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Pharyngeal Constriction as a Cause for Late Acquisition and Speech Sound Disorders of Rhotic Sounds in English, Spanish, and French

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Cover Page Footnote

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Introduction

Rhotics are an intriguing class of sounds, as thus far, widespread research has not yet agreed on one common articulatory or acoustic feature to unite them, despite their appearance in around 75% of languages (Lindau, 1985). Additionally, rhotic sounds are cross-linguistically acquired late, and are often the subject of a Speech Sound Disorder diagnosis in children. It is possible that these are related. Recent research has proposed secondary constriction at the pharynx as a common articulatory feature for rhotics and provided evidence for its presence in a number of languages (Boyce et al., 2016). I hypothesize that pharyngeal constriction is a likely cause for the consistently late acquisition and common errors in production of rhotic sounds. In this paper, I will provide the necessary background on classification of rhotics, give evidence for late acquisition and frequent Speech Sound Disorders for rhotics, and explore pharyngeal constriction as a potential cause.

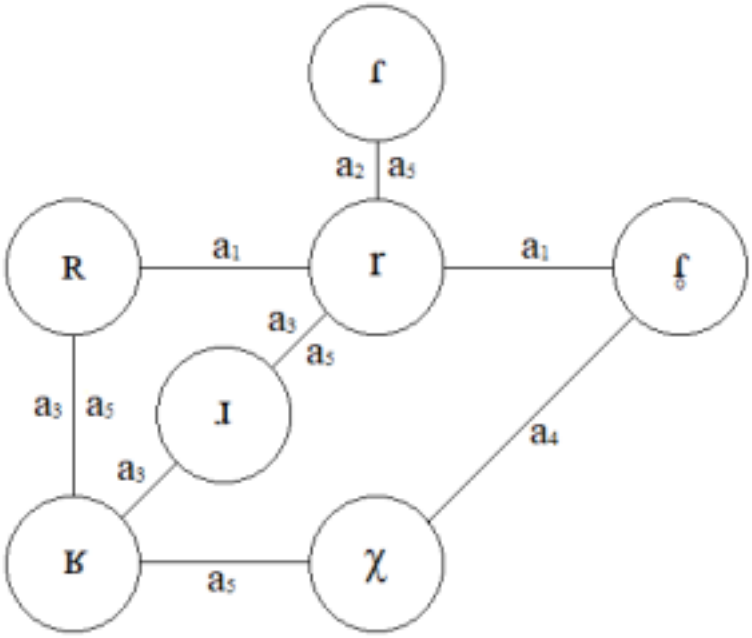
Background

While consistent phonological behavior provides evidence for rhotics as a class of sounds (Ladefoged & Maddieson, 1996; Lindau, 1985), classifying rhotics is still a difficult task due to the lack of consistency in place or manner of production. Additionally, rhotics vary widely within languages. English, for instance, has two varieties, bunched and retroflex, which have distinct tongue shapes despite being perceptually the same (Scobbie et al., 2015). A lowered third formant was proposed as a potential common feature for rhotic sounds, but this is not the case for most languages. For example, in English a lowered third formant is consistent among variants of /r/, but this contrasts with the French /R/ as the uvular tongue placement results in a high third formant (Lindau, 1985; Zhou et al., 2008). Also proposed was a family resemblance model, rather than one singular feature uniting rhotics. Figure 1 is a map of the rhotic sounds, connected by various features (Lindau, 1985).

Ladefoged and Maddieson (1996) acknowledged the possibility of "a phonetic similarity between all rhotics that has hitherto been missed" (p. 216), and research suggests a secondary constriction at the pharynx may be what phoneticians have been missing. This was first proposed as a similarity between certain rhotic sounds by Catford (1986), but has not been commonly accepted as universal among rhotic sounds. Others have used imaging technology to explore this hypothesis further (Delattre, 1971; Boyce et al., 2016). Of primary interest for this paper were the rhotic sounds of English, Spanish, and French, which together represent a wide variety of placements and manners of production. English contains one rhotic sound, /ɹ/, with two main forms, bunched and retroflex. Spanish has two rhotic sounds, the tap /ɾ/ and the trill /r/, and French has four rhotic sounds, /R/, /ʁ/, /ɾ/,

and /ɾ/, with the uvular sounds /R/ and /ʁ/ described as the most common (Boyce et al., 2016; McLeod, 2007).

