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AN ACOUSTIC PHONETIC STUDY OF BROAD, GENERAL, AND CULTIVATED AUSTRALIAN ENGLISH VOWELS*

Jonathan Harrington, Felicity Cox and Zoe Evans

ABSTRACT

The focus of this paper is an acoustic analysis of citation-form monophthongs and diphthongs produced by a large number of male and female talkers whose accents vary from broad to general to cultivated and who were recorded as part of the Australian National Database of Spoken Language (ANDOSL). Following an initial auditory categorisation of the talkers' accents, the formants frequencies were calculated and the data were labelled for vowel target positions. Four main kinds of analysis were carried out: of monophthongs, of onglides in /i u/ vowels, of the trajectories in rising diphthongs, and of the trajectories of falling diphthongs. Consistently with earlier studies, the results show that the broad/general/cultivated accent differences are confined mostly to the rising diphthongs and to ongliding in /i/. The production of the falling diphthongs was found to be phonetically the most variable of all vowel categories. Some proposals are included for a modification to the transcription system of Australian English.

1. INTRODUCTION

Australian English can be described as a regional dialect of English spoken by non-Aboriginal people who are born in Australia, or who arrive in this country at a linguistically impressionable age, and who spend their formative years interacting with an Australian English speaking peer group (Bernard 1981; Blair 1989). It is characterised by specific vowel pronunciations, intonation patterns, lexical items, and various paralinguistic features which distinguish it from other types of English (Cochrane 1989; Clark 1989; Mitchell 1946; Mitchell and Delbridge 1965b; Wells 1982).

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The Australian accent, like all spoken dialects, exhibits a great deal of variation. To make sense of this variability, linguists have devised a system for categorising speakers into three distinct accent types, traditionally referred to as *broad, general* and *cultivated* (Mitchell and Delbridge 1965a). These categories refer to continuous sociolectal and stylistic variation along a continuum of phonetic variation and do not constitute discrete dialects. Although it has become convenient to refer to the three varieties of Australian English as separate types, they should not be considered discrete entities as they display considerable phonetic overlap.

Cultivated Australian English, at one end of the continuum of variation, most closely approximates Received Pronunciation of British English (RP), and is considered to have the most overt prestige (Horvath 1985). Cultivated is a minority form and, according to Bernard (1981), is used by about 10% of the population. Broad Australian is at the other end of the continuum and shares some vowel features with London Cockney English (Cochrane 1989). Of the three accent types, broad Australian is perceived to have the most marked Australian characteristics and has historically been the most stigmatised (Cochrane 1989; Horvath 1985). General Australian falls between these two extremes. It is spoken by the majority of the population and there is some evidence to suggest that it is the most rapidly expanding of the three accent categories (Blair 1993; Horvath 1985).

It is generally acknowledged that regional accent variation in Australia is minor and restricted to a small number of words; but there is no firm evidence that Australian vowels can be used to identify a talker's regional background. On the other hand, a talker's accent along the cultivated-broad continuum is influenced by socioeconomic factors and also by gender and age (Blair 1993; Cox 1996; Gunn 1960, 1963; Horvath 1985; Ingram 1989; Ingram and Pittam 1987).

Phonetic variation along some form of the cultivated-broad continuum has been documented for some time. The first systematic account was carried out by Mitchell (1946) who described two varieties of Australian English which he labelled *broad* and *educated* due to its approximation "to the English style commonly referred to as Educated Southern English" (Mitchell 1970). In 1965, Mitchell and Delbridge published the results from their survey of the speech of 7082 Australian school pupils. The vowels which most effectively distinguished between the speakers were /eɪ, aɪ, i, aʊ, oʊ, u/. The resultant distribution of speakers according to accent type was 34% broad, 55% general and 11% cultivated. Mitchell and Delbridge acknowledge the difficulty of assigning some speakers to one of the three categories. They did, in fact, make use of intermediate categories for those who could not be easily classified.

The first detailed acoustic phonetic study of Australian was carried out by Bernard (1967b). This was a large scale study of 171 male speakers of ustralian English. His results of formant and duration measurements from ›ectrograms showed that there was not a great deal of accent variation in onophthongs. Consistently with Mitchell and Delbridge (1965), Bernard as able to verify that the greatest variation was in the vowels /eɪ aɪ aʊ oʊ i/. reanalysis of accent effects in the Bernard data by Cox (in press) showed at a broad accent is marked by the following characteristics relative to :neral and cultivated: the greatest onglide in /i/; a fronted /ɜ/; a lowered /u/; a tracted and raised first target for /aɪ/; a retracted first target for /eɪ/; a fronted ıd raised first target for /aʊ/; a lowered first target and a lowered and fronted :cond target for /oʊ/; and a diminished offglide for /ɪə/ and /ɛə/.

The principal concern of the present study is to reconsider the acoustic ıonetic characteristics of the vowels of contemporary Australian English as ell as the basis for the differentiation of broad, general, and cultivated :cents. The data that will be used in this present study is taken isolated word onosyllabic readings of over 100 talkers in the Australian National Database : Spoken Language (ANDOSL) project (Vonwiller, Rogers, Cleirigh and ɜwis 1995; Millar, Harrington and Vonwiller in press). These materials :clude talkers that are balanced for age, gender, and accent type.

We will begin by considering the impressionistic division of talkers into ıe three accent categories based both on analyses carried out at Sydney niversity as part of ANDOSL and listening tests carried out at SHLRC, lacquarie as part of the present study. We will then examine the accent ifferences and Australian vowel characteristics in four principal sets of data: ıonophthongs, onglides in /i/ and /u/ vowels, rising diphthongs, and falling iphthongs. The acoustic parameters are in all cases the first three ıtomatically tracked, and manually corrected, formant frequencies at vowel ırget positions. In the final part of this paper, we will reassess the principal ifferences between broad, general, and cultivated Australian citation-form owels, taking into account the earlier study of Bernard (1970) and more :cent studies including Cox (1996). We will also discuss the appropriateness f the revisions to the Australian English vowel transcription system iscussed in Clark (1989).

Throughout this paper, we will continue to refer to vowels using the tandard phonemic notation as listed in e.g. *The Macquarie Dictionary* and ased on Mitchell and Delbridge (1965) for ease of vowel identification.

. METHOD

.1 *Talkers*

'he words that were analysed were taken from the isolated word materials ollected under the Australian National Database of Spoken Language ANDOSL) project (Millar et al. in press; Millar, Vonwiller, Harrington and)ermody 1994). In selecting the talkers for ANDOSL, an attempt was made to cover three age ranges (18-30 yrs, 31-45 yrs, 46+ yrs) and also to select Australian English talkers from the three major accent types i.e. broad, general, cultivated (Vonwiller et al. 1995). The talkers were also balanced for gender. A total of 264 talkers were recorded as part of the ANDOSL project of which 138 subjects were non-accented native speakers of Australian English, born in Australia and, with the exception of three subjects, of Anglo/Celtic origin (Vonwiller et al. 1995). Six of these talkers did not complete the recording sessions for the list of single word utterances, leaving 132 subjects who participated in the isolated word task. The present study is concerned with the isolated word productions from these 132 talkers.

Although accent background had been carefully taken into account in selecting the talkers for the ANDOSL project, it has been recognised in many studies that it is not a staightforward matter to classify talkers as one of broad, general, or cultivated (Bernard 1989; Bernard and Mannell 1986; Blair 1977; Delbridge 1970; Horvath 1985; Lee 1989). Furthermore, Vonwiller et al. (1995) state that "the speakers selected represent both those for whom there was no difficulty in classifying them [as one of the three accent types], and those for whom there was overlap or some difficulty in allocating them to one of the M&D [Mitchell and Delbridge 1965] categories." Therefore, we decided to reanalyse the talkers as a further check on their accent categorisation. Following Mitchell and Delbridge (1965) (see also Gunn 1963), a listening experiment was carried out based on 5 words per talker giving a total of 5 x 132 = 660 word tokens. The words were: HAY, HEED, HIGH, HOE, HOW since their nuclei are known to be strongly influenced by accent type in Australian English. Three judges (the three authors of this paper) made independent ratings of each talker on a five-point scale (1 = 'most cultivated', 5 = 'most broad').

