Exposure-independent comprehension of Greek-accented speech: evidence from New Zealand listeners

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ABSTRACT

Accents provide extensive variation in speech, which can cause difficulties for comprehension. However, after a period of exposure to a foreign accent, listeners are usually able to understand it better. This study examined whether New Zealanders could adapt to consider Greek-accented raised /ɪ/ in English as part of their native centralised /ɪ/ phonetic category. Participants listened to a story in either Greek-accented or New Zealand-accented speech, and then underwent a cross-modal priming and lexical decision task as well as a rating task to examine perception at different levels of speech processing. Participants correctly identified words in Greek-accented English whether they had previous exposure to the accent or not. This effect extended throughout the speech processing system, from automatic lexical activation to deliberate categorisation. We discuss reasons for these results, including perceptual flexibility for variant forms of vowels and a high level of familiarity New Zealanders have with the Australian accent.

Keywords: Speech perception, perceptual learning, accent comprehension, dual mapping

1. INTRODUCTION

Foreign accents are known to be a challenge for speech comprehension. Previous research has shown that listeners are capable of adapting to accented forms of words by learning from prior exposure to the accent [7], [16]. They allegedly achieve this by broadening their mental representations of sounds in their native language, also known as phonetic categories, to accommodate more variation in sounds. They also adjust the internal structure of these categories so that their exemplar sound is closer to the accented form [18].

As groups of people speak with relatively similar accents, generalising comprehension from one speaker to another should be beneficial. Xie & Myers [17] found that when listening to Mandarin-accented English speech, which usually devoices word-final /d/, listeners' generalisation of /d/ comprehension from one speaker to another was constrained by how acoustically similar the two speakers were in their /d/ production. Bottom-up information from the speech signal (i.e. similar vowel duration, closure duration and burst duration in word-final /d/) therefore drives generalisation more than top-down knowledge that two speakers are from the same accent group (e.g. explicit knowledge that both speakers have Mandarin accents).

"Dual mapping" of multiple pronunciations to one lexical representation may assist in specific instances of generalisation. For instance, Samuel & Larraza [12] found that highly proficient Basque-Spanish bilingual listeners accepted incorrect pronunciations of Basque sounds by L1 Spanish speakers even when no exposure phase was given. Similar results were found in Catalan-Spanish bilinguals [13]. This suggests that dual mapping develops when listeners are accustomed to hearing accented speech, and could aid rapid comprehension of the accent when listeners consider its sounds as allophones of native categories.

Exposing New Zealand-accented participants to Greek-accented speech is a particularly interesting way of examining potential accent adaptation. Firstly, these accent groups have not been examined in previous accent adaptation studies. Secondly, Greek speakers often produce /ɪ/ as [i] in English, due to the lack of /ɪ/ in Greek [11]. Finally, the New Zealand-accented centralised /ɪ/ is further from /iː/ in the vowel space than other English accents [2], so there should be even further ground for New Zealand listeners to cover when broadening their native /ɪ/ phonetic categories to include [i]-like productions.

In the present study, we exposed one experimental group of participants to Greek-accented English and one control group to New Zealand English, to see whether this experience would cause the experimental group to shift their phonetic category boundary for /ɪ/ to include /i/-like productions. We then used a cross-modal priming and lexical decision task and a categorisation task to measure this potential accent adaptation. Priming examines subconscious, automatic, online speech processing, while categorisation examines conscious, deliberate, offline speech processing [18]. Performance on these tasks may reveal if a boundary shift occurs for the experimental group compared to the control group, and then how far through the speech processing system it extends.

2. METHOD

2.1. Participants

45 participants took part in the accent adaptation study online. They were aged 18-29, currently living in New Zealand, and spoke New Zealand English. Most participants were raised in and currently living in Tāmaki Makaurau (Auckland), but some were from other regions such as Te Whanganui-a-Tara (Wellington) and Waitaha (Canterbury).

2.2. Materials

2.2.1. Priming task

180 pairs of English prime words, target words and non-words were chosen for the online cross-modal priming and lexical decision task. Word frequencies per 100 million words ranged from 200-7000 [6]. All words and non-words were one syllable, with CV, CVC, CVCC or CCVC structures. All words and non-words were 3-5 orthographic characters long.

There were 9 types of trial in total, with the most relevant critical and filler trials described in more detail in Table 1. These trials were designed to examine whether hearing a Greek-accented word containing /ɪ/ primed that same word, or an /iː/ minimal pair of the word, and how this compared with normal same word or minimal pair priming. There were 15 of each relevant trial.

Trial type	Description	Example
Critical-same	/ɪ/ primes, same word targets	*kiss*-KISS
Critical-MP	/ɪ/ primes, minimal pair targets	*ship*-SHEEP
Filler-same	/ɔː, ɜː, ɒ, uː/ primes, same word targets	*boss*-BOSS
Filler-MP	/ɔː, ɜː, ɒ, uː/ primes, minimal pair targets	*lawn*-LEARN

Table 1: Relevant trials in cross-modal priming and lexical decision task. Trials are depicted as *auditory prime*-VISUAL TARGET.