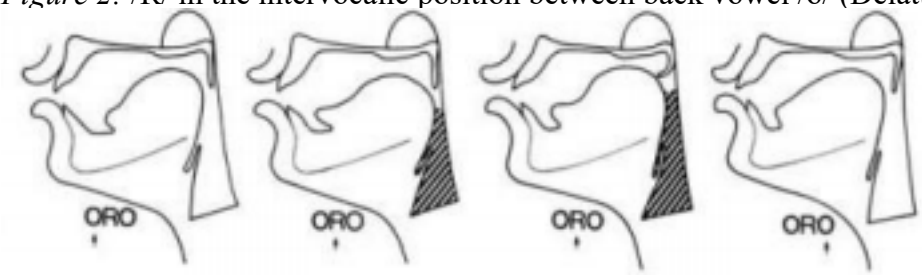
Figure 1: Chart of the acoustic relationships shared by all members of the rhotic class (Lindau 1985, p. 165): a1 = pulse pattern (trill); a2 = closure duration; a3 = presence of formants (sonorant); a4 = presence of noise; a5 = distribution of spectral energy (place of articulation).



Pharyngeal Constriction as a Cross-Linguistic Feature of Rhotics

While further research is needed to consider it a defining feature of the class, the presence of pharyngeal constriction has been confirmed with imaging technology in a number of languages. Using x-ray imaging, Delattre (1971) noted 11 cases of "consonant pharyngealization" across five languages, including in the English /ɹ/ sound. More recent studies have used ultrasound and magnetic resonance imaging to show that both varieties of the American English /ɹ/, retroflex and bunched, involve pharyngeal constriction (Boyce et al., 2016). Pharyngeal constriction was present across four different Spanish dialects in all productions of the rhotic trill sound /r/, but less consistent on productions of the tap, /ɾ/ (Rivera-Campos & Boyce, 2013). French /R/, the uvular trill, while heavily influenced by the features of surrounding vowels when in the intervocalic position, still featured pharyngealization in all cases, highlighted with shading in Figure 2 (Delattre, 1971). The other rhotic sounds in French require further study to confirm pharyngealization.

Figure 2: /R/ in the intervocalic position between back vowel /o/ (Delattre, 1971)



While not the focus of this paper, it is worth noting that several other languages have been shown to have distinct pharyngeal constriction in their rhotic sounds, including the German /r/, the Persian rhotic trill and its tap allophonic variant, and the Malayalam /r/ and /ɻ/ sounds. With the rhotic sounds of many languages confirmed to have secondary pharyngeal constriction, the question then becomes whether this is a feature of rhotics in general, or a feature of a subclass of rhotic sounds (Delattre, 1971; Boyce et al., 2016).

Late Acquisition of Rhotics and the Role of Pharyngeal Constriction

Another cross-linguistic commonality among rhotic sounds is being acquired relatively late. In a sample of 29 rhotic sounds across 22 languages, all were described as "late developing" (McLeod, 2007). English /ɹ/ has a large range, and is said to be acquired between the ages of 3;4 and 8;0 (McLeod, 2007; Sander, 1975), Spanish /r/ around 7;0 and /ɾ/ around 6;0 (Boyce et al., 2016), and while there is no specific data available for French, /R/, the French rhotic shown to have pharyngeal constriction, is described as "the most difficult consonant for most children" (McLeod, 2007, p. 375).