The judges were able to listen to each talker's set of words as many times as they wished. Each talker received one rating from each judge, and when none of these ratings differed by more than one point on the scale, the subject was assigned to the accent category depending on a majority rating. For example, if the three independent ratings for a given talker were 3 3 4, then the talker's accent was rated as 3. There were only 6/132 talkers who could not be unambiguously labelled for accent type according to this procedure (this would happen either if no two judges agreed – e.g. a rating of 3 4 5 – or if a combined rating differed by more than one point – e.g. a rating of 3 3 5). These six speakers were reassessed, and a collective agreement was reached with regards to their accent type. The five groups were then collapsed as follows. Talkers rated 1 or 2 were labelled *cultivated*; those rated 3 were labelled *general*; and those rated 4 or 5 were labelled *broad*.

A comparison with the accent-categorisations originally made for the ANDOSL project showed an agreement on 62% of the talkers. For the ANDOSL project, three linguists had independently categorised the talkers as ıroad, general, or cultivated from ten sentences that included "a high ıroportion of the distinguishing characteristics of the the three types of \ustralian English" (Vonwiller et al. 1995:178) as well as a number of digits. ;ince it is possible, indeed likely (e.g. Moon and Lindblom 1994), that alkers use a more formal pronunciation style in reading isolated words which ould affect accent categorisations, we decided to reassess those talkers for vhich there was a discrepancy by carrying out the same kind of classification ın between five and ten sentences that formed part of the phonetically ıalanced materials of the ANDOSL corpus. We then made adjustments to our ıriginal classifications depending on whether the new classifications from the entences supported our original scores or the categorisation in the original \NDOSL classifications. There were therefore two cases to consider. Firstly, f there was agreement across the three judges in categorising a talker from he sentences (e.g. all three judges categorised a talker as *general*), and if that ccent label was in agreement with the ANDOSL one, the talker's accent was ccordingly reclassified (this is therefore a validation of the ANDOSL lassification). Secondly, and again only if the judges were unanimous in :ategorising a talker from the sentences, if that category label agreed with the abel from our original isolated word classifications (e.g. both our isolated vord and sentence categorisations were *general*), then our original :lassification was validated (this is therefore a divergence from the ANDOSL ıccent label). Based on these adjustments, 12 talkers were removed from urther consideration because they could not be unambiguously classified; an ıdditional 1 talker was removed who produced pre-consonantal /r/s in the :entences. The distribution of the remaining 119 talkers is shown in Table 1. Of these 119 talkers, 88% of the accent labels agree with those of ANDOSL: he principal source of disagreement concerns talkers that had been :ategorised as *cultivated* by ANDOSL and that were reclassified as *general* in he present data. The final distribution of talkers in Table 1 shows predictably hat the *general* category comprises the largest proportion of the talkers; there ıre only a small number of male cultivated subjects in this database, but as nany female cultivated speakers as there are broad.

TABLE : THE FINAL DISTRIBUTION OF TALKERS ACCORDING TO ACCENT USED IN THE PRESENT STUDY.

	broad	general	cultivated	n
male	19	27	9	55
female	15	32	17	64
n	34	59	26	119

Although we will not be considering in any detail the relationship between vowel quality and age, we present in Table 2 the subcategorisations of the three age groups according to the three accent types. Firstly, we note that a reasonably even distribution of the three age groups (18-30 years; 31-45 years; 46+ years) has been maintained: the totals are 41, 41, 37 for these three groups which include 20, 19, 16 male talkers respectively and 21, 22, 21 female talkers respectively. There is some (expected) imbalance in the distribution of accent categories by age: the most dramatic of these affects the *cultivated* talkers which form a smaller proportion of the *young* and *mid* age groups compared with that of the *old* group.

TABLE 2: THE DISTRIBUTION OF THE SAME TALKERS AS IN TABLE 1 ACCORDING TO ACCENT (*b, g, c*, are *broad, general, cultivated*) AND AGE

	young			mid			old		
	b	g	c	b	g	c	b	g	c
male	6	11	3	6	10	3	7	6	3
female	5	12	4	5	12	5	5	8	8
n	11	23	7	11	22	8	12	14	11

2.2 *Materials*

As described in Miller et al. (in press) and Vonwiller et al. (1995), the ANDOSL talkers read citation-form productions of 25 different words. For the present paper, we selected the words which had monophthongal nuclei in a /hVd/ context and those which had diphthongal nuclei in a /hV/ context (the ANDOSL materials do not have citation-form monophthongs and diphthongs in identical consonantal contexts). In addition, we also selected HOIST and TOUR words to include /ɔɪ ʊə/ nuclei which occurred in neither of these contexts.

TABLE 3: THE NUMBER OF TOKENS OF THE DIFFERENT KINDS OF NUCLEI USED IN THIS STUDY.

Tense monophthongs			Lax monophthongs		
Word	Phoneme	n	Word	Phoneme	n
HEED	i	119	HID	ɪ	119
WHO'D	u	119	HOOD	ʊ	118
HOARD	ɔ	118	HOD	ɒ	118
HARD	a	117	HUD	ʌ	119
HEARD	ɜ	117	HEAD	ɛ	118
			HAD	æ	119

Rising diphthongs			Falling diphthongs		
Word	Phoneme	n	Word	Phoneme	n
HAY	eɪ	119	HEAR	ɪə	117
HOE	oʊ	119	HAIR	ɛə	118
HOIST	ɔɪ	119	TOUR	ʊə	100
HIDE	aɪ	118			
HOW	aʊ	119			

All of the word-tokens were labelled phonetically at SHLRC by the third author of the paper using the procedures described below and in Croot, Fletcher and Harrington (1992) and approximately 25% of the tokens were checked for accuracy by the other two authors. Any words which were incorrectly produced (e.g. /hæd/ for HARD) were removed from consideration; we also rejected all TOUR words which had been produced with a monophthongal /ɔ/ nucleus (as in HOARD). The final distribution of the words that were used in this study, together with their (phonological) subcategorisations as *tense monophthong*, *lax monophthong*, *rising diphthong*, and *falling diphthong* that are used in this paper, are shown in Table 3.

2.3 *Recording, digitisation, labelling*

The subjects were all recorded in an anechoic environment at the National Acoustics Laboratories. The material was recorded in a single session, and for the isolated word lists, was presented to the subjects on a computer screen one word at a time to avoid list intonation (see Millar et al., in press for further details). The speech data was digitised at SHLRC at 20000 Hz and the first four formant centre frequencies and their bandwidths were automatically tracked using the speech signal processing package Waves using a 12th order LPC model. All automatically tracked formants were checked for accuracy and hand-corrections were made when these were considered necessary. Formant tracking errors were especially common in vowels which have F1 and F2 close together (i.e back rounded vowels such as HOARD) and they were more common in the female than in the male speech data.

The acoustic onset of the vowel was marked at the onset of voicing as shown by strong vertical striations in the spectrogram, and by the onset of periodicity in the waveform. The acoustic offset of the vowel in the /hVd/ context was marked at the closure of the [d] corresponding to a cessation of regular periodicity for the vowel and/or a substantial decrease in the amplitude of the waveform. The acoustic vowel target was marked as a single time point between the acoustic onset and offset according to the following criteria. For high front vowels, the target was marked when F2 reached a peak; for high back vowels, the target was marked when F2 reached a trough; for open vowels, the target was marked at the F1 maximum (see Harrington and Cassidy, in press for a recent summary of the acoustic basis of vowel targets). When there was no evidence for a target based on formant movement (this happened occasionally in central vowels nuclei, e.g. HERD), then other acoustic criteria were used such as the time at which the amplitude reached a maximum value. If there was no acoustic evidence of any kind for a target – which implies neither formant nor amplitude change from the acoustic onset to the offset – the target was marked at the vowel's temporal midpoint. In rising diphthongs, two targets were marked using the same sets of criteria as for the monophthongs. For the three falling diphthongs, only the first target could be reliably marked at the F2 maximum (HERE, HAIR), or the F2 minimum (TOUR).