Other types of trials were designed to indicate how participants responded to targets when they were different to the primes. 90 trials also used word primes and nonword targets, so participants would properly attend to the lexical decision task.

It was predicted that the experimental group would respond more rapidly to critical-same trials where the target word matched the prime, as they would be more likely to correctly identify the prime.

2.2.2. Categorisation task

25 English words containing /ɪ/ that have /iː/ minimal pairs were used as auditory stimuli in the offline categorisation task. The words used in the offline task were also used in the online processing task in the critical-same or critical-MP trials.

2.3. Speakers

Speech was recorded from a Greek-accented speaker and a New Zealand-accented speaker.

The Greek-accented speaker speaks Greek as a first language. She is highly fluent in English. She recorded the story “Comma Gets a Cure” [8] for the experimental group exposure phase. She also recorded the 180 words that were used in the priming task, 25 of which were also used in the categorisation task.

The New Zealand-accented speaker is a monolingual New Zealand English speaker. She recorded the story “Comma Gets a Cure” for the control group exposure phase. She also recorded 10 words for practice trials of the priming task.

2.4. Procedure

The experiment was designed using the Gorilla Experiment Builder [1]. Participants completed the experiment virtually using their own laptop. They were instructed to sit in a quiet place and use headphones for the experiment.

Participants were provided with details of the study, including information on how to withdraw. After consenting to take part, they were randomly assigned to either the experimental group or the control group. The experimental group heard the story “Comma Gets a Cure” [8] in Greek-accented English, while the control group heard the story in New Zealand English. They then progressed to the remainder of the experiment.

2.4.1. Priming task

The first task employed cross-modal priming and lexical decision. In each trial, participants heard a Greek-accented prime word then made a lexical decision about a target on the screen, which may have been the same word, a different word or a nonword. They indicated their response using the keyboard. Response times were used to explore whether the target word had been activated when the auditory stimulus was presented. This task reflects online processing by probing instantaneous activation of lexical representations.

Participants were given instructions to the task, followed by 10 practice trials with auditory stimuli (using /ɛ/ and /aː/ vowels) produced by the New Zealand-accented speaker.

The main task was presented with breaks every 45 trials for a total of 180 trials. As soon as a button press was recorded, the next trial began. No feedback was given. Trials were presented in a randomised order, but primes and targets always appeared in the same pairs.

2.4.2. Categorisation task

After the priming task, the categorisation task began. All words in this task were also produced by the Greek-accented speaker. Words contained /ɪ/ sounds and had /iː/ minimal pairs, such as *ship* and *sheep*. Participants heard a word, then marked on a sliding 7-point scale between the two words where what they heard fell. A rating of 1 meant the word was heard strongly as its /ɪ/ version, such as *ship*, while a rating of 7 meant the word was heard strongly as its /iː/ version, such as *sheep*.

There were 25 trials in this task. This task probed offline processing by asking participants to make a conscious decision about word category.

2.5. Analysis

For the priming task, the effects of accent exposure and trial type on log response times were analysed using a mixed effects model. The group exposed to Greek-accented speech were the experimental group, and the group exposed to New Zealand-accented speech were the control group. For the categorisation task, effects of accent exposure on ratings of where words sat on the /ɪ/-/iː/ spectrum were analysed using a Mann-Whitney U test.

3. RESULTS

3.1. Priming task

3.1.1. Mean response time analysis

7759 out of 8100 trials were included for analysis, with those excluded being incorrect lexical decisions or outliers. A linear mixed-effects model with maximum likelihood was then used to assess response time averages. Exposure and Trial Type were included as fixed effects, while Participant and Item were included as random effects. Figure 2 shows the two groups' responses to the relevant trial types used in this model.

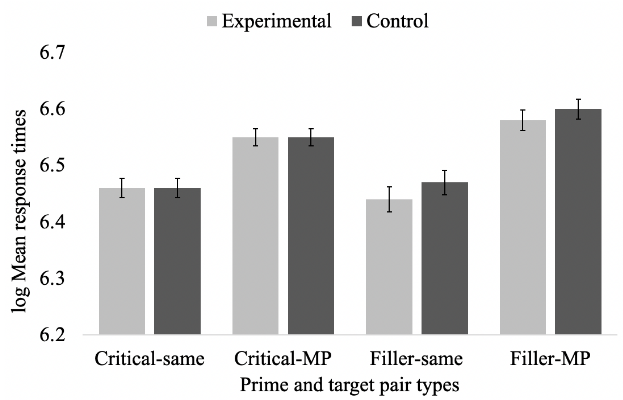

Figure 2: Log mean response times to different trial types by experimental group and control group participants in priming task.

