

# At the crossroads: where age meets accent in the F1/F2 vowel space

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## Abstract

As a departure from previous research on Australian English, extracts from archival news bulletins of 12 middle-aged male, middle-aged female and elderly newsreaders were re-recorded by the original speakers, and vowel targets measured acoustically to see which speaker group displayed the greatest accent change. Analysis of /æ/, /e/, /i/ and /ɛ/ confirmed auditory impressions that some of the female speakers had made the largest shift away from Cultivated Australian towards General. Results which also revealed frequent raising in the vowel space of both monophthongs and diphthongs in all 3 speaker groups suggest that while some variation may be linked to age and some to vowel change occurring more generally in the community, some may involve both.

## 1. Introduction

As with other varieties of English, certain vowels of Australian English (AusE) have undergone change over time. Following on from the large-scale impressionistic study conducted by Mitchell and Delbridge in the early 1960s which subsequently classified the population as speakers of Cultivated, General or Broad accents, Bernard (1970) carried out the first serious acoustic analysis of AusE vowels. Amongst other things he found that a phonetically lower onset of diphthongal movement for /ɛ/ was more likely to indicate a Broad accent, and Cultivated /i/ was characterized by more fronted and raised targets relative to Broad. Cox (1998:48), in reanalyzing Bernard's data, found that two markers of a broader accent in AusE were a retracted (rather than lowered) first target for /ɛ/ and a 'marked onglide' for /i/. These studies were conducted on the citation form speech of adolescent or young adult males. Harrington, Cox and Evans (1997), also using citation form speech, examined data across age ranges and gender, and found that the first target of Cultivated /ɛ/ was significantly fronted relative to Broad and General in women, and to General in men. For /i/ they found Broad male and female speakers had the lowest frequency F2 and the longest onglide relative to Cultivated and General speakers but that onglide length interacted with age for Broad male speakers, and they suggested that older male speakers may produce the greatest onglides. Lastly, the results of Cox and Palethorpe's synchronic and diachronic studies (2001) showed evidence of a lowered first target of /ɛ/, leading them to claim this is one of the changes in progress in AusE.

All of the research cited above explored the speech of the general community. This study looks at vowel variation within a population of past and present newsreaders from radio and television. Newsreading may be considered a useful genre for the analysis of language change thanks to the

large volume of recorded material it has been generating since the inception of broadcasting in Australia in the early 1930s, and archiving since about the 1940s. By way of background, the nascent Australian Broadcasting Commission was modelled on the BBC whose Received Pronunciation accent was the standard to which newsreaders generally aspired until around the 1960s, when a wave of social change and Australian patriotism at last allowed the local accent to be heard on air (although initially it had to be the 'educated' variety). Simultaneously a change in newsreading style occurred whereby it gradually became less formal and declamatory. This was later followed by the introduction of FM radio in the early 1980s which further contributed to a more 'conversational' style. Improved audio technology no doubt assisted with this since less voice projection was required for the sound to transmit clearly, resulting in a more natural speech style.

Newsreading was traditionally a male domain, and it was not until the late 1970s that women were employed in the field in Australia. By that time RP-like accents were no longer the norm, but the archival material obtained for this research suggests that there were women employed in news who either happened to have naturally Cultivated voices, or felt the need to imitate one. Conversely it would seem that most male newsreaders spoke with a General accent by then. Much of the previous research on AusE has concentrated on younger speakers, where according to Labov (1990) linguistic change is more likely to be found. This study looks instead at intra-speaker change in the middle-aged and elderly by impressionistically and acoustically comparing 12 newsreaders' re-recorded news extracts with the original recording, thereby creating a true real-time study.

News bulletins are a form of read speech whose objective is to communicate information as clearly as possible to either

a radio audience of listeners who cannot see the speaker, or to television viewers (including those who may be hard of hearing or vision-impaired for example). The newsreading style is thus much more deliberate and careful than natural speech, but this should not prevent newsreaders from sounding like their audience, since outside of their profession they are also members of Australian society and as such are participating in the same vowel variation identified by the aforementioned researchers. However, in further contrast to studies focusing on younger speakers, a potentially complicating factor here is any physiological changes the newsreaders may have undergone between recordings as a result of the natural ageing process (see Discussion section), so the challenge will be to disentangle the sociophonetic and stylistic influences from those that may be age-related.

