P.A., and was hypostetized long before it could be tested. The first empirical data on the model, reported by Meyer and by Russell, contradicted some tongue heights postulated by Bell, especially for [ɪ,e] and [ɔ,ɑ]. Phoneticians, already divided between the rival organic and acoustic paradigms, took sides in a bitter feud. Fischer-Jørgensen has given her personal recollections (3) of how the controversy was conducted.

Analysis of 38 sets of midsaggital vowel profiles (7,8,9), collected from the literature, confirm the anomalous heights reported by Meyer and Russell, and gave no evidence of intermediate configurative apertures, i.e., of Bell's class of central vowels. It was concluded that the classical model was based on an oversimplified acoustic theory and that it is contradicted by physiological data, which weakens its validity and explanatory power.

Catford and Fischer-Jørgensen argue that critics of the classical vowel model have tended to exaggerate. They question the value of radiographic data as evidence against Bell's model and they point out that not all sets of x-ray pictures contradict the model. Fischer-Jørgensen also maintains that criticism of the classical model is really directed at amendments introduced by Daniel Jones, and that an alternative articulation model based on resonance phenomena in the entire vocal tract would be less suitable for phonology.

CATFORD'S AND FISCHER-JØRGENSEN'S ARGUMENTS

The Value of Radiographic Data as Evidence

Catford emphasizes that Bell's and Sweet's vowel descriptions were based on perceived muscular sensation, not on objective (radiographic) records of actual tongue position. "There is obviously a close correlation between the objective and proprioceptive data, but one should not expect them to be identical" (p. 23). This recognizes the difficulties faced by Bell and Sweet when they judged tongue positions from muscular sensation. But the argument against the classical model is not just that Bell's kinesthetic vowel judgments are sometimes contradicted by radiographic evidence. That could easily be allowed for and corrected. For example, as Catford suggests, one could recognize [ɪ] as mid or half-open, although Jespersen rejected precisely that solution when he revised (10) in

response to Meyer's data. What the x-ray pictures fail to confirm are certain tongue positions predicted by the model itself from the inadequate acoustic theory on which it was based. The criticism is thus directed at the empirical and theoretical structure of Bell's model, and not at Bell's personality or his phonetic skill.

Bell's contemporaries nevertheless disputed several postulated tongue positions. For example, [ɛ] in English let is low according to Bell but mid according to Ellis, Sweet and Storm. The [a] of father is mid according to Bell and Sweet but low according to everyone else. Jespersen found the positions for mid back and low back vowels especially difficult to analyse. This is why phoneticians invented measuring devices like Grandgent's discs, Atkinson s probe, Zünd-Burguet's pneumatic height indicator and Meyer's plastograms, and why they finally turned to radiography. The x-ray profiles show that mid back and low back vowels are difficult because their heights are random. The fact that kinesthetic judgments of tongue position deviate from the true position underlines their unreliability and demonstrates the need for a more reliable method of observation.

Which Sets of X-ray Profiles Support the Model?

Catford and Fischer-Jørgensen point out that some sets of x-ray profiles agree with the traditional description. But any statistical survey of biological events will contain individual items that contradict the trend. The problem is that so many sets of x-ray profiles do not support the classical model on the intermediate apertures of central vowels, on tenseness and laxness and on the heights of mid and low back vowels. There must be other principles governing the articulation of these vowels. The radiographic data can be summarized as follows (7,8):

- So-called central vowels do not have intermediate configurative apertures
- The tongue is usually lower for high [ɪ] than for mid [e]
- Only one third of mid [ɔ] usually come out higher than low [a-ɑ]
- Two thirds of mid [o] usually come out higher than low [a-ɑ]
- Only one third of high [ʊ] usually come out higher than mid [o].

Clearly, this leaves room for many sets of profiles to come out all right. The most disturbing aspect of the x-ray data is the failure to substantiate the class of central vowels, which was Bell's revolutionary innovation. Jespersen (11, pp.18-19) had observed as early as 1889 that there were no low central vowels, since the tongue made a discrete transition between front and back apertures owing to the domed shape of the palate. The elusiveness of the intermediate apertures may well also be the reason why phoneticians started referring to the highest part of the tongue instead.

