Australian Journal of Linguistics
Vol. 31, No. 3, September 2011, pp. 275–303

Routledge
Taylor & Francis Group

Location, Location, Location! Regional Characteristics and National Patterns of Change in the Vowels of Melbourne Adolescents*

ROSEY BILLINGTON

University of Melbourne

Evidence of Australian English vowel shifting has been found recently, in data primarily from Sydney and surrounding areas. Although regional variation in the Australian accent remains under-investigated, some signs of regional vowel differences have been found, suggesting that data from other regional centres must also be considered to accurately assess the nature and extent of vowel change. This study contributes to the ongoing re-assessment of Australian vowel characteristics by examining formant data of the /hVd/ vowels of 13 female and nine male adolescents from Melbourne, in relation to recent data from Sydney and Adelaide and earlier data from New South Wales. Results yield evidence of regional vowel differences, with signs that these interact with vowel innovation, and that the presence of regional and innovative vowel characteristics differs for males and females.

Keywords: Vowels; Vowel Change; Australian English; Regional Variation; Phonetics

1. Introduction

Australian English vowels have been investigated with renewed vigour in recent years, after established descriptions of Australian vowel characteristics were found to be increasingly less relevant to the modern Australian accent. The auditory study by

*This paper discusses selected results from a study conducted for my 2008 honours thesis at Monash University. Thanks are due to my supervisor, Simon Musgrave, for his feedback along the way, and also to two anonymous reviewers for their valuable comments, particularly regarding the importance of the vocal tract size effect. I am also grateful to members of the audience at the 2009 Conference of the Australian Linguistic Society, where some of this material was presented, for their remarks, and to the students who participated in my data collection. Any remaining errors or incongruities are my own.

ISSN 0726-8602 print/ISSN 1469-2996 online/11/030275-29
DOI: 10.1080/07268602.2011.598628

Mitchell and Delbridge (1965b) and the subsequent acoustic study by Bernard (1970) founded the understanding of Australian vowels and provided reference points for their phonetic characteristics, but these phonetic characteristics appear to be changing. Incipient reassessment of the vowels using acoustic analysis has found that they have undergone an evolution (Cox 1996, 1999; Cox & Palethorpe 2001; Fricker 2004), with many monophthongs and diphthongs showing evidence of a vowel shift underway. This reassessment has been carried out largely based on data from the city of Sydney and surrounding areas of the state of New South Wales, and although the notion of geographical uniformity in the Australian accent has been maintained for a long time (Bernard 1970, 1989; Cochrane 1989; Mitchell & Delbridge 1965b: 87), recent findings indicate that it may not be practical to base discussion of all Australian vowels on data from one state. Previously, variation found in Australian English vowels was chiefly discussed in terms of the Broad, General and Cultivated categories identified by Mitchell and Delbridge (1946, 1965a), which were implicitly correlated with social class. The concept of Broadness variation, combined with the notion of regional uniformity, overrode any desire to examine regional variation in any great detail. However, these Broadness categories are currently being reassessed in terms of their changing vowel characteristics and the waning presence of the Broad and Cultivated varieties (Fricker 2007; Harrington *et al.* 1997; Horvath 1985), and evidence of regional accent differences within Australian English has begun to emerge, suggesting new directions for studies of Australian vowels. Observations of regional variation were foreshadowed in studies which found regional variation in the use of either /a:/ or /æ/ preceding certain nasal + stop clusters and also some fricatives (e.g. Bradley 1980, 1991). Across a wider range of contexts, Bradley (1989, 2004), Oasa (1989), and more recently Butcher (2006), Cox and Palethorpe (2003) and Fricker (2007) have all found some indications that regional vowel differences do exist. Cox and Palethorpe in particular found convincing evidence of vowel variation being closely linked with regional affiliation, finding differences between the vowels of adolescent females who were geographically close but separated by the New South Wales/Victoria state line. Though these findings have opened up a new avenue of inquiry into Australian English vowels, as yet no comprehensive survey of regional vowel variation in Australian English has been possible in order to catalogue regional vowel variants. Although our knowledge in this area is limited, there are signs that differences exist and it would therefore be premature to generalize about the current state of Australian vowels drawing solely on Sydney-centric data. To accurately assess the scope of vowel innovation in Australia, the picture must be pieced together from different regional centres to see how the diffusion of innovation interacts with regional variation.

In the context of vowel variation and change, other factors also have significant roles. The age of speakers is an important variable to consider, given that it is well established in the literature that young speakers are influential in advancing linguistic change (Chambers 1995), and in particular they are 'at the leading edge in the progress of sound change' (Labov 1994: 47). Adolescents are typically innovators and

also inclined to adopt new pronunciation variables that they are exposed to as their networks expand. New features are consolidated amongst peers, reinforcing group solidarity and concurrently distancing the adolescent cohort from adults (Eckert 1988, 2000). Thus, young speakers can be taken to show the most recent pronunciation features, and these embedded features may be carried forwards as language change. A person's accent is thought to change very little after adolescence [Trudgill 1983; but for the contrary, see Harrington (2006) on the Queen's English], so variation from younger to older speakers can be interpreted as evidence of language change in progress. Apparent-time studies operate on this premise, using samples stratified by age. Several studies looking at vowel change in Australian English have used this method (Cox 1996, 1998; Cox & Palethorpe 2001; Fricker 2004), finding that young speakers of Australian English demonstrate the most innovative vowel features.

Gender is also a pertinent variable in language variation and change, and some other studies on Australian English vowels have been limited by data from only one gender. Bernard's early study (1970) used only male speakers from New South Wales, and thus Cox's (1999) study also focused on only male speakers, comparing Bernard's data to her more current data. Cox and Palethorpe's (2003) study of regional variation involved only females, as did their (1998) study of regional variation in Sydney. So too did Butcher's (2006) study of the vowels of speakers from Adelaide. These studies have all contributed vital information to the understanding of Australian vowels, but it is important that both males and females be represented where possible so that gender effects can be taken into consideration. Typically, women adopt and maintain more standardized pronunciation variants with 'overt prestige', which often transcend regions, while males tend towards more localized phonetic variants (Chambers 1995). However, women are also more likely to adopt innovative phonological features which diverge from the standard, when they occur below the level of social awareness (Maclagan, Gordon & Lewis 1999; Eckert 1997). Labov (1990) refers to these differently motivated patterns of adopting variants as 'change from above' and 'change from below', and asserts that women are more likely to show evidence particularly of vowel innovations before men, and to use these innovations far more frequently while the changes are still new. There are indications of this pattern of female innovation in studies on Australian English vowel shifting; Fricker (2004) found that more vowel tokens showed substantial or statistically significant movement for female speakers than males, and suggests that the vowel shift is being generally led by female speakers. (See Labov (2001, 2010) for detailed discussion of how linguistic change begins and how the transmission of new linguistic forms is negotiated by speech communities with regards to the age, gender and other more locally defined social characteristics of their members.)

Thus a complex picture is emerging where regional, social, age-related and gender-related variables must all be considered for the analysis of vowels in Australian English at any given point in time, particularly in the midst of a vowel shift. The most current and detailed descriptive study to date of all the vowels of Australian English is that of

Cox (2006). To address the need for a revised reference point for discussion of the vowels of Australian English, Cox conducted an acoustic analysis of the vowels of Australian English in the /hVd/ phonetic environment, spoken by 120 male and female adolescents from New South Wales. Butcher (2006) has supplemented this with his study of the vowels of females from Adelaide, South Australia, but both concede that more comprehensive investigation into the vowels of Australian English is warranted.

To contribute to this investigation, the present study provides acoustic data of the formant frequency values for the monophthongs[1] of adolescents from Melbourne, the capital city of the state of Victoria. Formants represent the different resonant frequencies in the vocal tract, identifiable by the dark bands of acoustic energy shown when a recorded vowel is displayed as a spectrogram. Vowels generally contain between four and six visible formants, classified as F1 to F*n* and ranging from lowest to highest frequency. Formants can be quantified by their frequencies using acoustic analysis, and the first two formants, F1 and F2, contain the most important information necessary for speakers to distinguish between vowels (Jakobson *et al.* 1969). F1 relates to the auditory quality of height, while F2 relates to the auditory quality of frontness/backness (Ladefoged 2006: 85–88).[2] The F1 and F2 frequencies of the vowels of Melbourne adolescents offer a means of comparison with other Australian English vowel data.