As part of a larger study this paper will report on variation to /eɪ/ and /i/ (and to a lesser extent the monophthongs /e/ and /æ/) within male, female and elderly male speaker groups. Since impressionistic observation of vowel quality suggests some of the females have shifted further along the accent continuum away from Cultivated between recordings than the males it is expected that this will be reflected acoustically. It is also anticipated that the elderly speakers will show the greatest vowel variation, given the longer timespan between recordings.

## 2. Methods and materials

### 2.1. Corpus

Interviews were conducted with a range of Australian (past and present) radio and television newsreaders in quiet locations, and the speakers for whom archival news material had been obtained were asked to re-read a transcribed extract in their usual newsreading style. A Rode S1 condenser microphone was used with an external Tascam US-122 USB audio/MIDI interface device to record directly onto a laptop computer at a sampling rate of 44.1kHz with 16 bit resolution.

The archival material was variously supplied on VHS, DAT, audio cassettes and CD and was digitized using Sonic Foundry Sound Forge v.6 software at a sampling rate of 44.1kHz with 16 bit resolution. Some of the material was of limited duration and proved problematic in terms of the number of usable tokens it provided for analysis. A speech database was created using EMU software tools (see Cassidy & Harrington 2001). Wherever possible primary stressed monophthongs and diphthongs from the same words in both recordings were measured, but if additional acceptable tokens were available they were included. Vowel targets for monophthongs were deemed to be the mid-point of the section where the first and second formants were parallel and showed least deviation. Following Cox (1999) in the absence of such sections the highest point of F2 was taken as the reference for front vowels. Diphthong targets were measured at the points where there was minimal and maximal distance between F1 and F2, and similar points for the onglide were measured for /i/. Nasals, liquids, rhotics and glides were excluded unless there were insufficient tokens for analysis, and the number of analyzable tokens obtained varied from speaker to speaker. Vowel charts were created by plotting F1

against F2. For reporting purposes significance is defined as  $p<.05$  and trends as  $p<.10$ .

### 2.2. Speaker groups

Twelve speakers from television and AM radio were selected for analysis, being 4 middle-aged males aged between 45 and 50, 4 middle-aged females aged between 38 and 49, and 4 elderly males aged between 79 and 82. The distinction between male speakers who are elderly and middle-aged will be made by using the term 'elderly', when referring to one or more members of the elderly male speaker group and 'male' for the middle-aged male group. To avoid confusion with formant frequency labels the female speakers will be referred to as W1, W2 etc. The male speakers were aged between 19 and 26 at the time of their original recordings which took place between 1979 and 1984, and the female speakers were aged between 21 and 24. Three of the female speakers' original recordings were broadcast between 1980 and 1982, and the fourth was in 1989. The elderly speakers' archival bulletins were recorded in 1951, 1955, 1958 and 1965 when they were aged 28, 29, 35 and 39 respectively.

## 3. Results

Before reporting on the monophthongs and diphthongs chosen as the focus of this analysis some attention will be paid to the aspect of the overall vowel space. It is interesting to note that in the majority of cases the shape of the speaker's vowel space was maintained between the two recording dates. What is noticeable in female speaker W4 for example (see Figure 1) is the upward shift of the whole space. The raising she displays for /æ/, /e/ and /ɔ/ in her re-read is statistically significant at  $p=0.0001$ ,  $p=0.05$  and  $p=0.0009$  respectively.

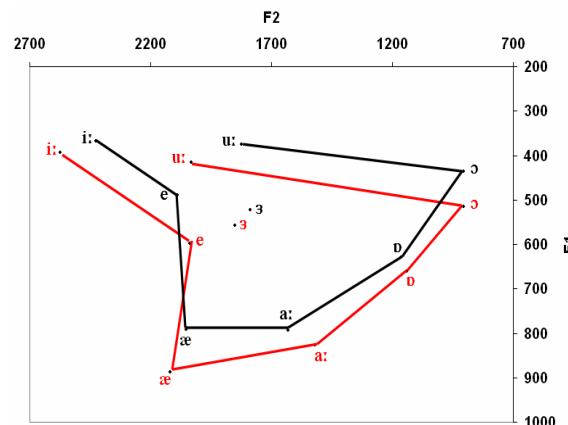


Figure 1: Speaker W4's vowel space from 1982 (red) to 2006 (black). Measurements are in Hz.

