Issues in the perception of the /el/ ~ /æl/ contrast in Melbourne:
Perception, production and lexical frequency effects

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Abstract
A sound change is underway in Australian English in which /el/ sequences are realised as [æl] by some speakers. In this study, we focus on a micro-level analysis of responses to a perception experiment, in which 345 listeners from Melbourne took part in a forced-choice experiment containing /el/-/æl/ and /el/-/æl/ stimuli. This experiment is part of a larger investigation, and was the second of three experiments presented to listeners. Results show that listeners made more errors in perception for /el/-/æl/ stimuli, and that lexical frequency and acoustic structure of the experimental items also appear to affect responses.

Index Terms: phonetics, sound change, Australian English

1. Introduction

1.1. The sound change in Australian English
The /el/-/æl/ sound change is a phenomenon in Australian English in which /el/ and /æl/ are realized, by at least some speakers, as [æl]. Despite the fact that a difference between these phonemes is preserved orthographically, vowels in words such as dwell and elf are produced as [æ], and minimal pairs such as malady-melody, pellet-palate and Ellis-Alice are no longer contrastive. There is another even less-cited (and possibly related) phenomenon concerning the same phonemes, where speakers produce words containing either /el/ and /æl/ with [æ] only. In these instances, speakers produce the first vowel in words such as alcohol or ballerina with an [æ] vowel (see [1]).

Available evidence currently suggests that the /el/-/æl/ sound change may be confined to speakers from the south-east of the mainland, specifically in Victoria and its capital Melbourne [1,2]. We refer to speech produced in this region as Melbourne English.

We note that the /el/-/æl/ sound change is similar to a parallel phenomenon in New Zealand English where it is well-researched [e.g. 3 and references therein]. Because these varieties are not connected and have different vowel systems, it is possible that similar physiological or universal processes have independently induced the sound change, and we address this in 1.3.

1.2. The sound change in production
In Australian English, very few studies have been carried out into the /el/-/æl/ sound change, and these have largely focused on production aspects. The first mention of the /el/-/æl/ sound change in Australian English was by Bradley [4] who observed for Melbourne speech that /el/ was often produced as [æl].

Fifteen years later, Cox and Palethorpe [1] carried out a study comparing vowels produced by three groups of young female speakers from regional New South Wales (NSW) and one group of young female regional Victorian speakers (from Wangaratta, close to the NSW border. Vowels were measured in /hVd/ and /hVl/ frames, and it was confirmed, through acoustic analysis of formant frequencies, that the /el/-/æl/ sound change was present in the speech of all of the Victorian girls but not in the groups from NSW. Acoustically, prelateral /e/ and /æ/ were significantly different only for the NSW girls.

Loakes [5] carried out preliminary acoustic phonetic analysis of the /el/-/æl/ sound change, comparing Melbourne speech recorded in 2002 (modern day data) and in 1959/1960 (1960s data). In that study, it was apparent that the lateral consonant (and the way vowels interact with /l/) appeared to be responsible for different vowel groupings. Analysis of the 1960s data indicated that speakers for whom /eC/ and /el/, and /æC/ and /æl/ patterned together (i.e. cases where prelateral vowels were no different to vowels in other contexts) were actually producing a more clear sounding [l], while the speakers who were merging prelateral /e/ and /æ/ were producing a darker sounding [l]. None of the modern-day speakers produced clear [l] in any environment. This was a surprising finding in that while it is well known that the postvocalic lateral influences vowel quality in Australian English and elsewhere, it is the changing lateral (i.e. increasingly velarised lateral), rather than the vowels as such, which appears to have most directly influenced the sound change.

1.3. Phonetic aspects of the sound change
The context /N/ + /l/ is a common site for vowel differences and change due to the fact that velarised /l/ (or [ɫ]) has significant coarticulatory effects, causing preceding vowels in different varieties of English to become lower and more retracted. Australian English /l/ can now be described as [l] in most, if not all, contexts (cf. [6]). While velarised /l/ is attributable to Australian English generally, the reason that the /el/-/æl/ sound change may be regionally defined may also be due to the fact that lax/short vowels in Melbourne/Victoria are reported to be phonetically lower than elsewhere [e.g. 5].