3. RESULTS

We will discuss in this section the extent to which the three accent types, *broad*, *general*, and *cultivated* are separated in various different acoustic phonetic analyses of the vowel data. We will consider the evidence from male and female separately because to do otherwise would require some form of acoustic vowel normalisation: although normalisation techniques can effectively reduce the confusion due to speaker effects, they can also distort the phonetic contribution to the vowel space in unpredictable ways (e.g. Disner 1980) and thereby possibly obscure an important acoustic phonetic effect caused by accent differences. In the discussion of the results, we will highlight accent differences in vowels that are evident in both the male and female vowel spaces.

The analysis will proceed firstly by making some general observations from averaged data as presented in various kinds of plots which are followed by statistical analyses based on a multivariate analysis of variance (MANOVA) and *post-hoc* univariate analyses (*t*-tests) to examine the specific contribution of an acoustic parameter to accent differences. For the MANOVA, there were usually three dependent variables (the first three formant frequencies at the vowel target) and two factors (ACCENT, AGE) each consisting of three groups. The reason for including the age groups was to check on the extent to which there were interactions with the accent groups: since, for example, we have noted that there is a greater proportion of cultivated talkers in the older age group in the present database (see Table 2), an observed acoustic phonetic difference due to accent might be predictable from age effects to the extent that accent and age are correlated with each other. In fact, with the exception of one case (discussed in Section 3.2), the MANOVA showed no significant interactions between ACCENT and AGE for any vowel either from the combination of the dependent variables or in the univariate analysis: this suggests that the acoustic phonetic differences due to accent can to a large extent be considered independently of the age categorisations. Consequently, we will not consider age effects further except in the single case of interaction with accent (this is not to say that there is no relationship between age and Australian English vowel quality). In reporting a MANOVA as *significant* in the analyses below, the probability threshold $p < 0.05$ is used in all cases. We will only consider univariate analyses for those vowels which were shown to be significant in the MANOVA: the significance level for the univariate analyses is corrected to .01 to account for the possibility of an inflated Type I error rate due to multiple testing (Tabachnick and Fidell 1989).

3.1 *Monophthongs*

Figure 1 shows ellipse plots in the F1-F2 formant plane for the tense and lax vowels for male and female talkers separately in which accent and age categories are pooled. The formant values were extracted at the acoustic vowel target in all cases.

Each ellipse includes at least 95% of the tokens in each vowel category. The Figure also shows the average positions for each of the three accent categories broad, general, and cultivated. (A large separation between these three symbols within any one ellipse implies a correspondingly large distinction of accent types for that vowel). In general terms, Figure 1 suggests that monophthong targets do not vary a great deal across the three accent types. However, the Figure does show some variation due to accent differences in both male and female subjects. Firstly, /u/ has the highest mean F2 value for the broad talkers and lowest for cultivated. Secondly, there is a similar effect for /ɜ/, although the F2 differences are more pronounced for the female compared with the male talkers. Thirdly, In both /ɪ/ and /ɛ/, F2 is raised for broad talkers compared with mean F2 for general and cultivated talkers (which appear to be undifferentiated). Fourthly, again in both males and females, mean F1 for /a/ (HARD) is lowest for broad talkers. Finally, there seems to be very little accent differentiation in the back rounded vowels /ɔ ʊ ɒ/.

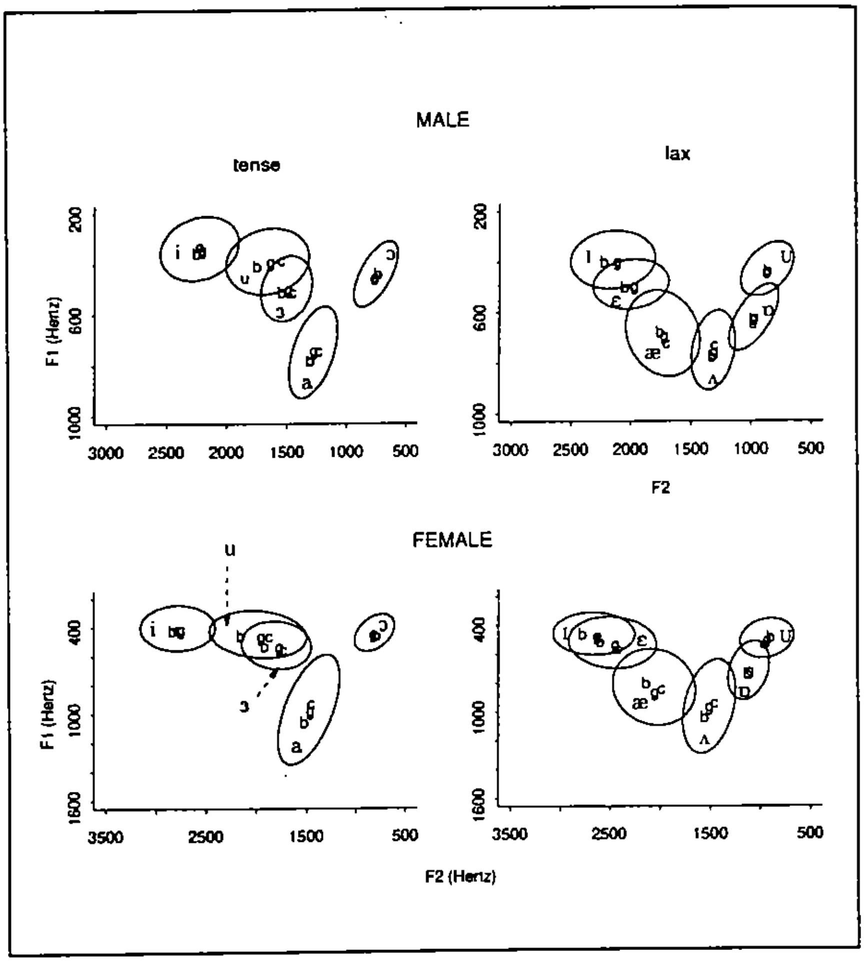

FIGURE 1: ELLIPSE PLOTS OF VOWEL TARGETS IN THE FORMANT PLANE FOR MALE (top row) AND FEMALE (bottom row) MONOPHTHONGS.

Each ellipse includes at least 95% of tokens irrespective of age or accent categories. Superimposed on each ellipse are the labels *b*, *g*, *c* which represent the mean F1 and F2 values of the *broad*, *general*, *cultivated* accent groups. The position of the phonetic symbols is simply to indicate the association of vowels to ellipses.

TABLE 4: RESULTS OF PAIRWISE ACCENT COMPARISONS ON F1-F3 AT THE VOWEL TARGET IN MALE AND FEMALE TALKERS.

MALE VOW	accent	parameter	df	F	p
u	b/c	F2	1,26	20.5	<0.01
	b/c	F3	1,26	8.4	<0.01
u	b/g	F2	1,44	9.03	<0.01

FEMALE VOW	accent	parameter	df	F	p
u	b/c	F2	1,30	19.2	<0.01
u	b/g	F2	1,45	17.9	<0.01
ɜ	b/c	F2	1,28	16.5	<0.01
ɜ	b/g	F2	1,45	15.3	<0.01
ɛ	b/g	F2	1,45	8.3	<0.01
ʊ	b/g	F3	1,45	14.0	<0.01

The pairs of accent groups on which the results were significant are shown in the second column e.g. b/c denotes a significant difference between *broad* and *cultivated*. The columns are: *vowel type*, *accent groups*, *parameter* (formant number), *degrees of freedom*, *F-ratio*, and *probability*.