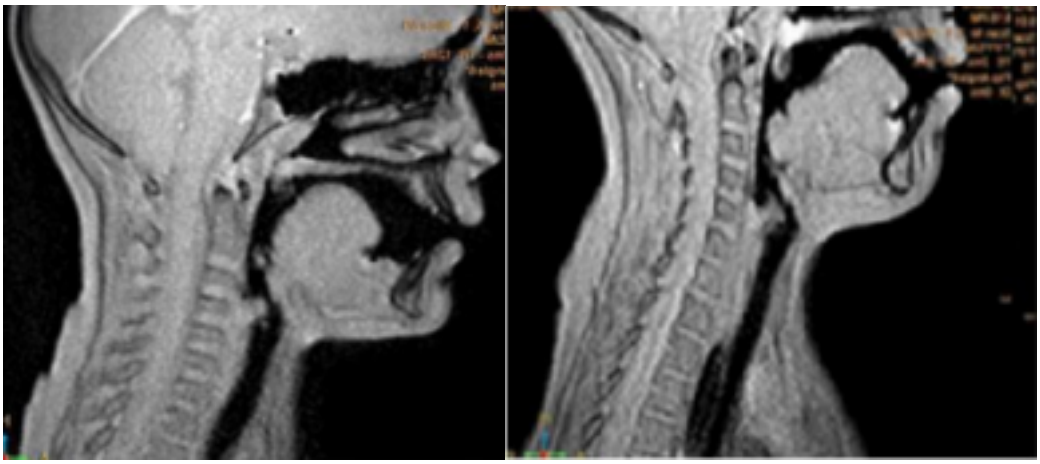
The motion of pharyngeal constriction is described as "unusual" (Delattre, 1971), and when combined with the primary constriction or other features, learning how to simultaneously move the tongue front and tongue root in opposite directions is a likely cause for late acquisition (Boyce et al., 2016). Alternatively, some researchers credit the difficulty of the Spanish trill mainly to the manner of production. Trill sounds have complex articulations even without considering pharyngeal constriction, requiring correct tongue placement and pressure (Lewis, 2004; Cummings-Ruiz & Montrul, 2020). The same can be said about the French /R/, and more research is needed in this area to determine what feature is the more common cause for error.

Clinical Relevance of Pharyngeal Constriction as it Relates to Speech Sound Disorders

A child with speech sound difficulties extending past the expected age of

mastery for a sound are said to have a Speech Sound Disorder, also known as a Residual Speech Sound Disorder. Rhotic sounds are often the problematic sound and cause for diagnosis (Boyce, 2015). As previously explained, the complex articulation of rhotic sounds is a likely cause of errors in production. Compared to late acquisition, however, the role of pharyngealization in misarticulations is clearer, as we can turn to knowledge gained from modern imaging technology. Distorted English /ɹ/ productions have been linked to a "highly curved, posteriorly located tongue shape, which likely results in loss of pharyngeal constriction" (Sjolie et al., 2016). Figure 3 illustrates this distortion and shows a Magnetic Resonance Image of a misarticulated /ɹ/ (left), and a correct /ɹ/ production (right). Note the lack of pharyngeal constriction during the misarticulated sound, and its presence during the correct production.

Figure 3: Left: Misarticulated /ɹ/, lacking pharyngeal constriction. Right: Correct ɹ/, with pharyngeal constriction present (Boyce et al., 2016).



Historically, clinical resources, textbooks, and techniques for remedying

English /ɹ/ production errors neglect the secondary constriction, and thus do not serve to fix errors with that feature of the complex articulation (Boyce, 2015). Ultrasound visualization is gaining in popularity as a clinical tool and is used to provide live feedback and cue clients to correct tongue placement errors. This would serve to remedy the aforementioned problem, and studies show promising results with small sample sizes (Adler-Bock et al., 2007; Boyce, 2015; Sjolie et al., 2016).

Conclusions

There is a growing body of evidence that shows pharyngeal constriction is characteristic of rhotics in many languages as seen through ultrasound, MRI, and x-

ray imaging, and convincing evidence that rhotic sounds are acquired relatively late and have a higher rate of Speech Sound Disorders cross-linguistically. It can be reasonably hypothesized that these patterns are related, but further research is needed. Specific areas for further research include analyzing the rhotic sounds of more languages in order to establish pharyngeal constriction as an articulatory feature of all rhotics, and to directly investigate the relationship between late acquisition and pharyngeal constriction, accounting for other difficult features, as seen in the case of the Spanish trill /r/.

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