More work needs to be carried out to fully determine the status of the /el/-/æl/ sound change in production in Australia. However, reasons for the occurrence of the vowel merger in the first place may also be crucially related to listeners’ experiences in perception.

1.4. The sound change in perception
Work in the area of perception, for this particular sound change, has been minimal. As part of a larger, ongoing,
investigation of the sound change in question, we have to date
carried out three different perception experiments, focusing on
how two groups of Australian English listeners (one from
Victoria, and one from elsewhere) react to /el/-/æl/ stimuli in
different contexts [2, also see 7]. The overall aim of that
investigation was to determine whether there was evidence
that the /el/-/æl/ sound change was in fact regionally defined
for listeners, as had been suggested in production studies (e.g.
[1]), and as is the case in popular perception. While only a
preliminary investigation, we observed evidence of
misperception amongst listeners from Melbourne/Victoria
regarding vowels in /el/-/æl/ contexts, and also saw that
listeners from other regions in Australia performed better on
the same tasks. In the three experiments, listeners from
Melbourne/Victoria consistently performed worse than
listeners from elsewhere in Australia when presented with /el/-
/æl/ stimuli. Additionally, in some cases listeners from
Melbourne/Victoria reported guessing their responses, and
they also failed to respond to certain stimuli. In contrast, non-
Victorians never reported guessing, and responded to all
stimuli in the forced-choice tasks. Finally, both groups tended
to report that they had found the tasks relatively easy, but
Melbourne/Victorians reported more difficulty overall.
Additionally, results indicated some degree of complexity
regarding experimental results, with both order of presentation
of the stimuli and lexical frequency appearing to influence
some listener responses.

Our previous work has suggested that the /el/-/æl/
change in Melbourne English is due to differences in
listener (mis)perception leading to hypercorrection for some,
i.e. /el/ -> [æl] -> /æl/. Results reported in [2,7] certainly
support this, although further investigation is needed to
understand patterns in (Melbourne/Victorian) listener
responses.

2. Aims

The aim of the current paper is to focus on the
Melbourne/Victorian listeners’ responses to one of the 3
previously mentioned experiments, in this case involving /el/-
/æl/ and /æl/-/æl/ stimuli. We concentrate here on the actual
perceptual results, before attempting to explain them. We
consider specifically: (a) the potential influence of the
phonetic form of the stimuli (in this case the formant structure
of the vowels and laterals), (b) lexical frequency effects; and,
more briefly, (c) order of presentation effects.

Possible lexical frequency and presentation effects on
listener responses, are identified by us elsewhere ([7]), in work
on a related experiment, as potentially influencing factors, but
requiring further investigation to understand better how they
influence listeners, if at all. Additionally, analysis of the
acoustic structure of the stimuli is something that has not yet
been considered for Australian English listeners, but has also
been flagged as a potential factor causing variability amongst
responses [2].

3. Method

3.1. Participants

345 native Australian English speaking listeners from
Melbourne participated in three listening tests. In this paper,
we focus only on the second listening test presented to
participants (described below). The listeners were high-school
students and their teachers, who were attending an English
Language workshop at The University of Melbourne.
Participants listened to linguistics-based lectures, and then

participated in questionnaire-based research. Their attention
was not drawn to the sound change at any point.

Due to the nature of the data collection, participants were
not balanced for age or sex. Of the 345 participants, the
majority was female (n=223, 64.6%), while their age
distribution is shown in Table 1.

Table 1. Participant Details.

<table>
<thead>
<tr>
<th>Age</th>
<th>% of Listeners</th>
</tr>
</thead>
<tbody>
<tr>
<td>14-16</td>
<td>1.2</td>
</tr>
<tr>
<td>17</td>
<td>71</td>
</tr>
<tr>
<td>18</td>
<td>21.1</td>
</tr>
<tr>
<td>19</td>
<td>2</td>
</tr>
<tr>
<td>24+</td>
<td>3.5</td>
</tr>
<tr>
<td>Unknown</td>
<td>1.1</td>
</tr>
</tbody>
</table>

The majority of listeners in the experiment were students aged
17 (n=245, 71%) and 18 (n=73, 21.1%), who were in their
final year of secondary school. A small percentage of student
listeners were either younger (1.2%) or older (2%).
Additionally, teachers aged over 24 years old made up 3.5% of
listeners, and a further 1.1% did not disclose their age.