### 3.1. Quantitative results

In terms of variation that was statistically significant, the elderly speakers showed the most for the vowels investigated, followed by the men and then the women, but of course the speaker numbers are very small (see Table 1).

Speaker group	e	ae	i	ei	Total changes	% of changes possible
Female	3	3	3	4	13	27
Male	4	4	1	5	14	29
Elderly	4	3	6	5	18	37.5

Table 1. Number of vowels showing statistically significant variation ( $p < 0.05$ ) per speaker group, and as a percentage of the maximum number possible, i.e. 8 for each monophthong and 16 for each diphthong.

The figures do not indicate the nature of the variation, for example that raising is responsible for 6 out of the 7 cases of significance for /e/ and /æ/ in the elderly speakers, 4 out of 6 for the women and 3 out of 8 for the men. In addition, 4 of the 5 instances of significant variation to both targets of the elderly speakers' /ei/ involve raising. A different phenomenon seems to be occurring for elderly /i/, since 5 of the 6 cases of significant variation (both targets) involve lowering, as opposed to the male and female speakers where 2 out of the 4 vowels showing significance involve raising for T1. This issue will be discussed in more detail below.

### 3.2. Qualitative results

Qualitatively, W1 and W3 show the greatest shift of all speakers by way of centralization into the V space for /i/ and /ei/, supporting the auditory impression of marked accent shift from Cultivated towards General for these women. The other 2 female speakers (W2/W4) who seem to have maintained their originally Cultivated accents over the 25-year period show the most marked phonetic raising (i.e. the greatest lowering of F1 frequencies) for /æ/ and they also show greater raising for /e/ than all other speakers apart from E1. They therefore show strong evidence of acoustic but not necessarily auditory shift. The expectation that the male speakers with General accents in their 1980s recording may not show as much difference acoustically as the women was confirmed for /i/ and /ei/ insofar as the measurements overall were smaller than those of the women.

### 3.3. Monophthongs

One of the principal findings of Cox & Palethorpe (2001) was the lowering of /æ/ as a change occurring in AusE. In the current study 11 of the 12 speakers showed statistically significant phonetic *raising* of at least one monophthong, and for 6 speakers this included /æ/ (3 of the elderly speakers with a strong trend for the fourth, 2 of the females and one of the males (with a trend for one of the others)). Only one female speaker (W1) showed non-significant but perceptually salient lowering of /æ/, whereas for those with significant /æ/ raising there was no difference in perceived vowel quality. The phenomenon of raising was more striking for /e/, with 3 elderly, 2 female and 2 male speakers displaying significantly lower frequencies for F1. Figure 2 illustrates the changes to /e/ between the original read and the re-read for each speaker. W1, who lowered /æ/ in the vowel space also shows non-

significant lowering of /e/, and again she is the only speaker to do so.

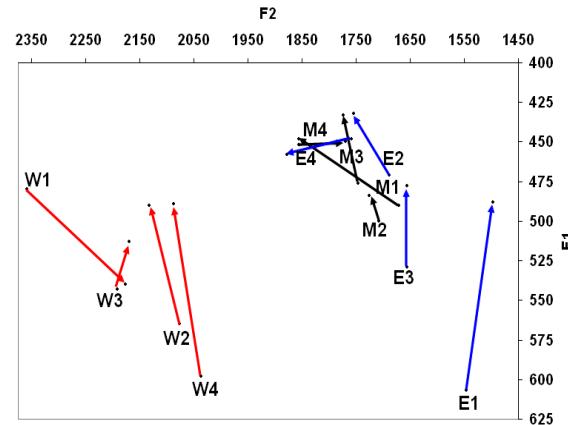


Figure 2: All speakers' average /e/ target midpoints. Arrows indicate direction of shift between original and re-reads. Red=females, black=males, blue=elderly. Measurements are in Hz.