The results of the statistical analyses with F1-F3 at the vowel target as the dependent variables are generally consistent with some of the observations from Figure 1. For female talkers, the MANOVA showed a main effect for accent in /u ɜ ɛ ʊ/ and in male talkers only for /u/. The subsequent univariate analyses (Table 4) which were carried out to investigate further the contribution of the individual formant parameters to the accent differences, showed that there were never any significant differences between the general and cultivated talkers. For both male and female talkers, F2 of /u/ is significantly raised in the broad group compared with either the general or cultivated groups (F3 is also raised in broad male talkers compared with F3 of cultivated talkers). In the female talkers only, F2 of /ɜ/ is raised for the broad group compared with both general and cultivated groups.

In summary, the accent differences in the formant positions of the monophthongs are confined principally to /u/ in male and female talkers and also to /ɜ/ in female talkers. A possible articulatory interpretation of these data is that broad /u ɜ/ are produced with a slightly more front tongue gesture and/or with less rounded lips since both of these articulatory differences are usually accompanied by a raising of F2 and F3 frequencies in mid and front vowels (Fant 1960; Lindblom and Sundberg 1971; Ladefoged and Bladon 1982): however, these interpretations of the acoustic data need to be qualified using a dynamic tongue and lip-tracking techniques of the kind used in e.g. Harrington, Fletcher and Beckman (in press).

3.2 *Onglides in high vowels*

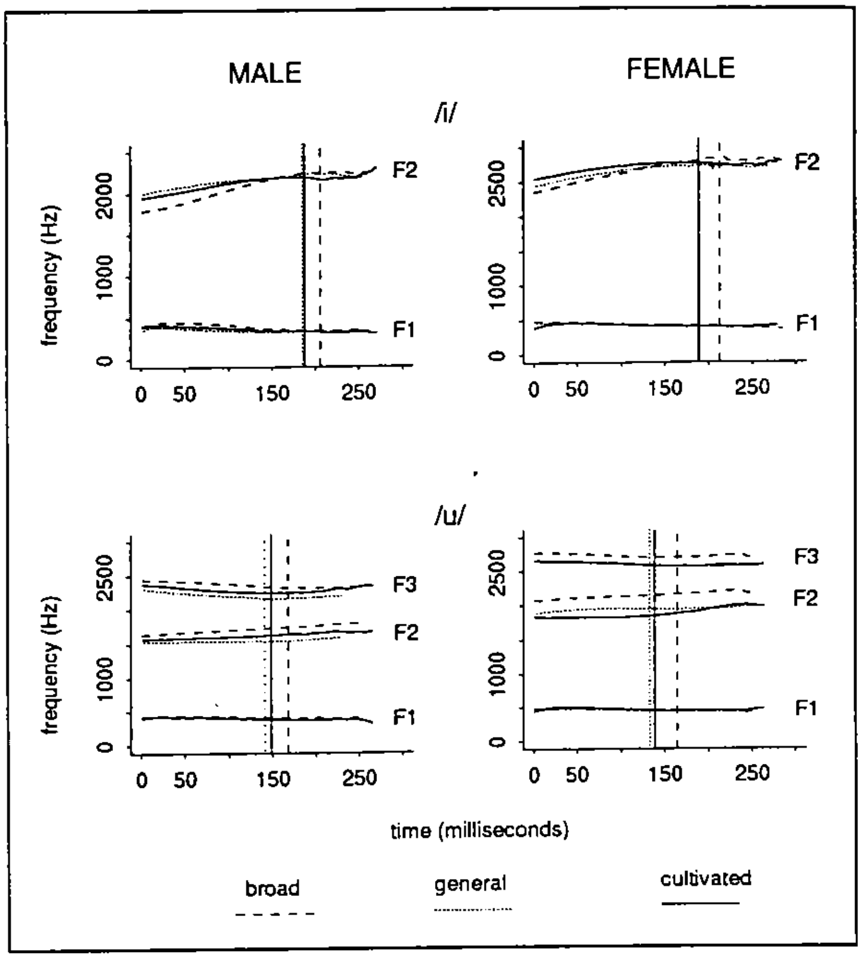

FIGURE 2: AVERGED FORMANT TRAJECTORIES AFTER ALIGNMENT AT THE ACOUSTIC VOWEL ONSET (t = 0 ms) OF MALE (top row) AND FEMALE (bottom row) /i/ AND /u/ VOWELS.

The vertical lines mark the average time of the vowel target for each accent category relative to the acoustic vowel onset. The formant trajectories extend to the mean acoustic offset time (for example, the mean duration of male cultivated /u/ is just under 275 ms, as shown by the termination of the solid formant trajectories at this time point).

Figure 2 shows formant trajectories in /i/ (HEED) and /u/ (WHO'D) vowels which have been averaged separately for the three accent categories. They were averaged after temporal alignment at the acoustic vowel onset (time t = 0) in order to be able to see any accent-specific effects close to this time point (the trajectories become progressively less reliable as time increases from the temporal alignment point at t = 0). Superimposed on these trajectories are vertical lines marking the average time at which the vowel target occurred relative to the vowel onset.

The plots in Figure 2 suggest that /i/ vowels have a late vowel target (long onglide) in accordance with existing acoustic studies of Australian English (Bernard 1981; Cox 1996) and also with recent kinematic investigations of tongue movement in Australian vowels (Harrington et al. in press; Fletcher Beckman, and Harrington 1996). The target is a good deal closer to the vowel's temporal midpoint in /u/ however. There is also clear evidence of an onglide in /i/ from a more central vowel at the acoustic onset (as shown by the higher F1 and lower F2 than at the target), but there is much less evidence of an F2 onglide in /u/, although there is some change in F3 from the onset to the target. As far as accent differentiation is concerned, one of the most striking features of the plots is that the average target time of broad Australian is considerably delayed compared with that of the other two accents in male and female /i/ and /u/. Secondly, the F2 onglide is lowest in frequency for broad /i/ and the F2 and F3 onglides are highest for broad /u/.

For the first part of the statistical analysis, a MANOVA was carried out with four dependent variables: the frequencies of F1-F3 at the acoustic vowel onset and the proportional time of the vowel target relative to the onset and offset. This last parameter is the time at which the vowel target occurs relative to the acoustic vowel onset and vowel offset. For example, if a vowel has a proportional target time of 0.5, the target is at the vowel's temporal midpoint. The lower and upper limits of this parameter are 0 (the target is at the vowel onset) and 1 (the target is at the vowel offset). As far as this analysis is concerned, the expectation is that cultivated talkers have proportional target times closer to 0.5 (the vowel midpoint) than broad talkers. The factors were, as before, ACCENT and AGE. The MANOVA showed a significant overall effect for accent in the male talkers for /i/ but not for /u/. For the female talkers, there were overall significant effects for both /i/ and /u/. The single occasion in all of the MANOVAs carried out in this study for which there was an AGE x ACCENT interaction occurred for the proportional target time of /i/ in male subjects.

Table 5 shows a summary of the individual parameters that were significant in the univariate analysis. We will consider briefly these results in the light of the averaged plots in Figure 2 separately for the two high vowels below.

TABLE 5: RESULTS OF PAIRWISE ACCENT COMPARISONS ON F1-F3 AND THE PROPORTIONAL TARGET TIME IN /i/ AND /u/ VOWELS.

MALE VOW	accent	parameter	df	F	p
i	b/c	F2 onset	1,26	13.12	<0.01
i	b/c	target time	1,26	8.15	<0.01
i	b/g	F2 onset	1,44	10.94	<0.01
i	b/g	target time	1,44	11.17	<0.01

FEMALE VOW	accent	parameter	accent	df	F	p
u	b/c	F2 onset	b/c	1,30	17.25	<0.01
u	b/g	F2 onset	b/g	1,45	17.77	<0.01

The pairs of accent groups on which the results were significant are shown in the second column e.g. b/c denotes a significant difference between *broad* and *cultivated*. The columns are: *vowel type*, *accent groups*, *acoustic parameter*, *degrees of freedom*, *F-ratio*, and *probability*.