The present data are analyzed in relation to the similar descriptive sets collected in Sydney by Cox (2006), in Adelaide by Butcher (2006) and in Sydney and surrounding areas of New South Wales by Bernard (1970). Given that the only comprehensive acoustic data for Australian vowels of the past is from New South Wales, the feasibility of a comparison of these with Melbourne data depends on the extent and nature of any regional vowel characteristics present in Melbourne English.

In light of the context of vowel change and the likelihood of regional vowel variation, the present study has three overarching hypotheses for investigation, as follows:

1. regional differences will be present in the vowels of different Australian states;
2. vowel innovation is likely to exist for Melbourne adolescents, but will interact with regional vowel characteristics; and
3. gender differences will be present in the degree to which Melbourne males and females orient towards innovation or regional affiliation in their vowel realizations.

[1] Diphthongs were also studied, but discussion of the findings is not included here both for the sake of brevity and also because the methods used in this study are less suitable for vowels with marked changes in formant trajectories (see Watson & Harrington 1999), though these methods are necessary here for comparative purposes.

[2] These distinctive features have been associated with tongue location in the vocal cavity, but they can be thought of as correlating more closely with the acoustic properties of vowels than just the articulatory position of the tongue, given the compounding effects of individual articulatory differences and factors such as lip rounding (Johnson 2003).

2. Methodology

2.1. Participants

Participants were recruited from a Catholic girls' secondary school and a Catholic boys' secondary school in the south-eastern suburbs of Melbourne,[3] in an area where the local community is largely middle-class and mainly consists of native speakers of Australian English. Students at these schools can be viewed as part of a homogenous group, as the two institutions are brother and sister schools which often run combined events and mixed-sex classes, and many students have family members and close friends attending the sibling school.

Volunteer students for the present study were sought based on criteria which aimed to control for extraneous linguistic and cultural influence and also to provide a sample representative of Australian English.[4] The criteria were as follows: participants had to be second-generation Australians; Australian English had to be the native language of each of them and both of their parents; they had to have lived in the region for at least eight years, and be in their final or penultimate year of secondary education at one of the two schools. All participants were judged by the researcher to be speakers of the General accent of Australian English; any Broad or Cultivated speakers would have been excluded from the study had they been present. The final sample consisted of 13 females and nine males aged 16–18.

2.2. Data Collection

Participants were organized into pairs for recording sessions, which were undertaken in a room on the school premises for all of the girls and five of the boys, and in a local library for the remaining four boys. Audio recordings of speech data were made using a Fostex FR-2LE Field Memory Recorder in mono, with a Behringer condenser microphone, at a sampling rate of 44.1 kHz with 16-bit resolution.

In order to be consistent with previous research by Bernard (1970), Cox (2006) and Butcher (2006), flash cards were used to elicit the stressed vowels of Australian English. These were presented in the /hVd/ phonetic environment following Cox (2006), shown in Table 1. Each participant read through the set of flash cards twice, and the set was shuffled between each turn and each participant. If a word was produced incorrectly, the participant was asked to repeat it, and if required,

[3] Cox (1996) has found no differences between government and Catholic schools in data of Australian vowels in the /hVd/ environment, and Clyne *et al.* (2005) similarly found little evidence that vowel variation was connected to speakers' attendance at either government schools or at non-government schools (Catholic and independent).

[4] In this study, Australian English refers to the standardized, dominant variety of English spoken mainly by native-born Australians or those who identify as such. It does not include the range of Aboriginal and ethnic varieties present within the country, nor does it include the different 'Broadness' varieties that have been noted for the Australian accent. Vowel variation in these varieties falls within the realm other sociophonetic research; for the comparative aims of this study, it is necessary to narrow the focus to the variety of Australian English that is the most widely used and recognized.

Table 1 The words used on the flash cards to elicit the corresponding vowels of Australian English, following Cox (2006)

Word	Vowel phoneme	Word	Vowel phoneme
Heed	/iː/	Horde	/oː/
Hid	/ɪ/	Who'd	/ʉː/
Head	/e/	Hood	/ʊ/
Had	/æ/	Heard	/ɜː/
Hard	/ɐː/	Heared	/ɪə/
Hud	/ɐ/	Haired	/eː/
Hod	/ɔ/		

prompted by the researcher with a rhyming word.[5] The total number of vowel tokens used for analysis was 852.

2.3. Analysis

Using Praat (Boersma & Weenink 2008), each vowel token was analyzed based on digital broad-band spectrograms, with formant tracks overlayed on the spectrograms and with aligned waveforms. To facilitate comparison with previous research by Bernard (1970), Cox (2006) and Butcher (2006) and to enable F1 and F2 values to be plotted against one another as points on a plane, the concept of the vowel target was used. From the formant tracks, vowel targets were identified manually. The target is understood to be the section of the vowel least influenced by the surrounding phonetic context, and the /hVd/ context is particularly suited to eliciting vowels with minimal effects of coarticulation, based on Lindblom (1963) and Lehiste and Peterson (1961).[6] Because vowel realizations can vary widely depending on the phonetic environment of the vowel, these results should not be taken to reflect the range of possibilities for Australian vowels; certainly, in some phonetic contexts, the vowels may have very different characteristics and also reveal differing regional tendencies, particularly in a pre-lateral environment (e.g. Loakes *et al.* 2010).

The monophthongs /iː, ɪ, e, æ, ɐː, ɐ, ɔ, oː, ʉː, ʊ, ɜː/ in the words HEED, HID, HEAD, HAD, HARD, HUD, HOD, HORDE, WHO'D, HOOD and HEARD were taken to have a single target. The vowels /ɪə, eː/ in the words HEARED and HAIRED were also analyzed as

[5] Tokens in which the word was produced incorrectly were excluded from the study, but overall the speakers were quite consistent. Five tokens (all from females) were excluded, primarily due to speakers misreading HEARED as HEARD, as well as one instance of a speaker inserting a post-vocalic /r/ in HEARED and another instance of the same in HORDE. It is acknowledged that the data in this study cannot be held to represent natural speech processes, due to the artificial stimuli and the relative formality of citation-style speech, but this is a useful starting point for comparative studies in this area.

[6] Lindblom (1963) found that the vowel target was an invariable attribute of a vowel because the central formant frequencies of stressed vowels in a CVC context were not phonetically influenced by circumscribing consonants /b, d, g/. Lehiste and Peterson (1961) found that the fundamental frequency, or pitch, of a vowel was reached soonest after a voiceless fricative such as /h/. The Cox (2006), Bernard (1970) and Butcher (2006) data are all from /hVd/ vowels.

monophthongs following findings that these vowels are best considered long monophthongs in the /hVd/ phonetic environment, with HAIRED showing no formant trajectory differences to the short vowel in HEAD, and HEARED only slightly more than in the short vowel HID (Cox 2006). This appeared to be consistent with the present group of Melbourne speakers.

Formant frequencies representing these targets were taken at a single point in the steady state of the monophthong, where there was the least evidence of change in the formants. Frequency values at these identified targets were extracted for the first and second formants. In the absence of an unquestionably steady state, the vowel target was identified using maximum and minimum formant values in the place of least formant change to estimate the target. Following Cox (2006), the maximum F2 combined with the minimum F1 were used for high front vowels, the minimum value of both F1 and F2 for high back vowels, and the maximum F1 was used for low vowels, and for low vowels change in F2 did not prove to be an issue. Formant frequency values were compiled for males and females respectively,[7] and the mean frequency values and standard deviations for each vowel were calculated.

Formant plots were then created for the Melbourne data based on the mean F1 and F2 values for vowel targets, using the established method of plotting F2 values on the *x*-axis and F1 values on the *y*-axis. Given that the F1 and F2 values are inversely proportional to the auditory qualities of height and frontness, reversing the scales on the axes means the resulting plots approximate the articulatory parameters represented by the cardinal vowel chart (Ladefoged 2006: 188). The features of the Melbourne formant plots are not discussed here, but the mean formant frequency values and standard deviations for Melbourne male and female adolescents can be found in the Appendix Tables A1 and A2. The mean formant values for the Melbourne data were compiled with /hVd/ data from recent studies by Cox (2006) in Sydney, Butcher (2006) in Adelaide, and older New South Wales data from Bernard (1970), and were represented as various formant plots for the purposes of comparison. Table 2 gives the abbreviations used to refer to each data set, as well as the relevant details for each set.

