

Comparison of oral to pharyngeal volume ratios across age groups in New Zealand English via magnetic resonance imaging

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Ageing causes a number of anatomical and physiological changes that influence the acoustic and biomechanical characteristics of human speech production. These changes occur across multiple components of the speech production system, including the laryngeal structures and the vocal tract [1,2]. Together, these changes contribute to measurable alterations in voice quality that become increasingly evident with advancing age.

The present study investigates age-related differences in vocal tract configuration in speakers of New Zealand English (NZE) using magnetic resonance imaging (MRI). A purpose-built MATLAB-based [3] toolbox was developed to convert MRI scans into three-dimensional vocal tract models, from which the vocal tract resonant frequencies (corresponding to speech formants [4]) and cavity volume ratios were derived. This work provides an exploratory analysis of how age-related anatomical changes affect cavity volumes and formant structure, and establishes a methodological foundation for larger-scale studies. Data from eight participants were analysed, including five individuals aged 23–25 and three aged 65–67. These scans used sustained /hVd/ words containing the target vowels, with two repetitions per speaker. Further details on the MRI data collection are provided in Watson [4]. Future work will focus on expanding this database to include a larger number of speakers across a wider age range.

In the analysis of the MRI data, age-related differences were most consistently observed for the /u:/ and /ɪ/ vowels, which showed differences in both resonant frequencies and oral–pharyngeal cavity volume ratios across speakers. Table 1 shows the averaged first two resonant frequencies, vocal tract length (VTL), and oral-pharyngeal cavity volume ratios for each speaker for the /u:/ and /ɪ/ vowels. For both /u:/ and /ɪ/, a small decrease in the first resonant frequency with age is observed, as well as an increase in the pharyngeal cavity volume ratio, with the exception of speaker Y1. For /u:/, a decrease in the second resonance with age was also observed.

The enlargement of the pharyngeal cavity, due to the descent of the larynx and lengthening of the vocal tract over time, is consistent with known ageing effects [1]. Also, the observed changes in the /u:/ and /ɪ/ vowels is consistent with the findings in Watson et al. [6], suggesting that the observed differences across ages may be due to a combination of anatomical changes and sound change in NZE. Furthermore, in Watson et al. [6], differences across ages also extended to the /æ/ and /ɛ/ vowels, however no clear differences were observed in the current study. This may be due to the participants being supinated instead of upright while in the MRI scanner, or the unnatural voicing of the vowels in the MRI machine, since speakers must sustain sounds for the scan duration, limit head movement, and compete with scanner noise [7].

As part of a broader programme on age-related variation in speech, this pilot study provides preliminary MRI-based evidence on anatomical changes due to vocal ageing in NZE. Future work will collect additional MRI data to further validate these findings, with an emphasis on increasing the number of older speakers and balancing gender representation, enabling a more detailed investigation of gender differences.

Table 1: First two resonant frequencies (F1 and F2), vocal tract length (VTL) and oral and pharyngeal cavity volume ratios for seven speakers. Speakers Y1-5 belong to the younger age group (23-25) and speakers E1-3 belong the elder age group (65-67).

VT	M/F	/u:/					/ɪ/				
		F1 (Hz)	F2 (Hz)	VTL (cm)	Oral %	Phar %	F1 (Hz)	F2 (Hz)	VTL (cm)	Oral %	Phar %
Y1	M	238	1584	18.2	25	75	313	1836	17.83	37	63
Y2	M	360	1742	18.68	47	53	393	1800	17.97	50	50
Y3	M	343	1831	17.08	46	54	500	1979	16.33	53	47
Y4	F	435	1821	16.85	47	53	528	1906	16.19	58	42
Y5	F	540	2062	14.78	56	44	573	2087	14.58	59	41
E1	M	318	1316	18.72	41	59	320	1966	18.00	39	61
E2	F	308	1151	17.15	42	58	240	2682	15.45	34	66
E3	F	270	1426	16.95	38	62	360	2049	16.12	47	53

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