3.2.1 *Onglide in /i/*

For the male subjects, Table 5 shows that F2 onset frequency is significantly lower and the proportional target time significantly greater for broad as opposed to general, and broad as opposed to cultivated talkers. However, the delayed target time in broad talkers interacts with age, as discussed above. A further analysis of the variation of this parameter by age showed that younger talkers have a significantly earlier target time ($F = 5.1$, $p < 0.05$) and *higher* F2 onset frequencies ($F = 6.92$, $p < 0.05$) than older talkers; i.e. the difference between young and old talkers on the parameters of F2 onset and F2 target time parallels that of cultivated as opposed to broad talkers. This implies, therefore, that old broad talkers may have the most extensive onglides and young cultivated talkers the least marked onglides of the groups under considerations. In fact, the order of the 9 possible age-accent groups ranked according to the proportional target time in Table 6 shows that young-cultivated talkers do indeed have the least marked onglide in /i/; and although old-broad talkers are not ranked last in this list, the old-cultivated group has a lower ranking than if the proportional target time were just based on accent. It may therefore be that that there is less of a tendency for young male talkers to produce more extensive /i/ onglides than older male talkers, but this question needs to be further investigated with a larger groups of subjects.

TABLE 6: THE MEAN F2-ONSET FREQUENCY (left column) AND MEAN PROPORTIONAL TARGET TIMES (middle column) IN MALE /i/ VOWELS AVERAGED ACCORDING TO THE NINE POSSIBLE AGE-ACCENT GROUPS.

F2-onset frequency (Hz)	Prop.target time	AGE-ACCENT group
2135	0.52	young-cultivated
1980	0.69	old-general
1991	0.71	young-general
1983	0.72	middle-cultivated
1876	0.75	middle-general
1875	0.76	old-broad
1869	0.78	old-cultivated
1677	0.79	middle-broad
1798	0.80	young-broad

The rank order is from lowest to highest of the proportional target time.

For the female speakers, there were no significant differences on any of the univariate parameters for /i/ vowels.

3.2.2 *Onglide in /u/*

There were no significant differences on any parameters for the male talkers and the only significant effect for female talkers is that F2 onset of /u/ is raised in frequency for the broad compared with the cultivated group.

Taking the male and female results together, and perhaps giving greater credence to the averaged trajectories in Figure 2 than the statistics would suggest, there is some evidence that F2 and F3 of broad /u/ are raised at the vowel onset relative to the other accents (see also Figure 2, bottom panels), but since these formants are also raised at the vowel *target* (see Section 3.1), this need not necessarily indicate that broad Australian /u/ has a greater *diphthongal* quality than in the other two accents. In order to consider this question further, the differences in formant frequencies between the acoustic onset and target were calculated separately for each accent group and for males and females separately. The results (Table 7) show that in all accents and for both males and females, F2 increases and F3 decreases from the acoustic onset to the target in /u/ vowels. A further examination of the results in Table 7 shows that broad /u/ has the greatest change in F2 and the least change in F3 from the vowel onset to the target, while cultivated has the least change in F2 but the greatest change (decrease) in F3.

TABLE 7: F1-F3 CHANGE FROM THE ACOUSTIC ONSET TO THE VOWEL TARGET IN MALE AND FEMALE /u/ VOWELS.

MALE	F1	F2	F3
broad	4	115	-118
general	-35	64	-148
cultivated	-45	17	-160

FEMALE	F1	F2	F3
broad	-28	93	-75
general	1	71	-75
cultivated	10	39	-95

A positive value means that the formant value at the target is greater than at the onset. All values in Hz.

These formant differences between the accents from onset to target could be interpreted as follows. Firstly, the fact that broad /u/ has the highest F2 and F3 frequencies from the onset through to the target may suggest that it has the least extensive lip-rounding since, in mid-front vowels, increased lip-rounding generally produces a decrease in F2 and F3, as discussed earlier. Secondly, the comparatively large change in F2 from the onset to the target may mean that there is the greatest extent of tongue movement (from a relatively more central position at the vowel onset) in broad /u/. However, the articulatory interpretation of formant movement in /u/ is complicated by the acoustic consequences of tongue-lip interaction and so these remarks must be considered speculative in the absence of a further kinematic study to track the movement of the tongue and lips.

3.3 *Rising diphthongs*

Figure 3 shows averaged trajectories for the three front-rising, and two back-rising diphthongs in the formant plane superimposed on a selection of vowel ellipses from Figure 1. The diphthong trajectories were obtained in the following way. First, all diphthongs were sectioned between the first and second target times. Secondly, these sections, which are of variable duration, were linearly time-normalised producing trajectories between the two targets of equal duration. Thirdly, these time-normalised trajectories were averaged by phonetic class, gender, and accent type.

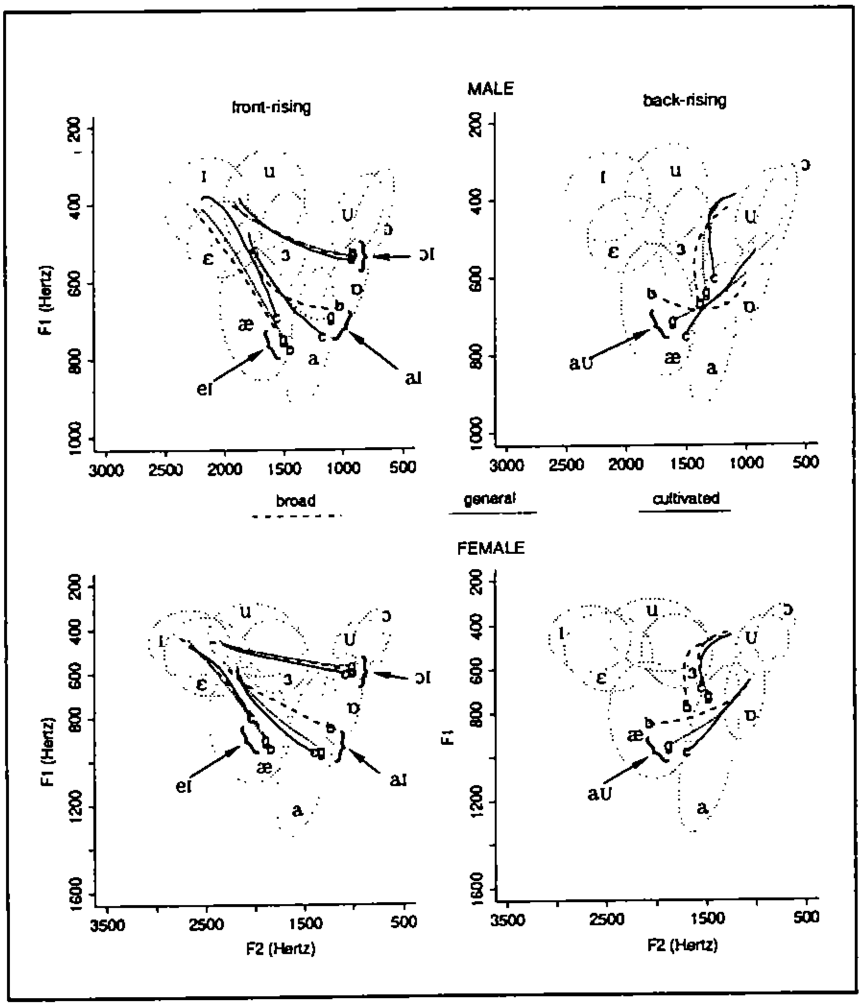

FIGURE 3: RISING DIPHTHONG TRAJECTORIES AVERAGED BETWEEN THE TWO TARGETS AFTER TIME NORMALISATION IN MALE (top row) AND FEMALE (bottom row) DATA.