Comparisons were made of the mean formant frequencies for each vowel target for each of the following combinations of data sets: MF & SF, MM & SM, MM, SM & BM, MF, SF & AF.[8] For the MM/MF and SM/SF data, statistical tests were used to test whether observed differences could be taken to be outside of random variation. Pairwise comparisons for these data were tested with two-tailed *t*-tests to determine the statistical significance of differences, using the grouping (by state and gender) as the independent variable and the mean vowel target formant frequency for F1 and F2

[7] Male and female formant data cannot be compared directly because physiological differences affect the formant frequencies of vowels for each gender. Females typically have shorter vocal tracts than males and produce higher average formant frequencies (Fant 1960).

[8] Before data sets could be compared, differences between the phonemic symbols used in different studies needed to be established. Appendix Table A3 presents the IPA symbols used to represent Australian vowels in each of the studies discussed, and how they relate to those used in the present study.

Table 2 Showing the abbreviation used to refer to each data set, as well as the state of origin, gender, average age and reference for each set

Abbreviation	State	Gender	Average age	Reference
MF	Victoria (Melbourne)	Female	16	Present study
MM	Victoria (Melbourne)	Male	17	Present study
SF	New South Wales (Sydney)	Female	15	Cox (2006)
SM	New South Wales (Sydney)	Male	15	Cox (2006)
BM	New South Wales	Male	Unspecified; high school students, tertiary students and university staff	Bernard (1970)
AF	South Australia (Adelaide)	Female	22	Butcher (2006)

of each vowel as the dependent variable (using GraphPad QuickCalcs software 2002). Unfortunately, standard deviations were not available for the AF data nor the BM data, so it was not possible to carry out statistical tests on differences between these data sets and sets MM, MF, SM and SF.[9] Thus, discussion of features in the AF and BM data sets is based on careful observation but not supported statistically. However, many differences were substantial and highly likely to be statistically significant if testing were possible, and thus these have been focused on, and slight differences have not been given undue emphasis. It is important to note that while the age groups are similar for these data sets, there remains the possibility that there could be an effect due to vocal tract size, particularly in the case of the AF and BM data. The potentially larger physical size of some participants, which typically incorporates larger vocal tracts, could lead to differing vowel realizations. Larger vocal tracts generate lower F1 and F2 frequencies (Borden *et al.* 1994), which correlate with more raised and retracted vowels. Given that the participants are all young, even a year or two may generate notable physical differences due to the rapid growth experienced during youth. This will be addressed in Section 5.

3. Melbourne Male and Female Vowels Compared with Sydney Male and Female Vowels

The formant plots for monophthongs are presented in Figures 1 and 2, and the complete statistical results for these comparisons are presented in Appendix Tables A4 and A5. A summary of the statistically significant differences is presented in Table 3.

3.1. Heed

For the high monophthongs, HEED differs for both Melbourne groups compared to the Sydney groups; the vowel is significantly lower for MM ($p \leq 0.05$) and

[9] Cox (1999) has previously discussed statistically significant differences between the Bernard (1970) data and Sydney data collected in the 1990s, and found indications of vowel change based on these.

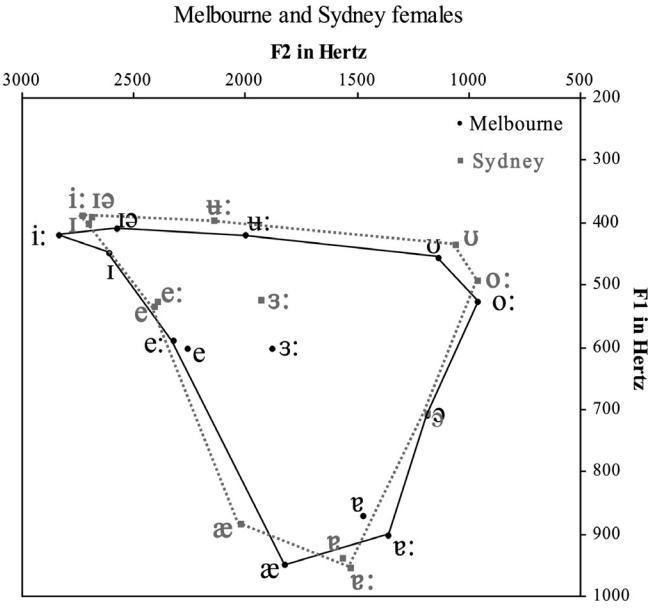

Figure 1 Formant plot showing the monophthong targets for Melbourne and Sydney females, based on the present data for Melbourne, and Sydney data from Cox (2006)

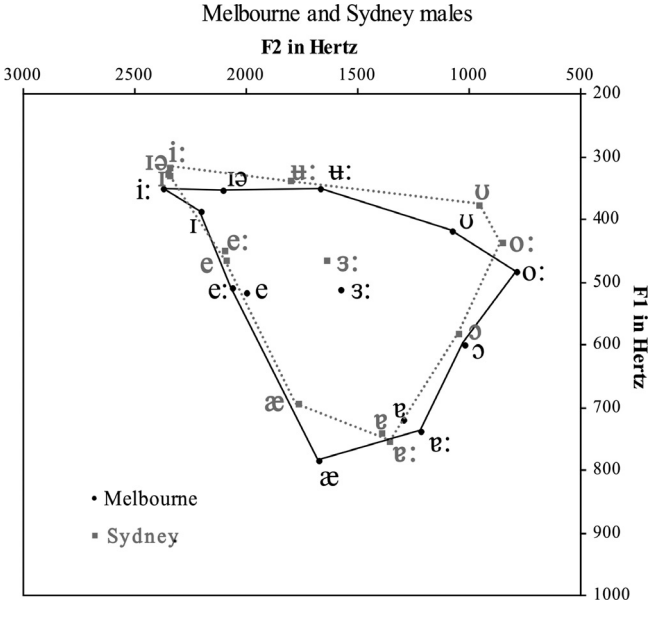

Figure 2 Formant plot showing the monophthong targets for Melbourne and Sydney males, based on the present data for Melbourne, and Sydney data from Cox (2006)

Table 3 Summary of the statistically significant differences between Melbourne and Sydney females and Melbourne and Sydney males

Melbourne vowels, compared to Sydney vowels		
Vowel	Females	Males
HEED	lowered fronted	lowered
HID	lowered	lowered retracted
HEAD	lowered retracted	lowered
HAD	lowered retracted	lowered retracted
HARD	retracted	retracted
HUD	raised retracted	retracted
HOD		
HORDE		lowered
WHO'D	retracted	retracted
HOOD	fronted	lowered fronted
HEARD	lowered	lowered
HEARED	retracted	retracted
HAIRED	lowered	lowered

significantly lower for MF ($p < 0.05$), and also significantly fronter for MF ($p < 0.05$). Fricker (2007) similarly found that Melbourne males had a lower target for this vowel than Sydney males. The findings for females support Cox and Palethorpe's (2003) observation that females from a school in Wangaratta, Victoria, had a notably more fronted HEED than that found for the females from the New South Wales schools across the border. The significant lowering of the vowel for Melbourne speakers can be posited as a regional characteristic because HEED has not been noted as raising or lowering in studies on vowel shifting; in the front–back dimension the situation is more complex, as will be discussed in the next section.

3.2. Hid, Heared

The high-front vowels HEED, HID and HEARED are closely clustered in the Sydney data, but more spread out for Melbourne speakers; HEARED is significantly more retracted for both MF ($p < 0.05$) and MM ($p < 0.001$) than for Sydney speakers, while HID is substantially lower for both MF ($p \leq 0.001$) and MM ($p \leq 0.001$), and also significantly more retracted for MM ($p \leq 0.05$). Fricker (2007) also noted a lower HID target for Melbourne speakers of the General accent when compared to Sydney speakers. Bradley's (1989) impressionistic observation that HID is more retracted for Sydney, particularly when compared to Melbourne, is not supported by these findings.