3.2. Experimental Task

Listeners read instructions, heard a male voice producing
words with /el/ and /æl/ tokens, and were then required to
make a judgement about what they had heard. The speaker
who provided data for use in the experiments is a 30-year old
male speaker of Australian English from Sydney who
contrasts /el/ and /æl/ prelaterally (see section 4.2).

At the beginning of the three listening tests, the
participants saw the text “This is an experiment about how
words sound”. For the second listening test, which we report
on in more detail in this paper, the participants heard a word
(played twice) and had to choose the correct word from two
possibilities. They were instructed to place a question number
next to their response if they had made a guess. The
experimental items, with correct responses in bold, are: (1)
shoe (played twice) and shoe; (2) had (played twice) and had;
(3) pallet (played twice) and pallet; (4) Allie (played twice) and
Allie; (5) telly (played twice) and telly. For this task participants
heard a foil (1), followed by /æ/ and /el/ vowels in (2) and (3), and
then prelateral tokens in (4)-(6). Two stimuli contained prelateral
/e/, while one contained prelateral /æ/.

4. Results

We now turn to a closer investigation of listener responses to
the stimuli. In 4.1 we address responses to the task, in 4.2 we
assess the acoustic structure of the /el/-/æl/ and /æl/-/æl/
stimuli, and in 4.3 we turn our attention to lexical frequency of
the items.

4.1. Analysis of listener responses

For this experimental task, 284 of the 345 listeners (82.3%)
made no errors at all in perceiving the test items. In this
section, we focus on the results for the remaining 61
participants (17.7%) who made one or more errors in
perception.

As seen in Table 2 below, the most common errors (always
above the sample average) occurred for the prelateral tokens
rather than in the foil or the /æl/-/æl/ stimuli. 325 listeners
misperceived the /el/ stimuli in the word pallet, choosing
pallete instead. The next most common error was the /æl/
stimuli in tally with 23 listeners choosing telly, followed by

| Unknown | 1.1 |

| 24+ | 3.5 |
| 19  | 2   |
| 18  | 21.1|
| 17  | 71  |
| 14-16| 1.2 |
the name Ellie which was confused as Allie by 15 listeners. The error rate for non-lateral items, on the other hand, was always below the sample average: the foil was confused five times, had was misperceived as head four times, and head was misperceived as had by one listener. We note that some listeners made more than one error with the three prelateral tokens, but none confused all three of the items. Five listeners confused both pellet and tally, three misperceived pellet and Ellie, and two confused both Ellie and tally.

Table 2. Total number of errors per item.

<table>
<thead>
<tr>
<th>item</th>
<th>No. of errors / 345</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>show</td>
<td>5</td>
<td>1.45</td>
</tr>
<tr>
<td>had</td>
<td>4</td>
<td>1.16</td>
</tr>
<tr>
<td>head</td>
<td>1</td>
<td>0.03</td>
</tr>
<tr>
<td>pellet</td>
<td>25</td>
<td>7.25</td>
</tr>
<tr>
<td>Ellie</td>
<td>15</td>
<td>4.35</td>
</tr>
<tr>
<td>tally</td>
<td>23</td>
<td>6.70</td>
</tr>
<tr>
<td>total</td>
<td>73</td>
<td>3.53</td>
</tr>
</tbody>
</table>

As seen in 3.2, participants were also instructed to indicate whether they had made a guess. 13 listeners (3.8%) reported that they had done so, but this was the case only for the /el/-/æl/ stimuli. One listener made a guess for all three stimuli, three listeners made a guess for two of the stimuli, and nine listeners made one guess (for various stimuli). Analysis of the items that these listeners had trouble with, and whether they were right or wrong in their responses, is useful in understanding responses to this task. Overall, the item that these listeners had most trouble with (with respect to guessing) was the name Ellie, with nine listeners reporting that they had guessed their response. However, only three of these listeners actually chose the alternative Allie, and the remaining six chose the correct response. Five listeners reported that they had guessed their response to tally, and three of these actually chose the alternative telly instead. Finally, four listeners were unsure about their response to pellet, and three of these chose palate. We note that the four listeners who made multiple guesses were right at least once. Despite the differences in the number of listeners who guessed the various /el/-/æl/ stimuli, for each item there were 3 different listeners who were wrong, with the other listeners guessing the alternative (and correct) answer.