### 3.4. Results for /ei/

The correspondence between the realization of monophthongs and diphthongs was noted in Cox (1999) and Cox & Palethorpe (2001). Results of the current study also indicate that for many of the speakers certain diphthongs have shifted in parallel with their corresponding monophthongs (see Figure 3). For example in his re-read M4 raises the first target of /ei/ to the same extent as he raises /æ/ and /a:/ (although in this instance none is statistically significant), and he realizes it in the same location within the vowel space relative to these 2 monophthongs as in his original read. His second target is also realized approximately the same distance from /e/ in both reads. Importantly, his (General) accent does not show perceptible change between recordings.

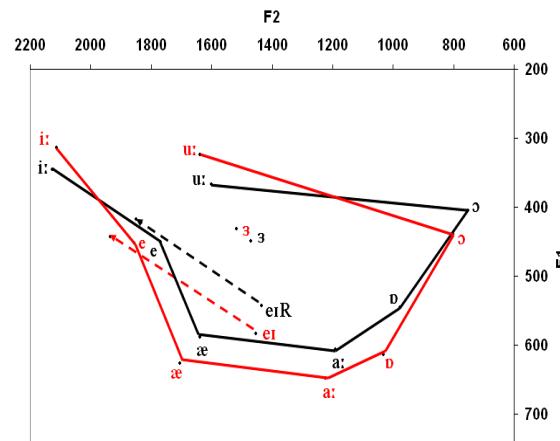


Figure 3: Speaker M4's vowel space and /ei/ diphthong from 1983 (red) to 2006 (black). Measurements are in Hz.

Results showing average shift for all speakers' first target of /ei/ are illustrated in Figure 4 below. In contrast to M4, acoustic analysis of M1's /ei/ diphthong shows significant lowering ( $p=0.001$ ) but non-significant retraction of T1 in the re-read, producing perceptually salient shift away from a Cultivated accent towards General. This result supports the combined findings of the aforementioned researchers in relation to increasing broadness of /ei/, and this despite the fact that citation form rather than connected speech data was examined. M2 shows limited non-significant raising/retraction for T1, yet to the ear his accent is slightly broader, and M3 shows even smaller non-significant raising/fronting for T1, producing no difference at all in perceived vowel quality.

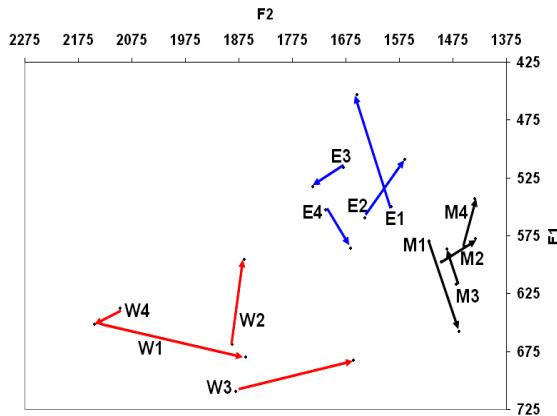


Figure 4: All speakers' average T1 measurements for /ei/. Arrows indicate direction of shift between original and re-reads. Red=females, black=males, blue=elderly. Measurements are in Hz.

Of the elderly speakers, E1 shows significant raising ( $p=0.0006$ ) and non-significant fronting for both targets of /ei/, which produces a slightly more diphthongal but not broader-sounding vowel, and E2 shows significant raising ( $p=0.01$ ) and non-significant retraction of T1 only, resulting in a slight perceptible shift from Cultivated towards General. E3 shows non-significant lowering/fronting of T1 which does not result in perceptible difference in vowel quality, and E4 shows non-significant lowering/retraction of T1 but significant raising/fronting of T2 ( $p=0.01/0.051$ ) which together produce a lower-onset, more diphthongal realization that places his accent closer to General than in his original recording.

As for the women, W2 shows non-significant raising for the first target of /ei/, and W4 shows non-significant lowering/fronting. Neither of them displays any accent shift. W3, however, shows significant retraction for T1 ( $p=0.0001$ ) and T2 ( $p=0.0003$ ), and W1 shows non-significant lowering but a strong tendency towards retraction for T1 ( $p=0.064$ ) which according to the previously mentioned research would suggest increasing broadness, as well as significant retraction for T2 ( $p=0.031$ ). Impressionistically both these speakers show a clear change in vowel quality for /ei/ that is now closer to General than Cultivated.