3.3. Head, Haired, Heard

Bradley (1989) also suggested that the near-high front vowel in HEAD was rising, a process that was more advanced in Melbourne, but this was likewise unsupported in the present study. The short HEAD vowel is lower and somewhat more retracted for both MM and MF speakers compared to Sydney speakers. For MF, the lowering is significant ($p \leq 0.001$), as is the retraction ($p \leq 0.01$), while for MM, the lowering is significant ($p \leq 0.01$) but the retraction does not quite reach significance ($p = 0.1107$). The HEAD vowel's long counterpart HAIRED is similarly lower for both MF ($p \leq 0.01$) and MM ($p \leq 0.001$). HEARD is lower for Melbourne speakers as well, significant for both MF ($p \leq 0.001$) and MM ($p \leq 0.01$). This suggests an emerging pattern of lower vowel realizations in Melbourne when compared to Sydney.

3.4. Who'd

The high-central vowel WHO'D is less fronted for Melbourne speakers than its Sydney counterpart. This is significant for both MF ($p \leq 0.01$), and for MM ($p \leq 0.01$). This is consistent with previous findings; Oasa (1989) observed that this vowel was less fronted for male and female speakers from Victoria than those in New South Wales, and Cox and Palethorpe (2003) found that this was also the case amongst the female speakers they studied. Fricker (2007) also found that WHO'D was less fronted for male and female speakers of the General and Cultivated varieties of Australian English, though this did not quite reach significance levels for females. Overall, it seems that the less fronted WHO'D vowel is likely to be a regional feature of Melbourne vowels, evident in both male and female speakers.

3.5. Hood, Horde

High-back vowels display even more conspicuous differences between Melbourne and Sydney speakers, particularly for males. HOOD is significantly more fronted for MF ($p \leq 0.05$), and somewhat lowered, although this does not quite reach significance

($p = 0.1001$). For MM, HOOD is not only significantly fronted ($p \leq 0.01$), but significantly lowered as well ($p \leq 0.05$), clearly visible on the formant plot. Cox and Palethorpe (2003) similarly found that Victorian speakers had a more fronted HOOD vowel than New South Wales speakers, though their study involved only females. The fronting of HOOD may then be a consistent regional characteristic for Melbourne/Victorian speakers. The lowering of HOOD could also be tentatively posited as a characteristic of Melbourne vowels, given the emerging tendency towards lower vowel realizations in Melbourne. For this vowel the lowering is much more pronounced for MM than for MF. For HORDE, the vowel for MF is slightly lower than for SF, though this does not quite reach significance ($p = 0.0718$), and for MM the lowering is significant ($p \leq 0.05$), and some retraction is noted but just outside defined significance levels ($p = 0.0735$). Thus, as for HOOD, the lowering of HORDE is more apparent for MM than MF, and perhaps regional characteristics of lower Melbourne vowels are more apparent in male speakers than female speakers.

3.6. Had

The low monophthongs contain the most telling evidence of regional variation between Melbourne and Sydney. The low-front HAD vowel is significantly lower and more retracted for MM and MF. The lowering is particularly substantial for MM ($p \leq 0.001$), combined with a degree of retraction ($p \leq 0.05$), while the lowering is still significant but less substantial for MF ($p \leq 0.05$), but coupled with considerable retraction ($p \leq 0.001$). The vast height difference between HAD for MM and SM is especially revealing. Male vowel spaces are typically less vertically 'stretched out' than those of females due to males having larger vocal tracts (Fant 1960); if the degree of difference between the states was consistent between the genders, the gap between the plotted HAD vowels for the females should be greater than or at least equivalent to the gap between HAD for the males. This is not the case, and may indicate that the lower realization of HAD is a characteristic of Melbourne vowels exhibited to a greater extent by the males. The retraction is exhibited more by MF, but this does not fall into any gender pattern the way lowering seems to for MM. Lowered and retracted HAD has previously been attested as a characteristic of Melbourne vowels in a study of female speakers (Cox & Palethorpe 2003), and the present study clearly shows that lowered and retracted HAD exists for both genders in Melbourne.

3.7. Hud, Hard

The realization of HAD appears to be related to the realizations of the neighbouring near-low central vowels HUD and HARD, short and long vowels respectively. For MM and MF, HUD and HARD are *higher* and more retracted than the Melbourne HAD vowel, and as the formant plots show, for SM and SF HUD and HARD are *lower* and more retracted than the Sydney HAD vowel. This illustrates the vowels for each state maintaining maximal contrast between phonemes (Liljencrants & Lindblom 1972).

Because HAD is so low in Melbourne, HUD and HARD are differentiated by being higher, and because HAD is higher in Sydney, Sydney HUD and HARD have the option of being distinguished by lowering. Thus HUD and HARD are higher for MF than for SF, significantly so for HUD ($p \leq 0.05$), and almost reaching significance for HARD ($p = 0.0789$). For MM and SM, the differences in height do not quite reach significance. The Melbourne HUD/HARD pair must also maintain enough retraction to be distinct from Melbourne HAD, and given that HAD is already more retracted for Melbourne than Sydney, HUD and HARD are likewise more retracted for Melbourne. Retraction is significant for HUD for MF ($p \leq 0.01$) and MM ($p \leq 0.01$), and likewise significant for HARD for both MF ($p \leq 0.001$) and MM ($p \leq 0.001$).

4. Present Melbourne and Sydney Male Vowels and Past New South Wales Male Vowels

The formant plot comparing the monophthongs for these data sets is presented in Figure 3.

4.1. Heed, Hid, Heared

HEED, HID and HEARED are closely clustered for SM, more so than for both BM and MM, but the BM and SM data are clearly more similar to each other than to the MM

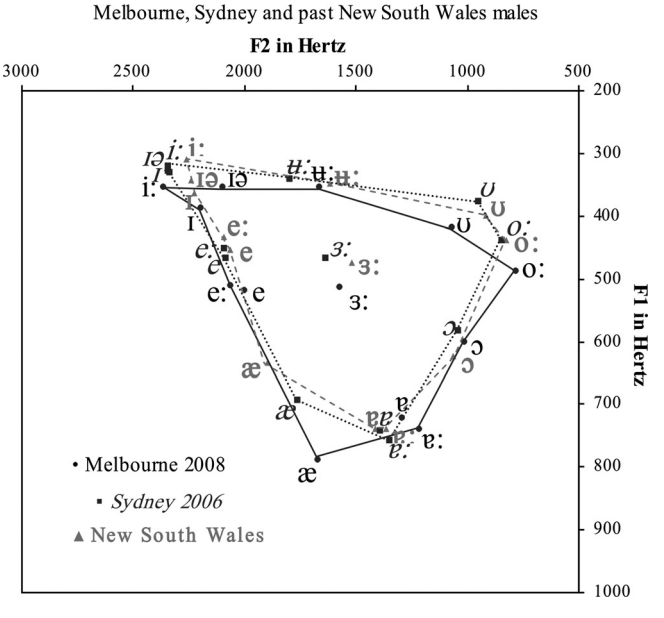

Figure 3 Formant plot showing current monophthong targets for males from Melbourne (present study), Sydney (Cox 2006), with past monophthong targets for males from New South Wales (Bernard 1970)

data for these vowels and most of the other monophthongs. HEED has clearly fronted from the time of Bernard's study to the recent Sydney study, as noted for females in Cox and Palethorpe's (2001) study. However, the vowel is most fronted for MM out of the three groups, a feature which was previously mentioned as a possible regional characteristic, and the MM vowel is also markedly lower than for both SM and BM. HEED has shown evidence of fronting associated with vowel change amongst New South Wales females, but not yet males (Cox & Palethorpe 2001). Given that in the previous section, MF had a more fronted HEED than MM, it is possible that the fronting of HEED is in progress for females in both states, but that it is either more advanced amongst Melbourne females than Sydney females, or that the more fronted Melbourne vowel is associated with regional distinctions along with lowering.

Cox (1999) noted innovative raising of HID for New South Wales speakers that is supported in the present comparison, which also indicates fronting. The MM vowel is markedly lower than for the SM and BM groups. It is a similar case for HEARED, which has been noted as showing a process of raising and fronting (Cox 1999) that is reinforced by the BM and SM data in the present comparison. MM HEARED is furthest back, but lower than the SM vowel and about the same height as the BM vowel. For these three vowels it would seem that Melbourne speakers maintain the tendency towards lower realizations, but no clear insight into possible vowel shifting in Melbourne can be gained here.