Figure 3 shows some of the known, distinguishing characteristics of Australian English diphthongs (all relative to the Australian monophthongal vowel space) including: the low first target of /eɪ/; the fronted (and raised for broad) first target of /aʊ/; and the raised and backed first target of broad /aɪ/ which extends into the boundary between the /a/ and /ɒ/ vowel spaces. The second targets of the front-rising diphthongs clearly point towards the /ɪ/ space, and while they end in this space for /eɪ/ and at the edge of this space for /ɔɪ/, the second target of /aɪ/ is much lower at the edge of the /ɛ/ and /æ/

spaces. The two back-rising diphthongs point towards the /ʊ/ space, but their second targets end well short of this. For /oʊ/, the second target is approximately midway between the centroids of /ʊ/ and /u/, while the second target of /aʊ/ is much more closely affiliated with /ɒ/ than with either /ɔ/ or /ʊ/.

One aspect of the diphthong trajectories which is discrepant with the data in Bernard (1970) and the more recent data in Cox (1996) is the second target of /oʊ/. In their data, the trajectory of /oʊ/ bends much more towards the /u/ space and this could mean that the second component of this diphthong is a good deal fronter than its phonemic transcription as /ʊ/ implies. However, the vowels from these studies were all produced in a /hVd/ context; and furthermore, since /d/ has its locus at 1800 Hz in male talkers which, as can be seen from Figure 3, is very close to the centroid of /u/, the observed fronting of the second component of /oʊ/ in Bernard (1970) and Cox (1996) may to a certain extent be an artefact of the coarticulatory influence of the final alveolar consonant. In the present data, in which /oʊ/ was produced in the open syllable HOE, there is certainly evidence from Figure 3 that the second component is fronted relative to /ʊ/ but the averaged trajectory suggests that it occupies a space midway between this vowel and /u/.

We can quantify this further by calculating whether the second target of /oʊ/ is probabilistically closer to /u/ or /ʊ/ in the F1-F2 space. For the male general talkers, which is the largest of the male accent categories, a Bayesian classification was carried out (Harrington and Cassidy, in press) by training the model on F1 and F2 at the vowel target for /u/ and /ʊ/ and testing on 27 (general) second target /oʊ/ diphthongs. The results of this classification show an approximately equal division between the two monophthongal vowels: 13 second-target /oʊ/ tokens were classified as /ʊ/ and 14 as /u/. When the same classification was repeated for the female general talkers, the results are 17 classifications of (female) /oʊ/ as /ʊ/ and 15 as /u/. These classification scores, together with the averaged trajectories in Figure 3, suggest that when /oʊ/ is free from coarticulatory influences of a closing consonant, the second target is approximately midway between /u/ and /ʊ/.

3.3.1 *First target: accent differences*

Focusing now on accent differences in the first target, there were significant multivariate accent effects in the male speakers for all five rising diphthongs except /ɔɪ/ and for all rising diphthongs in the female talkers. The results of the univariate analysis (Tables 8 and 9) show that the strongest first-target accent effects are in /aɪ/ and /aʊ/. For both male and female speakers, there are significant differences in F1 and F2 for /aʊ/ on all pairs of accent combinations (broad/general, general/cultivated, broad/cultivated) with the exception of F1 for broad/cultivated male talkers. The principal effect in /aɪ/ is that F2 is significantly lower (i.e. the first target is more retracted) for broad compared with that of general and cultivated talkers.

TABLE 8: RESULTS OF PAIRWISE ACCENT COMPARISONS ON F1-F3 AT THE FIRST TARGET IN DIPHTHONGS.

MALE VOW	accent	parameter	df	F	p
oʊ	g/c	F2	1,34	7.5	<0.01
aɪ	b/c	F1	1,26	4.5	<0.01
		F2	1,26	15.9	<0.01
aɪ	b/g	F2	1,44	9.8	<0.01
aʊ	b/c	F1	1,26	8.3	<0.01
		F2	1,26	25.7	<0.01
aʊ	b/g	F1	1,44	8.9	<0.01
		F2	1,44	22.4	<0.01
eɪ	b/c	F1	1,26	8.00	<0.01
		F2	1,26	8.22	<0.01

FEMALE VOW	accent	parameter	df	F	p
oʊ	b/c	F2	1,30	8.3	<0.01
oʊ	b/g	F2	1,45	24.8	<0.01
aɪ	b/c	F2	1,29	21.2	<0.01
aɪ	b/g	F1	1,45	7.42	<0.01
		F2	1,45	9.4	<0.01
aʊ	b/c	F2	1,30	24.0	<0.01
aʊ	b/g	F1	1,45	7.4	<0.01
		F2	1,45	13.6	<0.01
eɪ	g/c	F1	1,47	8.8	<0.01
		F2	1,47	9.7	<0.01
ɔɪ	b/c	F3	1,30	7.9	<0.01
	b/g	F3	1,45	7.5	<0.01

The pairs of accent groups on which the results were significant are shown in the second column e.g. b/c denotes a significant difference between *broad* and *cultivated*. The columns are: *vowel type, accent groups, acoustic parameter, degrees of freedom, F- ratio,* and *probability*.

For /eɪ/, F2 is significantly raised (i.e. a more fronted first target) for cultivated talkers compared with both general and broad female talkers, but only relative to male general talkers.

Broad /oʊ/ has a significantly raised F2 for female talkers compared with that of the other two accent groups (suggesting a more fronted first target); in the male talkers, F2 in the first target of /oʊ/ is raised for the general compared with that of the cultivated group.

Finally, /ɔɪ/ shows the least degree of accent variation in its first target: there are no significant differences for males while for females, the differences are restricted to F3 (significantly higher for broad compared with F3 in the other two accent groups).

3.3.2 *Second target*

There are considerably fewer systematic differences between the accent groups in the second targets of diphthongs. At least part of the reason for this is that the second target of diphthongs is much more variable than the first and often not attained (e.g. Gay 1968, 1970; Gottfried, Miller and Meyer 1993; Jha 1985; Pols 1977) even in citation-form speech (Harrington and Cassidy in press).

The MANOVA showed no overall significant effects for accent with F1-F3 at the second target as the dependent variables in the male talkers; there were significant differences in the female talkers only for /aɪ/ and /eɪ/: the subsequent univariate analysis showed only one significant result which was that F1 of female /eɪ/ is significantly raised for the broad category compared with that of the cultivated group (suggesting that broad has the phonetically most open second target).

3.4 *Falling diphthongs*

The acoustic analysis of falling diphthongs presents the difficulty that they are phonetically variable in Australian English. The most obvious variation, which is in fact phonemic, is that /ʊə/ in Australian has merged with /ɔ/ for many words: this trend, which is also characteristic of Southern British English (Wells 1982) is perhaps even more marked in Australian. Some words, like TOUR are nevertheless predominantly produced with a falling diphthongal nucleus, although in this corpus, 32/132 TOUR words were clearly produced with /ɔ/: these are removed from further consideration in the analysis in this section.

The extent to which the other two falling diphthongs are monophthongised in Australian is not clear. Casual listening would suggest that broad and general Australian speakers produce /ɪə/ and /ɛə/ either as long monophthongs (Bernard 1967a; Cochrane 1959), particularly when the syllable is closed by a consonant (necessarily alveolar); or else the diphthongal quality is so exaggerated that the production is distinctly bisyllabic.

Table 9 shows some results of careful listening to the three falling diphthongs in the present corpus, excluding those TOUR words which were produced with a /ɔ/ nucleus. Included in the category 'falling diphthong' are all diphthongal productions, irrespective of where they occur on the continuum from a diphthong to a bisyllabic production. The long monophthongs were in general produced as a long version of the corresponding lax vowel.