4.2. Acoustic structure of the stimuli

In this section, we focus on the acoustic structure of the vowels in /æl/-/æC/ and vowels and laterals in /el/-/æl/.

The F1/F2 vowel space for the speaker of the materials used in this experiment is shown in Figure 1 below. We note that this vowel space shows only the target of lax vowels, with experimental items capitalized ( /æC/-/æC/ stimuli) or outlined (/el/-/æl/ stimuli). Items other than these tokens were recorded and measured by the speaker on a different occasion, and provided to us for this study.

Turning to Figure 1 and focusing firstly on the /æC/-/æC/ tokens, we see that both are relatively unremarkable for Australian English, although /æ/ produced by our speaker is slightly higher (F1=620) and more retracted (F2=1654) than reported averages [8]. Unsurprisingly, the prelateral items are both lower and more retracted than their non-prelateral counterparts (as discussed in 1.3). This is especially so for the /æ/ in Ellie is slightly lower than that in pellet (F1= 551 and 533 respectively). However, Ellie is far less retracted than pellet (F2=1952 and 1582 respectively). In fact, as the vowel space shows, the /æ/ in pellet is more retracted relative to the peripheral diagonal than the /æ/ vowel in tally.

![Figure 1: F1/F2 lax vowel space for the male speaker who produced the experimental tokens.](image)

For the two /el/ tokens, it is clear that their structure is very different, with the vowel in Ellie being closer to the /æ/ that listeners initially heard in head. The vowel in pellet, on the other hand, is different to all of the other /e/ and /æ/ tokens heard in this experiment. This word was presented directly after head and had, and was the item that listeners had most trouble with. It appears then, that the more centralized acoustic structure of the vowel in pellet may well be responsible for listeners’ confusion with this item. Interestingly, an almost equal number of listeners misperceived tally, yet the /æ/ vowel in this item is acoustically much lower and more retracted than the three /e/ tokens. This suggests that another factor may be at play for this item, which we address in the following section.

First though, we turn to the structure of the lateral tokens, focusing on F2 at both the vowel-lateral (VL) transition and the midpoint of the lateral (L) to give an understanding of the role of the consonant (and its relative dark/clear quality) in the acoustic structure of the tokens (cf. section 1.3). F2 results at the VL transition and L target are shown in Table 4 below. F2 results for the preceding vowel are also given (also plotted in Figure 1).

Table 3. F2 of the /æC/-/æC/ tokens; V, VL and L

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>item</td>
<td>F2 V</td>
<td>F2 VL</td>
<td>B-C</td>
<td>F2 L</td>
</tr>
<tr>
<td>pellet</td>
<td>1582</td>
<td>1225</td>
<td>357</td>
<td>1225</td>
</tr>
<tr>
<td>Ellie</td>
<td>1952</td>
<td>1435</td>
<td>517</td>
<td>1330</td>
</tr>
<tr>
<td>tally</td>
<td>1341</td>
<td>1298</td>
<td>48</td>
<td>1274</td>
</tr>
</tbody>
</table>

Focusing on all three /l/ tokens, we see that the /l/ in Ellie is less dark (L has a higher F2) than in both pellet and tally, while pellet and tally have very similar, lower F2 values. The relative darkness of the /l/ corresponds with results discussed in 4.1, with the darkest /l/ present in pellet, the most frequently confused token (most likely due to its interaction with the vowel, shown above).

Aside from the lateral itself, the transition between the vowel and lateral could also potentially have affected listener responses. Table 3 shows that while the VL transition had the highest F2 in the word Ellie, this word also had the deepest plunge in F2 following the vowel midpoint (517 Hz compared to 357 Hz for the other /el/ token pellet). This drop in F2 may partly explain why more listeners guessed their answers for the Ellie stimuli (cf. 4.1). That is, the vowel was /e/-like initially (so listeners made less errors with the stimuli overall) but the plunge in F2 which caused the vowel to end much more retracted than it started likely caused some confusion (hence
more listeners reported guessing their responses for this stimuli than for the others). The acoustic analysis here goes some way in explaining listener errors in our sample set, with the tokens that were most confusable (pellet, tally) having vowels that are less like their /æC/-/æC/ counterparts when compared to the token that had the least number of errors (Ellie).