4.2. Head, Haired

The HEAD vowel has not received comment regarding possible change, beyond Bradley's (1989) auditory-based suggestion that it may be raising, which has been refuted by opposing evidence found using acoustic analysis (Cox 1999). The SM and BM short and long vowels HEAD and HAIRED are very close to each other on the plot, while the MM HEAD and HAIRED vowels are substantially lower. Compared to other vowels, HEAD and HAIRED have a degree of stability given the lack of noted change over time, and thus the lowering in Melbourne can best be considered as a regional distinction.

4.3. Heard

HEARD exemplifies the vowel space tendencies for each of the three groups in this comparison. The MM vowel maintains the tendency towards lower realizations in comparison to both groups. The SM vowel has a much more fronted nature than the BM vowel, with the MM vowel falling in between the two in the front/back dimension. Cox (1999) noted innovative fronting for this vowel which is evident in the difference between SM and BM. If the Melbourne retraction of this vowel is assumed to be a pre-existing regional tendency, we can speculate that comparable 1970s data for Melbourne may show HEARD to be both lower *and* further back than the BM vowel, potentially having also fronted over time, while incorporating regional

retraction. Without evidence this cannot be said with any certainty, but demonstrates that it is not practical to rely on earlier data from a different state when assessing change in Melbourne.

4.4. Who'd

The SM WHO'D vowel is the highest and most fronted of all three, while the MM vowel is notably less fronted and the BM vowel falls just behind this. Cox (1999) has noted innovative raising and fronting of this vowel, but it is interesting that while a more retracted Melbourne WHO'D vowel can be interpreted as a regional characteristic, as previously mentioned, in this comparison it is the BM vowel that is the most retracted. This suggests two possibilities: firstly, that WHO'D in Melbourne is following Sydney in a shift, which sustains a regional retraction, or secondly that the Melbourne vowel has not moved at all, and the New South Wales vowel has fronted so much that it has surpassed the Melbourne vowel and created a regional distinction of retraction that did not previously exist. These possibilities will be discussed further in the next section.

4.5. Hood

For HOOD, the SM vowel is slightly fronter and higher than the BM vowel. This supports Cox and Palethorpe's (2001) observation, based on male data from 1996, that this vowel is raising, and it was also indicated by Cox and Palethorpe (2001) that, at least for females, this vowel is fronting. For MM there is little indication of this shift, given the much lower and already more fronted nature of the vowel. However, it should be noted that in Cox and Palethorpe's study of females (2003) they found that the HOOD vowel was only *fronter* for Melbourne females compared to Sydney females, and did not note height differences for HOOD as a possible regional distinction amongst females. The present Melbourne data in Figure 1 shows that MF have a HOOD vowel that is close in height to that of SF, whereas in Figure 2 the HOOD vowel for MM is vastly lower than that of SM. It would seem, then, that the MF are more innovative than MM based on the raised nature of HOOD for MF and its association with vowel shifting. MM maintain a lower, fronted HOOD vowel which may be evidence of their potential lag in vowel shifting, or greater retention of the tendency towards lower vowels which seem to be regionally characteristic.

4.6. Horde

The HORDE vowel is virtually the same for the SM and BM data, and like HEAD, no comment has been made in the literature about innovative changes to this vowel. However, the MM equivalent is substantially lower and somewhat more retracted than both, reinforcing the suggestion in the previous section that the height difference for this vowel is purely regional.

4.7. Hod

For HOD, the SM vowel is clearly higher than the BM vowel, in accordance with Cox's (1999) observation of raising, while the MM vowel falls between them on the *x*-axis and displays slight retraction.

4.8. Had, Hard, Hud

The BM HAD vowel is clearly the highest and most fronted, and it has been established by Cox (1999) and Cox and Palethorpe (2001) in studies in New South Wales that this vowel is progressively lowering and retracting. However, the MM vowel remains the most retracted and by far the lowest, and given that this has consistently been established as a regional marker, its location cannot be interpreted as part of a vowel shift, though it may encompass change that has concurrently kept it regionally distinctive. It is possible that the change in Sydney HAD has effected changes in the HARD vowel, or vice versa; like the lower, retracted HAD, SM HARD is lower and slightly more retracted than the BM equivalent, previously noted by Cox and Palethorpe (2001). More detailed research into how the Sydney vowel space has changed over time would reveal whether the changes in these vowels are connected, and to what extent the vowel shift is operating systematically to maintain phonemic distinctions.

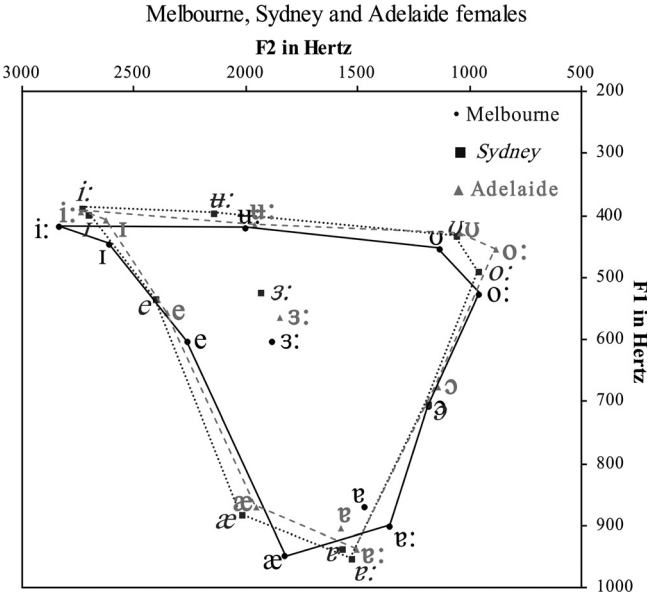

Figure 4 Formant plot showing the monophthong targets for Melbourne (present study), Sydney (Cox 2006) and Adelaide (Butcher 2006) females

5. Melbourne, Sydney and Adelaide Female Vowels

Formant plots for monophthongs in this comparison are presented in Figure 4.

5.1. Heed, Hid

For the high monophthongs, HEED is very similar for AF and SF, leaving the MF vowel outlying to the left of the plot. For HID, however, the AF vowel is as retracted as the MF vowel, though noticeably higher. The SF variant is as high as for AF and much less retracted.

5.2. Head, Heard

For HEAD, AF have a lower realization than SF, as noted by Butcher (2006), but the MF vowel remains the lowest and most retracted of the three. The pattern is similar for HEARD, where the SF vowel is highest, followed by a lower and more retracted AF vowel, and with the MF vowel exhibiting the most lowering, though less retraction than AF. Butcher suggests the possibility that HEARD may be more conservative in Adelaide than in Sydney, with regard to the fronting found for this vowel by Cox (1999), and perhaps the Melbourne vowel falls somewhere between the other two states in the degree of innovation, or perhaps it is too difficult to separate signs of innovation from regional characteristics.[10]

5.3. Who'd

Similarly, Butcher (2006) suggested that WHO'D may be more conservative in Adelaide; WHO'D was noted as fronting by Cox (1999), and the current comparison reveals the SF vowel to be the most fronted, followed by MF, with AF just behind. However, Butcher notes that the Adelaide vowel has 'moved considerably further forward' (2006: 450) since Oasa's (1989) acoustic study. Oasa noted then that Adelaide and Melbourne had significantly more retracted WHO'D vowels than those found in Sydney and Brisbane, and it is possible then that for all states this vowel has fronted, and yet maintained regional distinctions. Cox and Palethorpe (2003) found that WHO'D was less fronted for Victorian speakers than for New South Wales speakers, but they also noted that the F2 values were higher for Victoria and New South Wales than for both states in Oasa's study, indicating that a degree of fronting had occurred in the elapsed time for each state. Figure 5 compares the WHO'D vowel by plotting earlier data from Oasa (1989)[11] for Melbourne, Sydney and Adelaide

[10] It is possible that any regional generalizations made in this comparison of females' vowels may be underestimated, given that the previous sections indicate the possibility that Melbourne males show regional vowel characteristics more distinctly than females, and current sociolinguistic knowledge holds that males tend towards more localized phonetic variants (Chambers 1995).

