What Can We Learn About the Brain from Talking Like a Scotsman?

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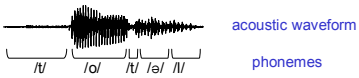
Introduction

Different dialects have different pronunciation patterns. Many adults can switch dialects depending on who they are talking to. What cognitive architecture makes this possible? How do dialect patterns interact with the coding system relevant for accessing words? We explore this issue in a dialect training study on Glaswegian English.

Noisy Signal, Discrete Representation: The physical speech signal is variable and noisy, yet the brain tracks the sounds of speech in terms of discrete categories, or *phonemes*. Why does the consonant **t**, e.g., always sounds like *t* in spite of the fact that no two pronunciations are identical?



Categories within categories: Some phonemes have qualitatively distinct variants, or *allophones*. Glaswegian English (**GE**) has different variants of the phonemes /t/ and /r/ from American English (**AE**). The /r/ in GE "rope" and "area" is like the /t/ in AE "city": A flap [ɾ]. The /t/ in GE "city" is like the /t/ in AE "two": aspirated [tʰ].

In our study, speakers of **American English** tried to imitate **Glaswegian English**.

Category (phoneme)	Position in word	American English	Glaswegian English
/t/	initial (*two*)	[tʰ]	[tʰ]
	medial (*pity*)	[ɾ]	[tʰ]
/r/	all (*race, berry*)	[ɹ]	[ɾ]

1. Can speakers learn to use [tʰ] where they would normally use [ɾ]?
2. Can speakers learn to use [ɾ] where they would normally use [ɹ]?

Learning from examples: **Exemplar models** and **neo-generative models** make different predictions with regard to (1) and (2).

Models

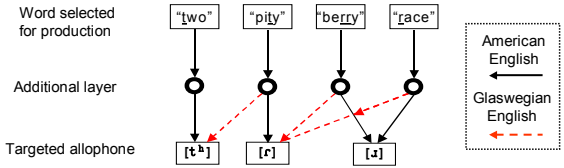
Exemplar models

- Speech events are represented in great phonetic detail and organized based on acoustic similarity.
- Categories emerge as clusters of similar event representations.
- Captures important results showing that phonetic details of particular speech events are accessible during later speech activity (Johnson, in press; Goldinger 1998).
- Associating allophones with new phonemes is predicted to be slow and incremental, and depends on the emergence of new allophones from clusters of new exemplars.

Neo-generative models

- Phonetic details of speech events are mediated by an abstract level of representation.
- Associating allophones with a new phoneme is predicted to be fast, general, and categorical. (Maye, in press; Peperkamp, to appear).

Key Difference: Additional layer supports generalization to new words.



Experiment

Materials

- Four types of target sentences; **/r/** or **/t/** occurs only in final word:
  - **t-initial**: He gave away his only token.
  - **t-medial**: The damp wind made him all sweaty.
  - **r-initial**: All the family's belongings lay beneath the rubble.
  - **r-medial**: The boy swallowed mud because he was curious.
- Non-target sentences include no **/r/** or **/t/**:
  - **non-target:** A display of the dig can be seen in the lobby.
- 192 target sentences were randomized into 4 sets of 48 sentences.
- 36 non-target sentences were randomized into 3 sets of 12 sentences.
- Adult male speaker of Glaswegian English. Recorded onto CD.

Procedure

Week One

Baseline: Participants read 1st set of target sentences aloud in their native dialect.

Training 1, 2: For 2nd set, participants listened to a recording of each sentence in Glaswegian and attempted imitation. Task repeated as Training 2.

Generalization 1: Participants tried to generalize the dialect to new sentences, without hearing a recording.

Week Two

Non-target 1, 2, 3: Before each target set in week 2, participants were refamiliarized with accent by listening to non-target set.

Training 3: Repetition of 2nd set (from Training 1, 2). No recording provided.

Generalization 1R: Repetition of 3rd set (from Generalization 1). No recording provided.

Generalization 2: Production of entirely new block. No recording provided.

Results

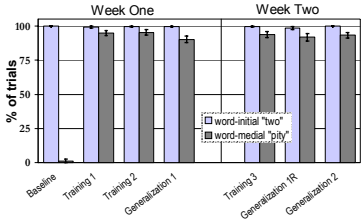


Figure 1. Mean rate of substituting [tʰ] for [ɾ].

Overall: Successful recruitment of [tʰ] for /t/.

Position: Medial /t/ slightly less accurate than initial /t/.

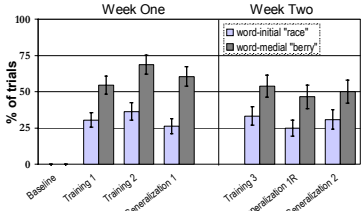


Figure 2. Mean rate of substituting [ɾ] for [ɹ].

Overall: Moderate success at recruiting [ɾ] for /ɹ/.

Position: medial /ɹ/ > initial /ɹ/ in all conditions.

Practice: Training 2 > Training 1.

Lexical Effect: Training 2, 3 > Generalization 1, 1R, but only slightly.

Time Effect: Week 2 shows only a small decline from week 1.

Summary/Discussion

Word-specific vs. general learning
- Dominant effect was general learning; word effects were secondary.

Categorical versus parametric learning
- Most subjects (variably) remapped flap allophone to /r/.
- Some phonetic innovations, especially in poor (strong, initial) flap contexts.
- Some subjects made no progress at either level.

Positional constraints
- Remapping was more successful in better (weak, intervocalic) flap contexts.

Exemplar models vs. neo-generative models
- Dominant effects accord with neo-generative models such as Maye et al., Peperkamp et al.
- Word effects recall effects found by exemplar theorists (Johnson, in press; Goldinger 1998).
- Total picture supports a hybrid model (Pierrehumbert 2002).

References

Goldinger, S. (1998) Echoes of echoes? An episodic theory of lexical access, *Psychological Review*, **105**, 251-279.
Johnson, K. (in press) Resonance in an exemplar-based lexicon: The emergence of social identity and phonology. *Journal of Phonetics*.
Maye, J., Aslin, R. N., & Tanenhaus, M. K. (2005) The weckud wetch of the wast: lexical adaptation to a novel accent. Submitted.
Peperkamp, S., Le Calvez, R., Nadal, J.-P. & Dupoux, E. (to appear) The acquisition of allophonic rules: statistical learning with linguistic constraints. *Cognition*.
Pierrehumbert, J. (2002) Word-specific phonetics. In C. Gussenhoven and N. Warner eds. Laboratory Phonology VII, Mouton de Gruyter, Berlin. 101-140.