Daniel Jones and the Cardinal Vowels

Fischer-Jørgensen states that the objections to the classical model are only valid as regards revisions introduced by Daniel Jones in the classical system for the purpose of his cardinal vowel chart (2, p.260; 3, p.82). She particularly mentions (i) use of the highest point of the tongue as a reference point, and (ii) rejection of tense/lax.

These points are not supported by the chronology.

Jones's cardinal vowel scheme, with its articulatory limits and auditory scales of timbre, was a compromise between the organic and acoustic paradigms. But the first editions of Jones's textbooks (12,13) were completely in the organic tradition. The Outline (13) was already in press in 1914, but publication was delayed by the war. Jones's recognition of Meyer's report (13, p.19) survived all the subsequent revisions of (13). The cardinal vowel scheme was introduced in 1917: the x-ray pictures (14) were made in January, the gramophone recording (15) was issued shortly after, and a cardinal diagram was included in Dent's dictionary (16). A brief preface was added to the 1922 reprint of (13), but a full account was not given until 1923 (17, pp.24, 27-41), followed by Jones's contribution to the 1925 Copenhagen conference (18) and the 1932 revision of (13). The cardinal vowel scheme was introduced after Meyer's report, while (13) was not fully revised to include the cardinal scheme until after Russell's report. One can hardly conclude that Meyer's and Russell's reports were directed at Jones. On the contrary, Russell (19) welcomed the timbre scales of the cardinal vowel scheme. But Jones and his associates also assumed that equal increments on the timbre scales corresponded to equal increments of tongue position in Bell terms, so that the cardinal scheme has preserved the classical model within itself. In that sense it is open to the same criticism as the classical model.

The highest point of the tongue, used by Jones as a reference in all his books from (12) onwards, is not a necessary component of the cardinal vowel scheme. For Bell, the size and location of the postulated configurative aperture were congruent with the high/low and front/back position of the upper surface of the tongue. The immediate problem was to identify what part of the tongue was raised and how far. By the 1880s, this had evidently been reduced to determining the highest part of the tongue (Jespersen had occasion to emphasize that this does not coincide with the narrowest part of the mouth channel, see above). The highest part of the tongue was already a well established reference point at a time when Jones was still a child. He did not introduce the concept, he adopted an established practice.

Jones's first stand on tenseness was similar to Sweet's, tensing or relaxing of the tongue with no difference of height (12, p.12). But there were others, like Jespersen (11,20), who believed lax (broad) vowels were slightly lower than the corresponding tense (thin) vowels. He held that this was achieved by furrowing the tongue, or, especially for lower vowels, by lowering it. The issue was disputed, see Sweet's correspondence with Storm (21). Sweet believed it was a matter of convexing versus flattening of the tongue, all at the same height. The problem was thus whether laxness was distinct from height or whether it could be subsumed with raising/lowering.

Jones gradually amended his initial stand. He reported Meyer's results (13, pp.19-20) and modified his own view of laxness to admit lowering. He finally rejected laxness in favour of lowering in the 1932 revision of (13).

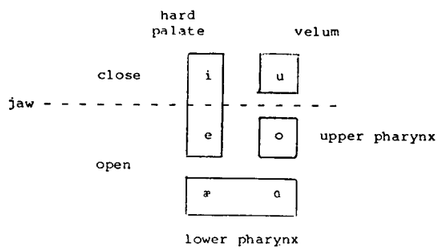
The criticisms of the classical model are clearly not aimed at Jones's usage, which represents his various stands on older issues. His changing views on tense/lax, and especially his innovation of the cardinal vowel scheme, were surely his way of coming to terms with these very same objections to the classical model as the were made by Meyer and Russell. The objections refer to the fundamental structure of the classical model as it was conceived by Bell himself, and concern Jones only in so far as the cardinal scheme reflected and perpetuated the classical model.