[11] For this vowel, Oasa (1989) used the word BOOT to elicit the /ʉː/ monophthong in the consonant–vowel–consonant phonetic environment, whereas the current studies have used WHO'D. This difference should not significantly affect formant values, particularly since this comparison only involves vowel targets.

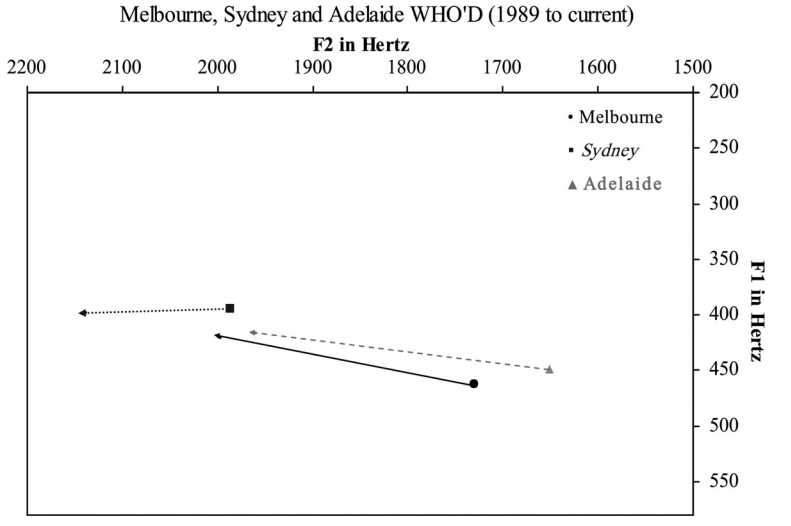

Figure 5 Formant plot showing the monophthong WHO'D for Melbourne (present study), Sydney Cox (2006) and Adelaide (Butcher 2006) females, comparing current data Oasa data from (1989) for each state

against the recent data for this vowel in the MF, SF and AF data sets. The plot clearly shows that for each of the states, WHO'D has fronted since 1989, but maintained the distinctions already present between the regions in 1989 for this vowel. Thus the distribution in 1989 has the Adelaide vowel as the most retracted, with the Melbourne vowel slightly fronter, and the Sydney vowel the most fronted. The current data maintain this distribution while incorporating fronting for each state. The forward movement in the Melbourne vowel was significant ($p \leq 0.001$), and it was also significant for the Sydney vowel ($p \leq 0.01$). Significance could not be tested for the Adelaide vowel realizations, but the movement between mean F2 values is visibly greater than for the other two states. The movement of WHO'D is probably one of the most concrete examples of Australian vowel shifting available, given that real-time data are available for three states for comparison of this particular vowel and yield undeniable evidence of change. It is concurrently one of the most concrete examples of regional vowel differences, given that even though change has occurred for each state, regional distinctions for WHO'D have been preserved. While it is difficult in this study to make strong claims about patterns in the more recent data, given that it is collected by different researchers and may incorporate different methods of identifying vowel targets as well as physiological differences between subjects, the fact that the distribution of the current vowels mirrors that of Oasa's (1989) data, with added fronting, is very encouraging. Oasa's data were collected from subjects who were all adults and thus physiologically similar, and presumably consistently measured and analyzed, so this result for WHO'D, of steady change balanced with regional distributional differences, is especially valid.

5.4. Had, Hud, Hard, Hod

For the lower vowels, HAD, HUD and HARD are more closely related for AF and SF; MF maintain the marked variation in these vowels when compared with AF. However, these three vowels are all slightly higher for AF than for SF, and HAD is slightly more retracted, in line with Butcher's (2006) observation of a tendency towards higher vowel articulations amongst Adelaide females compared to Sydney females. This is the same for HOD, for which the MF and SF vowels are virtually identical, while the AF vowel remains distinctively higher. As noted in Section 2.3, it is possible that there are effects of vocal tract size to be considered here. Given that the Adelaide females are older than the Melbourne and Sydney females used in this comparison, it is possible that their vocal tracts are physically larger, which would lead to lower F1 and F2 frequencies. The Adelaide speakers have the most raised vowels, as well as more retracted vowels than Sydney and sometimes Melbourne, which could be an indication that vocal tract size is a factor in the observed differences. However, the Melbourne speakers, the next oldest group, have the lowest vowels, and although they display retraction compared to Sydney, the lowering contradicts the typical effect of larger vocal tracts. Considering the supporting evidence for particular regional vowel realizations in other studies, it is likely that vowel differences between these states, as observed here, are not chiefly artefacts of physical size, but that it is certainly something that will need to be accounted for in future research.

5.5. Horde, Hood

HORDE is substantially higher for AF than for MF and SF, again paralleling the tendencies in F1 values that seem to be emerging; Adelaide showing a more raised vowel than Sydney, and Sydney a more raised vowel than Melbourne. The AF vowel is also substantially more retracted than for the other two states. For HOOD, however, AF and SF have virtually the same vowel realization, and it is the vowel for MF that stands out; in this case it is lower and more fronted, features which have been discussed above as potential regional characteristics for this vowel in Melbourne.

6. Discussion

6.1. First Hypothesis: The Presence of Regional Vowel Characteristics

The formant plots comparing Melbourne and Sydney vowels for both genders and comparing Melbourne, Sydney and Adelaide vowels for females clearly show that each state has a unique vowel space. The main differences are at the extremities of the vowel space, but there are differences to some extent for virtually every vowel. Melbourne monophthongs are distinguished from Sydney monophthongs by lower and fronted HEED, lower and retracted HEARED, retracted WHO'D, lower and fronted HOOD, lower and retracted HID, lower HEAD, HAIRED and HEARD, retracted HUD/HARD and, most saliently, lower and more retracted HAD. These differences are present to

different extents amongst males and females respectively in Melbourne. Lower and more retracted HAD also holds as a feature distinguishing Melbourne vowels from Adelaide vowels, and is thus probably the main marker of Melbourne vowels. In the data at hand, Melbourne vowels appear to be generally lower than Adelaide vowels, and often have a similar degree of retraction, as for HID, HEARD and HOD. Compared to Adelaide, Melbourne vowels also maintain the more fronted HEED, and lower and more fronted HOOD, and furthermore have a lower and more fronted HORDE, as well as higher and more retracted HUD and HARD. However, it is essential to note the possibility that vocal tract size may have a significant role in producing these differences. Without firsthand knowledge of the participants of the other studies used in the comparison, it is difficult to estimate how likely this may be and, if they (particularly the Adelaide speakers) did have larger vocal tracts, the extent to which this may affect the results. For future research it will be necessary to collect data from groups which are highly comparable physiologically, or use some normalization techniques to ensure that vowel spaces are being analysed on a strictly comparable scale. This is a difficult thing to test, and possibly best suited to larger samples than were used to collect data for this study, given the concurrent possibility that normalization can potentially also obscure some genuine sociolinguistic differences.

Beyond the possibility of vocal tract differences, it is very difficult to gauge to what extent the observed differences are purely regional, or how they may incorporate processes of vowel change. Some vowels in Australian English, such as HEAD and HORDE, appear to be somewhat 'stable', or rather, no evidence of vowel change has been noted for these in previous research based on acoustic analysis. Despite their apparent stability, these vowels are markedly lower in Melbourne than in Sydney or Adelaide. If vowels such as these are not riding on the coat-tails of a vowel shift, then it is possible that these differences can be attributed to synchronic rather than diachronic variation. If this difference is found in future research, it would lend support to the interpretation of the lowered realizations of other vowels as a regional characteristic for Melbourne speakers. However, generalizations about patterns in the vowel space do not apply uniformly to every vowel, particularly in the aforementioned retraction apparent for some vowels. Variation along the F1 axis is easily visible, but variation along the F2 axis is less conducive to sweeping statements about regional patterns; in many instances, such as for HID, WHO'D, HEAD, HEARD and HAD, both Melbourne and Adelaide have more retracted vowels than Sydney, while for some vowels, the regional difference appears to be of fronting, as seen for HEED in Melbourne and to a lesser extent in Adelaide. For HOOD, the Melbourne vowel is fronted but in Adelaide the vowel is in virtually the same location as for Sydney on the formant plot.