TABLE 9: THE THREE SUB-CATEGORISATIONS OF MALE AND FEMALE /ɪə/, /ɛə/, AND /ʊə/ IN THE PRESENT CORPUS BASED ON AN AUDITORY ANALYSIS.

	long monophthong	falling diphthong	rhotic	n
/ɪə/	10	95	10	115
/ɛə/	8	101	11	120
/ʊə/	1	95	4	100
n	19	291	25	335

An examination of Table 9 shows that the preference for falling diphthongs is striking, although this could be an artefact of the current corpus in two ways. Firstly, since these are citation-form words produced in isolation, it is likely that many talkers hyperarticulate them which could result in the production of the nucleus with an exaggerated diphthongal component (by e.g. increasing the phonetic distance between the two targets). The fact that 25 talkers produced these falling diphthongs with clearly perceptible *rhotic* vowels – a larger proportion in fact than those who monophthongised them – points strongly towards the possibility of hyperarticulation. Secondly, the falling diphthongs all occur in open syllables (HERE, HAIR, TOUR) and so there is no possibility that the second component of the diphthong is influenced by a following consonant. On the other hand, in the more usual /hVd/ context, which was also the context used in Bernard (1981), the closing consonant is likely to influence strongly the preceding /ə/ of the falling diphthong, both because alveolars have the most stable loci of the three consonant classes (Cassidy and Harrington 1995; Fant 1972; Öhman 1966; Sussman, McCaffrey and Matthews 1991), and because schwa vowels are themselves highly prone to coarticulatory influences. Therefore, the monophthongisation of the falling diphthongs which has been observed in other acoustic phonetic studies of Australian English (Bernard 1981; Cox 1996) may be, in part, a consequence of the contextual influence due to the closing alveolar consonant. There is evidence from Horvath (1985) that the monophthongisation of /ɪə/ and /ɛə/ is more likely in the context of a following consonant and she also reports a high incidence of bisyllabic realisations, especially in prepausal position.

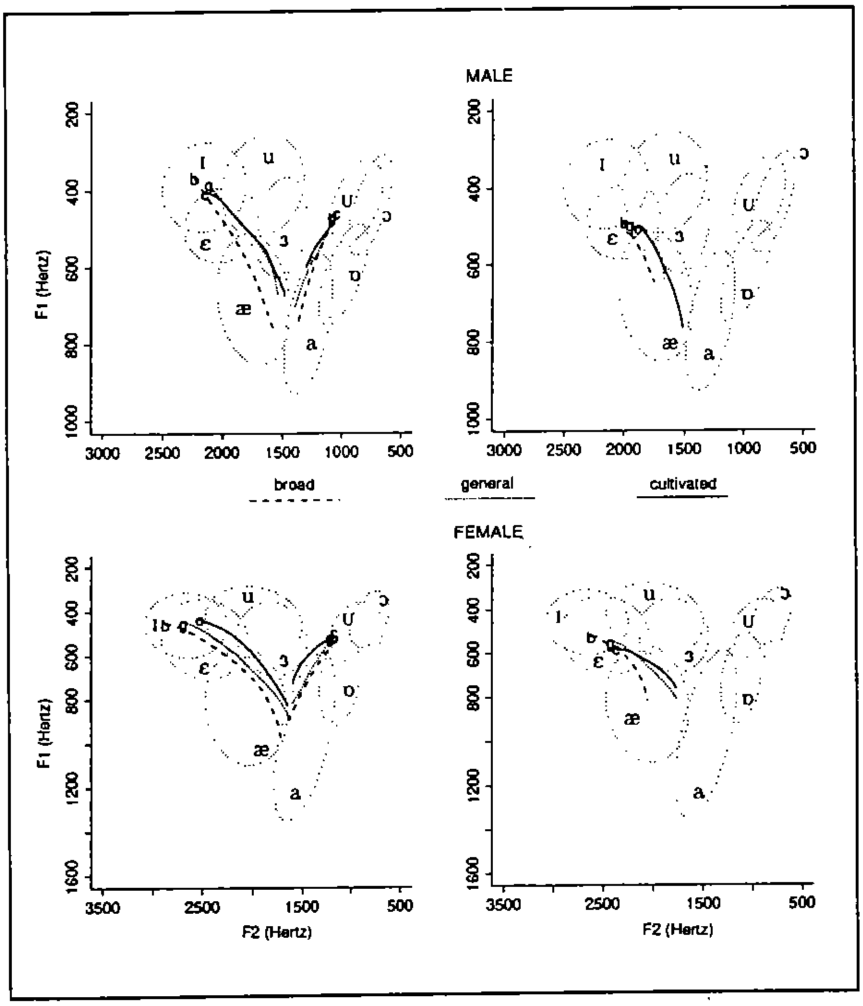

FIGURE 4: FALLING DIPHTHONG TRAJECTORIES AVERAGED BETWEEN THE FIRST TARGET AND ACOUSTIC VOWEL OFFSET AFTER TIME NORMALISATION IN MALE (top row) AND FEMALE (bottom row) DATA.

The left panels show /ɪə ʊə/, the right panels show /ɛə/. The trajectories are superimposed on a selection of vowel ellipses from Figure 1. The phonetic symbol shows the average formant position of the first target in all cases.

Figure 4 shows averaged trajectories of the 291 diphthongs which were identified as examples of falling diphthongs in this corpus (Table 9). Since it was generally not possible to mark a second target for these diphthongs (the formants did not become horizontal towards the vowel offset), the averages extend from the first target to the vowel offset. The averaging was done in the same manner as for the rising diphthongs i.e. after time-normalisation in this case between the first target and vowel offset. It is emphasised that these averages must be interpreted much more cautiously than in earlier plots because of the widespread variability in the realisation of the falling diphthongs (along the diphthong-bisyllabic continuum) referred to earlier.

Figure 4 shows that the first targets of /ɪə/ and /ɛə/ are closest to the centroids of the /ɪ/ and /ɛ/ ellipses respectively, and that the first target of /ʊə/ is slightly opener and fronted relative to the centroid of /ʊ/. The falling diphthongs terminate in the open vowel /æ/ or /a/ space, or at the boundary between the two.

As far as accent differentiation is concerned, Figure 4 suggests that the first target of broad /ɪə/ is raised (male) or fronted (female) relative to /ɪə/ of the other accents. Broad female /ɛə/ has a clearly fronted and slightly raised first target compared with that of the other accents, although this is not replicated in the male data. There is no evidence of accent differentiation in the first target of /ʊə/ in either the male or female data.

There is also some evidence from Figure 4 that the broad falling diphthongs have phonetically more peripheral trajectories than those of the other two accents. Thus throughout their extent, the trajectories of broad /ɪə/ and /ɛə/ are clearly fronted in both male and female speakers compared with those of the other accents: and both male and female /ʊə/ have an averaged trajectory which is retracted throughout its extent relative to that of other accents, although marginally so in the female data (and to emphasise the point again: the trajectories are averages which mask the potentially high degree of variability alluded to earlier). The extensive trajectory of the cultivated male /ɛə/ is surprising and at odds with that of the (expected) corresponding female cultivated /ɛə/ which terminates in the phonetically most central position of the three accent types.

The results of the statistical analysis to investigate accent differentiation at the first and second targets are as follows. The MANOVA with the first three formants at the first target as the dependent variables showed an overall effect for accent in /ɪə/ and /ɛə/ for male talkers and in /ɛə/ for female talkers. There were no overall effects at the first target for /ʊə/. The subsequent univariate analysis (Table 10) showed that F2 of broad /ɛə/ in female talkers is raised relative to the cultivated accent category ($F = 10.9$, $df = 1,24$); F3 of female broad /ɛə/ is also raised ($F = 12.0$, $df = 1,24$) relative to F3 of the cultivated, but there were no other significant individual effects at the first target.