### 3.5. Results for /i/

Results for /i/ will focus on the shift in the start point of the onglide between readings for all speakers (see Figure 5).

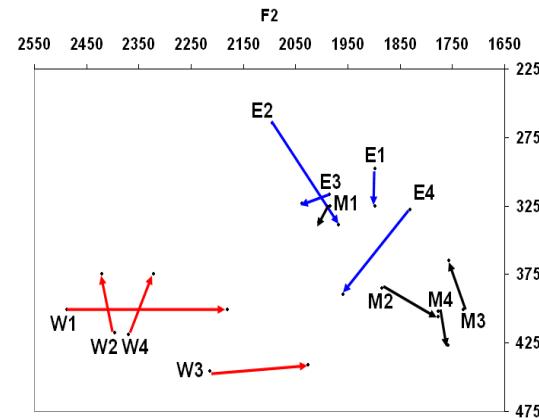


Figure 5: All speakers' average measurements for the start of the /i/ onglide. Arrows indicate direction of shift between original and re-reads. Red=females, black=males, blue=elderly. Measurements are in Hz.

Similarly to /ei/, each speaker group (with the exception of M1 whose realization of /i/ was closer than the rest of his cohort) separates into its own 'zone' within the vowel space. What is immediately noticeable is that all the elderly speakers show lowering between recordings, as do 3 of the males. E1, E2 and E4's lowering is significant ( $p=0.009$ ,  $p=0.0005$ ,  $p=0.0003$  respectively), but of the males only M3's raising is significant ( $p=0.003$ ). E2's re-read onglide starts lower and further back in the space and effectively sounds broader than in the original. E4's re-read onglide is more fronted, but his lowering may be responsible for a perceptible accent shift away from Cultivated. The non-significant lowering for E1 and lowering/fronting for E3 do not result in perceptible difference.

Of the female speakers only W2's raising is significant ( $p=0.033$ ) although W1 ( $p=0.092$ ) and W3 ( $p=0.094$ ) retract sufficiently towards the centre of the space to produce very clear shift in vowel quality from Cultivated to General. W1's displacement is more obvious to the ear than that of W3, having started from the most fronted (and therefore most Cultivated) position. W3 commences her original recording onglide at a similar (F2) position in the vowel space to the onglide of W1's re-read, and in fact her accent already sounds General in her original read. This may also be due to her phonetically lower realization of the vowel in both reads compared with the other female speakers.

M2 and M4, who non-significantly lower/retract and lower respectively, sound slightly more General in the re-read than in their archival recording, while M1 who lowers/fronts non-significantly, makes only a very slight shift away from Cultivated towards General. W4 and W2, who realize their /i/ at the Cultivated end of the accent spectrum and M3 who realizes his at the Broad end, all show raising of /i/ over time but manifest no accent shift at all.

#### 4. Discussion and Conclusion

The findings of most interest would seem to be firstly that there was an unexpectedly high incidence of phonetic raising for /æ/ and /e/ in all speaker groups and some for the first target of /eɪ/, secondly that 3 of the 4 members of the elderly group showed significant lowering of the /i/ onglide, and thirdly that lowering and/or retraction in the vowel space and retraction coupled with raising almost always produces broadening of accent for /i/ and /eɪ/, whereas raising and/or fronting does not. Retraction then, it would seem, is the key to broadening of accent. Finally, it was observed that for /i/ and /eɪ/ each speaker group appears to occupy an identifiable first target 'zone' within the vowel space linked to accent type.