Given this, one of the most credible statements regarding regional markers for Melbourne vowels is based on the vowels at the floor of the vowel space. The alignment of the vowels HAD, HUD and HARD clearly indicates a different distribution for the vowels of Melbourne English, encompassing a lowered, retracted HAD present for both male and female speakers, an attribute which seemingly urges the HUD/HARD

pair backwards and somewhat higher in the vowel space to maintain maximal contrast between phonemes. For Sydney and Adelaide, these tendencies are inverted, and the states display a more fronted, raised HAD which occurs with a more fronted, lower HUD/HARD pair. This connected arrangement of neighbouring phonemes indicates that the height features present in HAD are possibly significant enough to affect the features in the HUD/HARD pair, and is a testament to regional variation working within the parameters of the vowel space.

However, the most credible indication of regional variation is found for WHO'D, simply because it is the only vowel for which formant values from comparable studies are available for Melbourne, Sydney and Adelaide for earlier (1989) data as well as current data. Results strongly support the inferences of retraction drawn based on patterns in other Melbourne vowels; WHO'D was in 1989 the most retracted for Melbourne, followed by Adelaide, with Sydney showing the most fronted vowel. This observation is more robust because it is less likely to be significantly affected by variation in vocal tract size. Oasa's 1989 data were collected from speakers aged 18–33, so variation in vocal tract size is likely to be on a speaker-by-speaker basis rather than due to the differing physiology between adults and adolescents. The same pattern of regional retraction was present in the current data; the distinctions were preserved even in the throes of change.

6.2. Second Hypothesis: Evidence of Vowel Change

In this study, it is difficult to perceive overarching evidence of vowel change in Melbourne English. The clear differences between the current vowel spaces for Melbourne and Sydney mean that no conclusions can be drawn based on comparison of Melbourne data to earlier New South Wales data, as regional differences which are apparent now must surely have existed to some extent during the 1960s when Bernard collected data for his seminal acoustic study of Australian vowels (1967a, 1967b, 1970). Furthermore, much of the vowel innovation found by Cox (1999) and Cox and Palethorpe (2001) based on data from New South Wales involves raising and fronting, and given that many Melbourne vowels seem to be lower and more retracted than those in Sydney, it is virtually impossible to know to what extent differences are regional, or to what extent they may encompass progression or lag in vowel shifting. There is some evidence of innovative raising of HOOD for Melbourne females.

For example, some features could be interpreted as evidence of more advanced vowel shifting in Melbourne. The fronting of HEED has been identified as both a characteristic of Victorian vowels compared to New South Wales vowels, but has also been noted as a feature of vowel shifting in data from New South Wales only. Similarly, the fronting of HOOD has been posited as a feature of Victorian vowels compared to those in New South Wales, but has likewise been found as a recent innovation in New South Wales vowels. HAD is lower and more retracted in Melbourne than in Sydney, but has also clearly lowered and retracted in New South

Wales over the last 30-odd years. Thus, these features could be interpreted either as evidence of sound change in Melbourne that has progressed further than in Sydney, or instead as essentially regional differences.

To complicate matters, differences in other Melbourne vowels could be interpreted as a lag in the sound change. For example, HEARED has been noted as raising and fronting in New South Wales, and yet the Melbourne vowel is lower and more retracted than for Sydney and even than for the Bernard data. In the same way, WHO'D has been described as showing raising and fronting over time in New South Wales data, but the Melbourne vowel is somewhat lower and much more retracted than for Sydney, though in this case it is not so different from the Bernard vowel. This ostensible indication that Melbourne vowels are less advanced with regard to innovative vowel features is, however, clearly part of a more complex situation. The apparent tendency in Melbourne vowels to be lower and more retracted clashes with the interpretation of lower/retracted vowels as lagging behind in the adoption of the vowel shift. As mentioned above, the lowering and retracting tendency in Melbourne vowels is given weight because vowels that do not seem to be enmeshed in the vowel shift still manage to display significant differences between the states, but the possibility of vocal tract differences is again a complicating factor.

Nonetheless, there is one concrete example of vowel change in Melbourne English, and that is in the real-time data available for WHO'D. As mentioned, the pattern of Adelaide showing the most retracted WHO'D vowel, followed by Melbourne and then Sydney, is present in the 1989 data as well as current data. For these three states the vowel has in fact moved over time; for Adelaide, Melbourne and Sydney, WHO'D has shifted forwards relative to its previous position for each state, with the movement reaching statistical significance for Melbourne and Sydney, while significance could not be tested for Adelaide. The forward movement of this vowel has been attested as a global phenomenon affecting many different varieties of English, particularly in the southern hemisphere, establishing 'interesting sound change parallels between varieties which are geographically fairly widely apart' (Schneider 2004: 1117). The fronting demonstrated in the present study is consistent with that found by Cox (1999) based on New South Wales data for WHO'D, and the fact that the vowel has moved forward for each state exemplifies that the vowel change in progress in Australian English is present in at least these three states. Moreover, this is positive evidence that even in the midst of a vowel shift, regional affiliation is important and the resulting vowel at a given point in time will encompass a negotiation of both innovative and regional characteristics for Australian states.

6.3. Third Hypothesis: Gender Differences in Regional Characteristics and Vowel Change

Sets of both male and female data for a state were only available in the comparison of Melbourne and Sydney vowels, but there is variation present between the males and females from these states which indicates that gender plays a role in the way speakers orient to regional characteristics and innovative forms. The presence of regional

characteristics has been suggested for some vowels, but often these characteristics are not uniformly distributed between the males and females from the same state. However, because vocal tract differences prohibit direct comparison of male and female formant frequencies, in the present study these differences have been explored based on comparisons between Melbourne and Sydney females and Melbourne and Sydney males, respectively. Observation based on these comparisons still offers insight into whether particular types of variation are present consistently for both genders in Melbourne, and the different degrees of variation can be observed based on whether vowel realizations for females in Melbourne are more closely related to the vowels of females in Sydney than the vowels for Melbourne males are to the vowels of Sydney males, or whether they are more different. Greater differences imply more pronounced regional variation between the two states for a given gender.

The monophthongs HEED, HID, HEAD, HAIRED, HEARD, HOOD, HORDE and HAD have lower realizations in Melbourne than in Sydney, which has been discussed as part of a possible general pattern of lower vowels in the Melbourne vowel space. Of these monophthongs, the lowering in HEED, HID, HEAD, HAIRED and HAD is more pronounced amongst the Melbourne males than the females, often very substantially, and for HOOD and HORDE it is only the males who show lowering to a level of significance, and again it is by a substantial amount.

The situation is even more complicated in the front/back dimension of the Melbourne vowels, because the different distribution of the Melbourne vowel space means that some vowels are regionally distinct by being fronter, while others are more retracted. Some vowels display retraction for both genders, such as HEARED, WHO'D, HAD, HUD and HARD. Of these, HEARED is more retracted for males, and furthermore HID is retracted for males alone. HID has not been noted as changing, so perhaps this could be regional retraction preferred by the males; then again, HEARED has been noted as fronting, and we cannot tell whether Melbourne males show regional retraction or a lag in vowel change. Females show significant retraction for HEAD which has not been noted as part of a vowel shift, so perhaps this is regional retraction shown by females; on the other hand, females show more retraction for HAD than males, and given that retraction of HAD is a progressive change that has been noted, perhaps females are actually more open to innovation than regional ties. The case is similar for the fronting of HEED, which is evident for both genders in Melbourne but much more so for females, but uninterpretable because fronting of this vowel has likewise been noted as both a regional trend as well as an innovation. This illustrates the complexity of the situation in Australian vowels, and that differences are not manifested uniformly between the genders and cannot always be neatly assigned to male or female tendencies. With the data available and the overt presence of regional vowel characteristics, the degree of vowel innovation for males and females respectively cannot be examined in any great detail.