4.3. Lexical Frequency Analysis

In [7] we argue that lexical frequency effects appears to play some part in listener responses in a related experiment, and we also address this for the current experiment, which contains some of the same words (pellet, tally). As in [7], we used the ICE-AUS corpus to assess lexical frequency of the /æC/-/æC/ and /el/-/æl/ stimuli. We searched for occurrences of the stimuli (as well as their alternatives) in the spoken language section of the corpus, which involved both public and private discourse, and scripted and unscripted speech (total corpus: 46946 sentences).

As also seen in [7], the most troublesome experimental item for listeners was pellet, which was also least frequent in the ICE-AUS corpus (no occurrences). The alternative palate occurred slightly more often in the corpus (3 times), and was chosen by 25 listeners. Similarly, listeners also had trouble with tally, which was again less frequent than its counterpart telly (3 occurrences compared with 11). The other /el/ item, Ellie, was misperceived as Allie by 15 listeners. Ellie was only marginally less frequent than Allie in the corpus, with occurrences almost equal (3 tokens compared with 4), so results are less clear for these items. For pellet and tally though, results confirm what was also seen in [7] for the same experimental items but in a different task. That is, listeners make more errors in cases where the alternative stimuli (palate, telly) have a higher lexical frequency.

While only a small number of errors were made for head and had, it appears that alternative processes are at play. That is, had is much more frequently occurring than head (1642 occurrences compared with 181), but listeners made more errors with had (which was also presented first). This result may be explained through acoustic factors; the speaker is from Sydney and likely produced an /æ/ vowel that is higher than Melbourne listeners typically experience (cf. 1.3).

5. Discussion

In [7] order of presentation is also identified as a possible influencing factor on listener responses. However, in this experiment order of presentation can almost be ruled out as a factor, both in the experiment as a whole because the foil and /æC/-/æC/ tokens were presented first and very few listeners made errors for these tokens, in the set of /el/-/æl/ tokens, and considering the responses of listeners who guessed for various stimuli. However, we cannot rule order of presentation out completely given the discussion of the non-prelateral head-had stimuli in 4.3 above. In the /el/-/æl/ set, pellet was presented first and did actually have the largest number of errors (25), but tally was presented last and had an almost equal number of errors (23). Instead, frequency effects discussed in 4.3 appear to account for these responses. Still considering order of presentation, the participants who guessed their responses only made guesses for the three /el/-/æl/ stimuli, not for the first three items presented to them. This subset of listeners were most confused by the Ellie token (presented second), and made the least number of guesses for pellet (presented first in the /el/-/æl/ set). As discussed in 4.2, it is acoustic factors that appear to account for these results. Acoustic factors also seem to account for the fact that even though listeners had trouble with the two /el/ stimuli, the most misperceived item (pellet) has a vowel that was also acoustically least like /æ/ in other contexts, as well as a darker /l/. Results showing relative darkness of /l/ for the other two /el/-/æl/ items also confirm that the darkness of the /l/ impacts on listener responses.

6. Conclusion

This paper is a further contribution into how Australian English listeners respond to a sound change in progress, and the factors that influence their responses. We have seen previously that as well as merging /el/-/æl/ tokens in production, listeners from Melbourne also have more trouble distinguishing /el/-/æl/ stimuli in perception compared to other Australian English listeners [2, 7]. In [7] we suggested that both lexical frequency and order of presentation appeared to affect how listeners respond to such stimuli, but we were not sure of the degree of impact of these factors due to the need for more data. Here, the extra data allows us to confirm the role of lexical frequency effects, but order of presentation appears to not particularly affect listener responses (at least toward the /el/-/æl/ stimuli).

Additionally, this experiment provides helpful evidence that the acoustic structure of the stimuli also affects the degree of misperception across the items. In particular, we saw that the structure of both the vowels and the lateral is likely to be influencing listener responses.

While more work is needed to determine how acoustic structure affected responses in the other two experiments we carried out, described in [2], the results of this micro-analysis are useful. Firstly, they illustrate the different types of factors affecting Australian English listeners’ responses to (this) sound change. Secondly, these factors will need to be accounted for when designing further, larger-scale investigation into the /el/-/æl/ sound change which we have planned for the near future.

7. Acknowledgements

Thanks to Joshua Clothier for providing vowel formant data.

8. References