With regard to the MANOVA analysis on F1-F3 at the vowel offset, the results showed no overall effects for accent in any of the falling diphthongs for the female speakers, and an overall effect for /ʊə/ in the male talkers although the subsequent univariate analysis showed no significant effect at the vowel offset of /ʊə/ for any accent combination.

A summary of the main acoustic phonetic differences between the three accent groups in falling diphthongs is as follows. Firstly, and excluding the 1/3 TOUR words produced with an /ɔ/ nucleus, the very large majority of citation-form productions of HERE, HAIR, and TOUR words were produced with a clearly falling diphthongal nucleus of which the tokens varied considerably along the continuum from diphthongal to bisyllabic. Secondly, the initial target of these diphthongs were close to the centroids (in the F1-F2 plane) of the corresponding lax monophthongs /ɪ ɛ ʊ/ respectively, while the offset of these diphthongs terminated near the /æ a/ space. Finally, there are very few accent differences in the falling diphthongs: the most salient is the fronted first target of broad /ɛə/ relative to the cultivated accent category.

TABLE 10: PROPOSED TRANSCRIPTIONS SYSTEMS OF AUSTRALIAN ENGLISH (LEFT) AND THOSE OF CLARK (1989) AND MITCHELL (1946).

Word	Proposed symbol	Clark (1989)	Mitchell (1946)
heed	iː	iː	i
who'd	ʉː	ʉː	u
heard	ɜː	ɜː	ɜ
hoard	oː	oː	ɔ
hard	ɐː	ɐː	a
hid	ɪ	ɪ	ɪ
hood	ʊ	ʊ	ʊ
head	e	e	ɛ
hod	ɔ	ɔ	ɒ
hud	ɐ	ɐ	ʌ
had	æ	æ	æ
hay	æɪ	æe	aɪ
hoe	əʉ *or* əʊ	əʉ	oʊ
hoy	ɔɪ *or* oɪ	oɪ	ɔ̇ɪ
high	ɑe	ɐe	aɪ
how	æɔ	æɔ	aʊ

Alternatives for HOE and HOY are included because of the different results in the present study and the acoustic analyses of Bernard (1967b) and Cox (1996).

4. DISCUSSION

The present study is consistent with many impressionistic (Mitchell and Delbridge 1965) and experimental (Bernard 1967b; Cox 1996) studies of Australian English vowels. Both this study and earlier ones show that the main source of phonetic difference (within the vowels at least) between broad/general/cultivated accents is in the diphthongs /aɪ aʊ/. There are also differences in the diphthongs /eɪ oʊ/ but these are less marked than in /aɪ aʊ/. The differences between the accents for /eɪ/ are in the same direction as in Bernard (1967b): however in the Bernard data, the differences are statistically restricted to F2 (cultivated has the highest F2 and therefore the most fronted first target), whereas here the differences are in F1 and F2. As far as /oʊ/ is concerned, in our data, the accent effect is in F2 of the first target which is raised for broad speakers indicating fronting. In Bernard (1967b), the accent effect is restricted to F1 of the first target suggesting that broad talkers have a more open first target (see also Cox in press). The Bernard talkers also demonstrate an accent effect for the second target of /oʊ/, an effect which is not present in the results obtained here. Perhaps /oʊ/ is in the process of change as suggested by Cox (1996).

The monophthongs provide considerably fewer acoustic cues to accent differences. The greatest effects are in the fronting of /u/ (most front for broad) and also in the extent of the /i/ onglide. However, as Cox (1996) also suggests, the degree of onglide in /i/ varies with age (so the relationship between ongliding and accent differentiation cannot be stated without taking age into account) and seems to be less marked for younger compared with older talkers. The falling diphthongs showed very little accent differences, which is in contrast to Bernard (1967b), who showed strong second target differences in /ɪə/ and /ɛə/: as discussed below, the inconsistency between these two studies may be attributable to the different contexts (open syllables in the present study, closed by an alveolar consonant in Bernard 1967b) and because there was considerable phonetic variability in how the falling diphthongs were produced.

Beyond the accent effects, there is close agreement between the present findings in the ANDOSL corpus and those of Bernard (1967b): both /u/ and /a/ are central vowels in Australian English and although both /i u/ have onglides, the onglide is more marked for /i/: all these characteristics have also been found in Cox (1996). In the case of the diphthongs, consistently with both Bernard (1967b) and Cox (1996), the first target of /eɪ/ is close to /æ/; the first target of /aʊ/ is close to /æ/ and intermediate between /æ/ and /ɛ/ in broader talkers; and the first target of /aɪ/ is more retracted than /a/ (HARD). In Bernard (1967b), Cox (1996) and ANDOSL, the second target of /aɪ/ terminates at a more open vowel quality than that of the other rising diphthongs: there is a closer association between the second target of /aɪ/ and

HEAD than HID. The second target of /au/ is a good deal opener than its phonemic transcription would suggest and, consistently with Bernard (1967b) and Cox (1996), it terminates in the vicinity of the HOD vowel space. As far as the falling diphthongs are concerned, the auditory analysis in the present study shows that they are variable and can be produced as a long monophthong, diphthong, or as two syllables. However, there is no evidence from the present ANDOSL data that there is any preference for monophthongal productions (the contrary, in fact) although, as discussed earlier, the choice of context (open syllables in all cases) as well as the way in which the words were elicited (citation-form speech in a recording studio) may have had some influence on their production. Certainly, this is an area which warrants further investigation with a wider range of contexts and speaking styles.

It has been clear for some time that the system for the transcription of Australian English vowels which is based on Mitchell (1946) is in need of some revision: certainly, there is still no agreement on a standard for Australian English transcription (see e.g. Durie and Hajek 1994; Ingram 1995; Durie and Hajek 1995). Modifications to a transcription system are always likely to result in a good deal of controversy, partly because of a reluctance to abandon a system which is widespread and well-established, but also because a transcription system is a compromise between many different factors such as phonetic accuracy, the phonological system of Australian English and its relationship to that of other English accents, ease of use in teaching and no doubt other criteria including, for example, the preference for using Roman symbols wherever possible (Durie and Hajek 1995).

This analysis provides considerable support for the revisions to the transcription system proposed by Clark (1989) shown in Table 10 based to a large extent on the Bernard (1967b) data. The three further modifications we would propose to his system are as follows. Firstly, since the first target of HIGH is somewhat more retracted than the target of HARD, we would transcribe it with the cardinal vowel 5 symbol i.e. [ɑ] (it is quite possible, as suggested by e.g. Clark (1989) that the first component is produced with some lip-rounding in broad Australian, but this needs to be investigated experimentally). Secondly, we want to reflect the evidence from the present ANDOSL corpus which shows that that the second targets of HAY and HOY terminate very near to the HID space whereas the second target of HIGH is intermediate between HID and HEAD, and possibly closer to HEAD. On the assumption that the HEAD vowel is to be transcribed as [e] (Clark 1989), we would propose [ɑe] for HIGH. (We have also modified the Clark system by using the existing IPA symbol [ɐ] and its lengthened equivalent [ɐ:] in HUD and HARD to replace [ɵ] and [ɵ:]: this is because we would prefer to avoid diacritics whenever possible).

Finally, there are unresolved issues in the transcription of the first target of HOY and the second target of HOE. In our data, the first target of HOY is certainly closer to HOD than to HOARD, whereas in both Bernard (1967b) and Cox (1996), it is somewhat closer to HOARD. The transcription of the second target of HOE is problematic for the same reason: in ANDOSL, the second target seems to be midway between WHO'D and HOOD, whereas in Bernard (1967b) and Cox (1996), it is clearly closer to WHO'D. It may be that the context differences discussed earlier may be partially responsible for these differences, but further investigation in both cases is necessary.

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Jonathan Harrington, Felicity Cox and Zoe Evans
Speech Hearing and Language Research Centre
Macquarie University
Sydney NSW 2109
AUSTRALIA