The more conspicuous lowering of vowels for Melbourne males than females is the strongest testament to gender differences in regional affiliation; when compared to Sydney, the Melbourne data indicate that males may tend towards more localized

vowel characteristics, while females' vowel characteristics may surpass the emphasis on state affiliation to an extent, and tend towards more supra-local features. Research in language change and sociolinguistics has found that females frequently lead in the adoption and spread of sound change, while males are more likely to maintain phonetic features that are regionally significant. If this holds true for the present study, we can speculate that Melbourne females are showing a greater preference for features which are closer to the vowels of Sydney females than Melbourne males are for the vowels of Sydney males, and thus that males are expressing regional identity more profoundly than females. If the females are less concerned with state affiliation, it is possible that they are more likely to display evidence of vowel innovation, and there is some suggestion of this is the more raised HOOD for Melbourne females relative to Melbourne males. Overall, however, this is speculation which cannot be supported by the results at hand. While this study has analysed speakers from a relatively homogenous social group, there are also signs that vowel variation between males and females within Melbourne may be influenced by social factors, such as socio-economic class (Fricker 2007; Clyne *et al.* 2005), adding another dimension for consideration in future research.

These findings demonstrate that there are no clear-cut correlations between gender and vowel innovation that can be gleaned from the present study, but that there are some signs supporting a correlation between gender and regional affiliation as signalled by vowel characteristics. Melbourne data from opposite ends of a period of time will be needed for any tangible findings of how Melbourne males and females continue to negotiate innovation and regional affiliation. For the time being, we cannot say definitively how they differ in this negotiation, only that there are differences present which require further investigation.

7. Conclusion

This study has investigated three hypotheses and some supporting evidence has been found for each of them, but further research will be needed to give weight to speculations made based on the current data. There is evidence for regional differences between the vowels of the different Australian states discussed, and knowledge from other regions of Australia will continue to develop the picture of vowel variation across the country. It is clear that regional differences need to be investigated using groups of speakers which are highly comparable in terms of their background and physiology, to control for possible influences from not just social factors but also vocal tract size. The overt presence and nature of unique vowel characteristics in Melbourne has meant that comparison with previous data from New South Wales cannot be used to measure vowel innovation in Melbourne, but some concrete examples of change have been found for individual vowels, particularly for WHO'D. Vowel shifting in Melbourne will need to be assessed using Melbourne-only data; the formant data provided in this paper may be of use in future studies, but it would be most useful to conduct a study utilizing audio recordings spanning several decades. Some signs of gender differences

were found for Melbourne adolescents which indicate support for general trends in phonetic variation and change; males displayed more evidence of regional vowel characteristics, while females tended towards supra-local features which were at times indicative of innovation. However, these claims will require more targeted and thorough exploration if they are to be accepted. While this study has contributed to a gap in the current knowledge on Australian vowels, it has at the same time indicated that the current realizations of Australian English vowels are part of a complex situation. More detailed acoustic analysis beyond vowel targets will offer additional insight into the nuances of vowel realizations and how they vary among speakers, and utilizing additional analytical techniques such as normalization and distance measures may help to tease out which vowel characteristics are genuine products of consistent regional variation. More comprehensive sociophonetic analysis incorporating naturalistic speech data will be required to explore the presence of variation and change in the vowels of males and females across the country.

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Appendix A:

Table A1 The means and standard deviations of F1 and F2 frequency values of the vowels of adolescent Melbourne females

Vowel	Symbol	F1 $\bar{x}$	F1 σ	F2 $\bar{x}$	F2 σ
HEED	/iː/	420	42	2,833	179
HID	/ɪ/	449	39	2,606	217
HEAD	/e/	605	42	2,256	179
HAD	/æ/	951	85	1,821	96
HARD	/ɐː/	903	92	1,355	102
HUD	/ɐ/	872	94	1,468	84
HOD	/ɔ/	710	60	1,182	97
HORDE	/oː/	529	42	955	105
WHO'D	/ʉː/	421	52	1,996	165
HOOD	/ʊ/	457	37	1,132	119
HEARD	/ɜː/	605	44	1,877	101
HEARED	/ɪə/	410	49	2,575	222
HAIRED	/eː/	591	41	2,321	188

Table A2 The means and standard deviations of F1 and F2 frequency values of the vowels of adolescent Melbourne males

Vowel	Symbol	F1 $\bar{x}$	F1 σ	F2 $\bar{x}$	F2 σ
HEED	/iː/	354	31	2,364	260
HID	/ɪ/	389	35	2,197	234
HEAD	/e/	520	34	1,995	154
HAD	/æ/	788	58	1,668	119
HARD	/ɐː/	740	63	1,213	57
HUD	/ɐ/	723	66	1,290	88
HOD	/ɔ/	602	46	1,011	76
HORDE	/oː/	487	55	782	115
WHO'D	/ʉː/	354	39	1,659	129
HOOD	/ʊ/	420	30	1,069	153
HEARD	/ɜː/	514	30	1,573	111
HEARED	/ɪə/	355	37	2,095	189
HAIRED	/eː/	511	36	2,059	153

Table A3 The IPA symbols used for the vowels of Australian English by different authors whose work has been used for the purposes of comparison in the present study. Transcription conventions used in the present study follow Harrington *et al.* (1997), as do those in Cox (2006), and vowel symbols used by Butcher (2006) and Bernard (1970) have been reconciled with these where necessary, to avoid confusion

Word	The present study and Cox (2006)	Butcher (2006)	Bernard (1970)
HEED	/iː/	/i/	/i/
HID	/ɪ/	/ɪ/	/ɪ/
HEAD	/e/	/e/	/ɛ/
HAD	/æ/	/æ/	/æ/
HARD	/ɐː/	/a/	/a/
HUD	/ɐ/	/Λ/	/Λ/
HOD	/ɔ/	/ɒ/	/ɒ/
HORDE	/oː/	/ɔ/	/ɔ/
WHO'D	/ʉː/	/u/	/u/
HOOD	/ʊ/	/ʊ/	/U/
HEARD	/ɜː/	/ɜ/	/ɜ/
HEARED	/ɪə/		/ɪə/
HAIRED	/eː/		/ɛə/

Table A4 The results of the *t*-tests which were conducted to test the statistical significance of differences between mean formant values for Melbourne females and Sydney females

		F1			F2		
Vowel	Symbol	*t*	d*f*	*p*	*t*	d*f*	*p*
HEED	/iː/	2.21	71	0.0301	2.19	71	0.0319
HID	/ɪ/	3.78	71	0.0003	1.85	71	0.0688
HEAD	/e/	3.55	71	0.0007	3.13	71	0.0026
HAD	/æ/	2.25	71	0.0272	5.95	71	0.0001
HARD	/ɐː/	1.78	71	0.0789	5.32	71	0.0001
HUD	/ɐ/	2.22	71	0.0295	3.24	71	0.0018
HOD	/ɔ/	0.09	71	0.9310	0.00	71	1.0000
HORDE	/oː/	1.83	71	0.0718	0.03	71	0.9736
WHO'D	/ʉː/	1.67	71	0.0993	2.99	71	0.0038
HOOD	/ʊ/	1.67	71	0.1001	2.25	71	0.0274
HEARD	/ɜː/	3.95	71	0.0002	1.43	71	0.1567
HEARED	/ɪə/	1.41	71	0.1622	2.16	71	0.0344
HAIRED	/eː/	3.20	71	0.0021	1.45	71	0.1510

Table A5 The results of the *t*-tests which were conducted to test the statistical significance of differences between mean formant values for Melbourne males and Sydney males

		F1			F2		
Vowel	Symbol	*t*	d*f*	*p*	*t*	d*f*	*p*
HEED	/iː/	2.33	67	0.0229	0.39	67	0.6973
HID	/ɪ/	4.14	67	0.0001	2.25	67	0.0279
HEAD	/e/	3.38	67	0.0012	1.62	67	0.1107
HAD	/æ/	3.47	67	0.0009	2.22	67	0.0300
HARD	/ɐː/	0.64	67	0.5258	4.21	67	0.0001
HUD	/ɐ/	0.75	67	0.4575	2.91	67	0.0050
HOD	/ɔ/	0.83	67	0.4067	1.02	67	0.3114
HORDE	/oː/	2.40	67	0.0190	1.82	67	0.0735
WHO'D	/ʉː/	0.87	67	0.3857	2.84	67	0.0061
HOOD	/ʊ/	2.59	67	0.0117	2.98	67	0.0040
HEARD	/ɜː/	2.96	67	0.0043	1.64	67	0.1059
HEARED	/ɪə/	1.68	67	0.0971	4.45	67	0.0001
HAIRED	/eː/	3.83	67	0.0003	0.60	67	0.5483