Since Bauer (1985) also found lowering of F1 in the connected speech of 3 RP-speakers re-recorded over a 20-year period (which he surmised may be age-related) and other researchers have considered the physiological effects of ageing on the vocal tract as a factor in vowel variation (see Henton 1983, Harrington, Paletorpe & Watson 2000, 2005, and Watson, Paletorpe & Harrington 2004), an explanation for the frequent occurrence of raising in the current study was sought in the gerontological literature. Endres, Bambach and Flösser (1971) found lower formant frequency values in the same 6 male and female speakers over a period of between 13 and 15 years for monophthongs including /i/, /e/ and /æ/ and the diphthong /aɪ/ (/eɪ/ was apparently not investigated). Linville and Rens (2001) found lowering of average formant values across gender from young adulthood to old age, which they suggest might result from supraglottic vocal tract lengthening caused by lowering of the larynx. Linville and Fisher (1985) also found significant lowering of F1 and F2 for sustained phonation of /æ/ in elderly female speakers aged between 70 and 80 compared with younger speakers aged between 25 and 35, and Liss, Weismer and Rosenbek (1990) noted that the formant frequencies of 14 very old males (i.e. over the age of 87) for /u/, /a/, /æ/ and /i/ demonstrated a centralizing tendency towards the formant measurements normally associated with /ə/. Finally Rastatter and Jacques (1990) and Rastatter, McGuire, Kalinowski and Stuart (1997) showed that F1 values for /i/ were significantly *higher* in elderly male speech than those of their younger counterparts in the environments of isolated vowel production and carrier sentences respectively (though interestingly the 1997 study demonstrated that this was not true for the elderly female speakers).

Given the above findings, the raising noted for /e/, /æ/ and /eɪ/ in the present study and the lowering of /i/ for the elderly male speakers seem less surprising. At this point it is necessary to address the question of which incidences of vowel shift may be age-related, which might be sociophonetically influenced and whether newsreading style itself could be a factor. The idea of a 'crossroad' where age-related and accent-related variation might intersect is quite literally illustrated in Figure 5 via W1's /i/-retraction (accent) and W2/W4's /i/-raising (age). E2's raised and retracted /eɪ/ (see Figure 4) is an example of this phenomenon occurring in the *same* speaker. His perceived broadening of accent might normally be expected to result from *lowering* and/or retraction as per the definitions previously summarized. E4's lowered and retracted /eɪ/ would therefore seem to fit more

closely with the claim made by Cox & Paletorpe (2001) that lowered /eɪ/ is a change in progress in AusE, but his retraction could also be an example of the aforementioned centralizing tendency associated with elderly speech. Equally, E2's lowered and retracted /i/ onglide (sounding broader) could be the outcome of ageing as per Rastatter *et al* (1997) or he may simply have accommodated to General Australian. However his entire vowel space appears to have 'shrunk' (or centralized) between recordings, suggesting that age may therefore be the dominant influence. Unlike the elderly speaker group, lowering and/or retraction of /i/ and /eɪ/ in the middle-aged males and females (e.g. M1's /eɪ/ and W1/W3's /eɪ/ and /i/) is more likely to be sociophonetically influenced than a factor of age, whereas raising for any of these speakers' vowels could potentially be age-related.

By way of a possible alternative explanation for the phonetic raising observed in the current study, Liénard and Di Benedetto (1999) and Traunmüller and Ericksson (2000) found amongst other things that vocal effort increases fundamental frequency (F0) and F1 values. It may be possible that speakers increased vocal effort in their early recording due to particular stylistic requirements or norms, lack of experience and training, or less sophisticated audio technology, but that in their later recording they decreased vocal effort for the opposite reasons (plus perhaps the fact that the re-recording was not a live broadcast). All this would result in lower F0 and F1 values.

While the physiological and sociophonetic influences on speech can be researched, style is somewhat more elusive. What can easily be observed by watching or listening to contemporary Australian news bulletins is the considerable number of presenters with General or even General-Broad accents, suggesting that whatever stylistic constraints they are subject to, a Cultivated sound is not one of them. Another interesting point to make here is that it was surprising how often a speaker re-read their archival news text with exactly the same phrasing and stress patterns as in the original recording, although this would largely have been dictated by the writing style. Presentation style therefore remained fairly constant between recordings. Finally, although the interviews revealed all speakers to have a more natural conversational style compared with their 'professional' speech style, neither their accent type nor their voice pitch (F0) varied between the two. Impressionistically, however, it seems the male and female speakers' F0 has lowered between recordings (it should be noted that Endres *et al* (1971) also found that F0 decreased with increasing speaker age).

Despite the particular characteristics of this small population of newreaders, the acoustic measurements for the speakers showing perceptible shift along the continuum away from Cultivated conform to the acoustically-defined definitions of broader AusE accents summarized earlier. Their profession has thus not isolated them from the linguistic changes taking place around them. The unexpected result in the form of phonetic raising for both age groups suggests researchers should not underestimate the effects of ageing as a potential influence on vowel variation. Lastly, the differing degrees of variation between groups and between individual speakers within those groups raise further questions including the relationship of speaker age to the process of accent change itself.