The Utility of a Model Based on the Whole Vocal Tract

Fischer-Jørgensen does not expect an alternative model based on the whole vocal tract to be better than the classical model. She doubts whether sound typology supports the four locations analysed from x-ray data in (9) and she claims that this type of model is less useful for phonology.

The model in question recognizes four major classes of vowels depending on the part of the vocal tract that is narrowed - palatal[i-ɛ,y-œ]-like vowels, velar [u-ʊ,ɯ] -like vowels, upper pharyngeal [o-ɔ,ɤ]-like vowels and low pharyngeal [æ-a-ɑ]-like vowels. Within each class, vowels are differentiated by local manoeuvres involving the lips, tongue blade, tongue posture, larynx depression etc. (9,23,24,25).

These manoeuvres are related to the parameters of the classical model as follows:



Fischer-Jørgensen's reference to typology does not take into account the allophonic variation that is typical of "small" vowel systems: A two-phoneme system like Kabardin contrasts a set of low pharyngeal [æ ɑ]-like allophones with a set of palatal, velar and upper pharyngeal (uvular) allophones, phonemically low pharyngeal versus the rest. In three-phoneme systems, there is usually variation between velar [u]-like and upper pharyngeal [o]-like allophones. The same goes for the four-phoneme system quoted by Fischer-Jørgensen. Whatever the language and however simple the vowel system in terms of phonemic contrasts, the speaker utilizes all four locations.

Fischer-Jørgensen cites instances of vowel systems that, she claims, cannot be handled without three or four degrees of height (openness), whereas I proposed just two degrees of jaw position. This was based on radiographic data that showed the jaw opening tended to be narrower than about 9 mm for [i-u]-like vowels (typically 5-7 mm) and wider for [e-o-a]-like vowels (typically 10-12 mm) (23,24,26). The term openness is used in two different senses here, lingual and mandibular respectively. In the view of vowel articulation outlined above, the classical heights are redistributed between the open/close jaw positions and the four locations along the vocal tract. The categories for which Fischer-Jørgensen requires four heights are still available, but now defined in terms that more closely reflect the manoeuvres used in speech.

For example, using more tongue heights enables her to make more generalizations, such as recognizing that mid [e,ø,o] diphthongize to [iə,yə,uə], while low [ɑ] does not, a case that would be impossible to express without more heights. Let us say instead that [ɑ] is low pharyngeal, characterized by hyoglossal and glossopharyngeal activity, while [e,ø,o] and [i,y,u] share genioglossal or styloglossal activity:

$$\begin{bmatrix} \{+\text{pal} \\ +\text{vel}\} \\ +\text{open} \end{bmatrix} \longrightarrow [-\text{open}]$$

This solution makes predictions about the motor reorganization underlying this change.

I prefer to ask if it is possible to handle vowel systems in terms of resonator shaping by observable manoeuvres with known neuromotor activity. Such a model is a more effective instrument of prediction and explanation and should yield more plausible phonetic explanations for phonological problems. A test case is vowel harmony, which Fischer-Jørgensen believes can only be formulated very clumsily in terms of four places of articulation. However, Svantesson (22) has found that precisely this type of model provides the key to a solution of the problem of harmony and vowel shift in Mongolian, by focusing and capturing the variations in pharyngeal width that characterize this phenomenon. Formulating the problem in this way, Svantesson demonstrates that harmony in East Mongolian and its an-

cestor languages Ancient and Classical Mongolian are related. The shift from fronting harmony to pharyngeal harmony turns out to be a simplification, which offers an explanation for why there are no known examples of a shift in the opposite direction.

CONCLUSION

Catford and Fischer-Jørgensen have defended the classical model by questioning the data and by suggesting that the objections were really aimed at Daniel Jones. I have argued that hypotheses about articulation must be tested with the best available data, and I have shown that Jones's various amendments in fact represent his personal stands on older issues and that they were introduced in response to the data that contradicted the classical model.

The evidence against the classical model continues to recur and the same data consistently support an alternative solution. I do not see it as an exaggeration to report that the same data simultaneously provide confusing evidence for one interpretation and consistent evidence for an alternative interpretation.

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