ANOVAs between potential models found that a model with Exposure removed was not significantly different from the original model (X^2 = 0.07, p = 0.7859), indicating that participants performed at similar levels in this task irrespective of the accent they had been exposed to at the start. Further analysis was then completed using this model, with Category as a fixed effect and Participant and Item as random effects. This model's explanatory power (R^2 = 0.41) is substantial.

To investigate the potential effects of priming in the different types of trials, a post-hoc Tukey's test for mixed effects models was performed. This revealed that critical-same (e.g. *kiss*-KISS*)* and filler-same trials (e.g. *boss*-BOSS) mostly showed significantly different mean response times to six other trial types. The one exception was critical-MP trials (e.g. *ship*-SHEEP), which did not show significant differences in mean response times with both critical-same (p = 0.054) and filler-same (p = 0.08) trials. There was no significant difference in mean response times between critical-same and filler-same trials (p = 1.00).

These results suggest that priming was occurring, as trials in which primes and targets were the same word were responded to faster than trials with contrasting primes and targets. Additionally, accented /ɪ/ words successfully primed their written counterpart in the same way as words with no effect of accent, although there did appear to also be a small priming effect for /iː/ minimal pairs in the critical-MP trial.

3.1.1. Learning across task

To examine whether the groups showed different patterns of response times throughout the course of the experiment, mean response times at trial numbers 1-180 were calculated for each group.

All means showed a general downwards trend as trials progressed, which is likely to reflect a growing familiarity with the experiment. Mean response times for critical-same and critical-MP trials do not appear to show different directionality to the trend across all trials. This suggests that little learning occurred in these types of trials that was different to learning across the experiment. Control participants were therefore unlikely to have learned the Greek accent by hearing the speech in the task.

3.4. Offline processing task

A Mann-Whitney U test was conducted to measure the potential difference between groups in their responses in this task. This non-parametric test was chosen instead of an independent samples t-test as the responses are ordinal rather than continuous, and were not normally distributed.

There was no significant difference in median responses between the group exposed to Greek-accented speech (Mdn = 2) and the group exposed to New Zealand-accented speech (Mdn = 2) ($W = 155604$, $p = 0.63$), This indicates that both groups tended towards perceiving what they heard as /ɪ/ versions of the words, as intended by the speaker.

4. DISCUSSION

The results of this study indicate that participants correctly identified potentially ambiguous words in a foreign accent even without prior knowledge of this accent. This was indicated in the priming task, where accented /ɪ/ words successfully primed their written form, and in the categorisation task, where participants mostly rated the word they heard as being on the /ɪ/ side of the minimal pair scale. This accurate comprehension therefore occurred at both subconscious online and conscious offline levels of processing, which indicates that knowledge of the intended sounds could be extended throughout the speech system. Crucially, these results were almost identical for participants who had exposure to Greek-accented speech and for those who did not.

These results are mostly inconsistent with previous findings. Other studies [7], [18] found that experimental groups who had been exposed to accented speech responded rapidly to an equivalent of critical-same trials, but control groups did not. Xie et al. [18] also examined offline processing of accented words, and again found differences between experimental and control groups. Similar results were found in studies examining learning of accented vowel sounds [4], [10], [16].

Xie et al. [18] did also find that participants were unable to eliminate minimal pairs as competitors to accented words. They suggested that multiple aspects of accent that do not appear in lab-generated speech, among other factors, may have contributed to this. This may apply to the present study, in addition to participants having little prior knowledge of the accent (3 minutes for the experimental group and 0 for the control group). Minimal pairs may not have been eliminated as strongly as they would be if the acoustic signal only contained one altered feature from native speech or if participants had more exposure to the accent. It is worth noting that the difference in response times between critical-same and critical-MP trials was close to reaching significance, so the activation of minimal pairs when hearing an /iː/-like /ɪ/ word appeared to be low.

It is unlikely that the control group's ability to correctly identify accented /ɪ/ words was due to learning the accent in the online processing task, as response times in critical trials were consistent across the whole experiment. Various other factors may have contributed to this ease of processing.

The Greek-accented speaker is highly fluent in English, so her accent may have been relatively easy to understand compared to someone who does not speak English as fluently. Listeners may also generally be more willing to accept variation from their native categories in vowels than in consonants, as has been suggested by previous studies [14], [15]. New Zealand being highly multicultural [9], and therefore perhaps highly multilingual, may also contribute to this perceptual flexibility.

Another possibility is that New Zealanders may be highly familiar with the Australian accent, which is also known for its raised /ɪ/ [3]. Due to regular exposure to the Australian accent in their daily lives, New Zealand listeners may have accommodated Australian-accented vowels as allophones of their native categories, in line with the "dual mapping" theory proposed by Samuel & Larraza [12]. Greek-accented /ɪ/ may then follow these routes to be correctly categorised with ease. Further research is required to investigate whether these types of relationships do exist not only in bilingual environments, but in environments where multiple accents occur at high frequencies.

This study found that participants could understand accented speech at all levels of processing without necessarily having prior exposure to that accent. Further research may reveal factors that facilitate quicker and more successful accent comprehension.

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