## 5. References

- Bauer, L. (1985). Tracing phonetic change in the received pronunciation of British English. *Journal of Phonetics*, 13, 61-81.
- Bernard, J. (1970). Towards the acoustic specification of Australian English. *Zeitschrift für Phonetik*, 2/3, 113-128.
- Cassidy, S. & Harrington, J. (2001). Multi-level annotation of speech: an overview of the EMU speech database management system. *Speech Communication*, 33, 61-77.
- Cox, F. (1998). The Bernard data revisited. *Australian Journal of Linguistics*, 18 (1), 29-55.
- Cox, F. (1999). Vowel change in Australian English. *Phonetica* 56, 1-27.
- Cox, F. & Palethorpe, S. (2001). The changing face of Australian English vowels. In D. Blair & P. Collins (Eds.), *English in Australia* (pp.17-44). Philadelphia: John Benjamins Publishing Company.
- Endres, W., Bambach, W., & Flosser, G. (1971). Voice spectrograms as a function of age, voice disguise, and voice imitation. *Journal of the Acoustical Society of America*, 49, 1842-1847.
- Harrington, J., Cox, F., & Evans, Z. (1997). An acoustic phonetic study of broad, general, and cultivated Australian English vowels. *Australian Journal of Linguistics*, 17, 155-184.
- Harrington, J., Palethorpe, S., & Watson, C. (2000). Monophthongal vowel changes in received pronunciation: an acoustic analysis of the Queen's Christmas broadcasts. *Journal of the International Phonetic Association*, 30(1/2), 63-78.
- Harrington, J., Palethorpe, S., & Watson, C. (2005). Deepening or lessening the divide between diphthongs: an analysis of the Queen's annual Christmas broadcasts. In W.J. Hardcastle & J. Mackenzie Beck (Eds.), *A Figure of Speech: a Festschrift for John Laver* (pp.227-261). London: Lawrence Erlbaum Associates.
- Henton, C.G. (1983). Changes in the vowels of received pronunciation. *Journal of Phonetics*, 11, 353-371.
- Labov, W. (1990). The intersection of sex and social class in the course of linguistic change. *Language Variation and Change*, 2, 205-254.
- Liénard, J-S., & Di Benedetto, M-G. (1999). Effect of vocal effort on spectral properties of vowels. *Journal of the Acoustical Society of America*, 106(1), 411-422.
- Linville, S.E., & Fisher, H.B. (1985). Acoustic characteristics of perceived versus actual vocal age in controlled phonation by adult females. *Journal of the Acoustical Society of America*, 78, 40-48.
- Linville, S.E., & Rens, J. (2001). Vocal tract resonance analysis of aging voice using long-term average spectra. *Journal of Voice*, 15(3), 323-330.
- Liss, J. M., Weismier, G., & Rosenbek, J.C. (1990). Selected acoustic characteristics of speech production in very old males. *Journal of Gerontology*, 45, 35-45.
- Mitchell, A. G. & Delbridge, A. (1965). *The speech of Australian adolescents*. Sydney: Angus & Robertson Pty Ltd.
- Rastatter, M.P., & Jacques, R.D. (1990). Formant frequency structure of the aging male and female vocal tract. *Folia Phoniatrica et Logopaedica*, 42, 312-319.
- Rastatter, M.P., McGuire, R.A., Kalinowski, J., & Stuart, A. (1997). Formant frequency characteristics of elderly speakers in contextual speech. *Folia Phoniatrica et Logopaedica*, 49, 1-8.
- Traunmüller, H., & Ericksson, A. (2000). Acoustic effects of variation in vocal effort by men, women, and children. *Journal of the Acoustical Society of America*, 107(6), 3438-3451.
- Watson, C., Palethorpe, S., & Harrington, J. (2004). Capturing the vowel change in New Zealand English over a thirty year period via a diachronic study. In S. Cassidy, R. Mannell & F. Cox (Eds.), *Proceedings of the 10<sup>th</sup> Australian International Conference on Speech Science & Technology* (pp.201-206). Sydney: Australasian Speech Science and Technology Association.