Tracking the Timecourse of Perception: Ambiguous Rhoticity in Glasgow

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RESEARCH BACKGROUND

Rhoticity in Glasgow is changing. Middle class (MC) speakers are producing more strongly-rhotic variants in words such as *car* and *hurt* [1,2], but working class (WC) speech is undergoing **derhoticisation**, where /r/ is a weaker, pharyngealised variant [1,3].

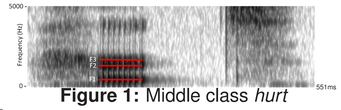


Figure 1: Middle class *hurt*

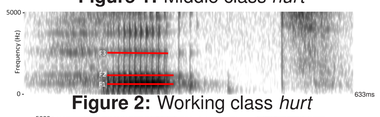


Figure 2: Working class *hurt*

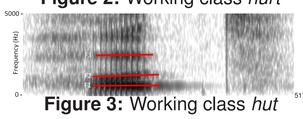


Figure 3: Working class *hurt*

A similar place of articulation in **derhoticised** /**r**/ and /ʌ/ (pharynx/uvula) causes perceptual ambiguity in /CʌrC, CʌC/ minimal pairs (Figs.2&3). Previous experiments show listeners' ability to distinguish pairs improves after long term familiarity (residence in Glasgow) [4] and short term learning (5min lab exposure) [5].

This paper tests the ability of Glaswegians (the most 'fluent' listeners) in distinguishing e.g. *hut/hurt* of a **MC talker** & of a **WC talker**, then examines performance under more difficult listening conditions: when the talkers are **mixed**.

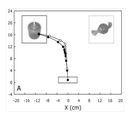
Research question:

How does hearing two talkers together affect /r/ perception?

In order to answer this question in the greatest detail, mouse tracking was used, as it allows for in-depth analyses such as spatial attraction.

MOUSE TRACKING

MouseTracker [6] records trajectories, allowing competitor strength to be measured [7]. This may highlight detail in the time course of decisions where there are differences between cohort and control conditions [8].



EXPERIMENT

Stimuli: 1xMC & 1xWC Gla. males, wordlist data.
Target words: *hut/hurt bud/bird fussed/first* etc.

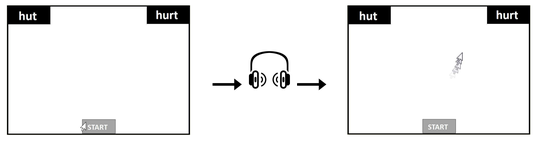
Design: 3x 2AFC tasks: 2x blocked by talker (for separate analyses of resp. to Single talkers) & 1x Mixed (analysis of resp. to Mixed stimuli).

Single MC → Single WC → Mixed MC+WC

(Order of Single blocks alternated per participant, for balance)

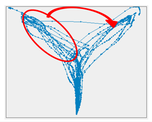
Single blocks: 12 target (+12 distr.) min. pairs
Mixed block: all 24(+24) MC & WC pairs
Total = 192 trials (~30min)

Procedure: On each trial, 51 native Glaswegians clicked 'START' to play the word (500ms delay). They were instructed to move the mouse upwards and click the word they thought they heard.

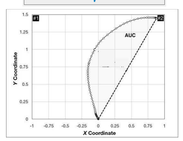


ANALYSIS

Correct trajectories ending at the top-left were flipped right, for ease of analysis.



Area Under the Curve [6] measures spatial attraction to competitor. Area between each trajectory and an idealised straight line calculated, then averaged.



Discrete Cosine Transformation defines curves as sinusoid coefficients [9]: k*0*=mean, k*1*=slope, k*2*=curvature etc. This facilitates comparison of differences between components of trajectories, as well as statistically modelling the coefficients.

RESULTS

Accuracy:
hut/hurt discrimination replicates [4] & [5]:
- MC = **99.01%**; WC = **90.27%**

Statistical modelling:
Mixed Effects Models run in R's lme4 package; best-fit models found with lmerTest's step()

Area Under the Curve: Interaction: Pr(>F)=0.01, F=6.02

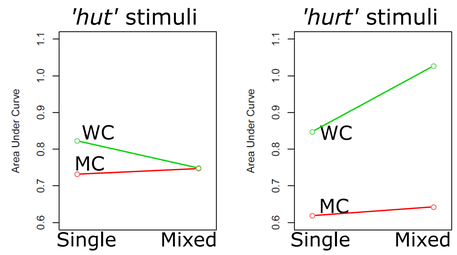


Figure 4: Sig. interaction: Class X Block X *hut/hurt*

- **AUC:** Higher = more spatial attraction to incorrect competitor
- Higher AUC for WC than MC stimuli
- Smallest AUC for **MC *hurt*** trajectories in Single block: **easiest stimuli to distinguish from *hut***
- Largest AUC for **WC *hurt*** in Mixed block: **hardest stimuli to distinguish from *hut***
- Larger AUC for all MC stimuli in Mixed block: more difficulty when heard with WC stimuli

Discrete Cosine Transformation: Int.: Pr(>F)=0.004, F=8.51

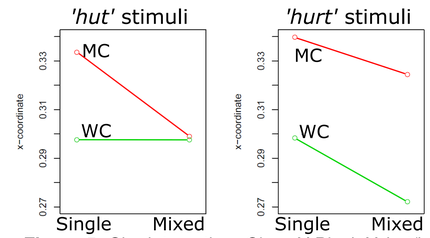


Figure 5: Sig. interaction: Class X Block X *hut/hurt*

- **k*0* (mean x-coord.):** Higher = greater/earlier horizontal movement towards correct response
- Earlier movements to correct MC response than to correct WC response
- Earlier movements to correct MC response in Single block than in Mixed block

Figure 6: x-coords/time, reconstructed from DCT coeffs. k*0*-k*3* (time=0: 'START' clicked, time=100: 'response' clicked)

- Comparison of Figs. 5&6 shows DCT is very effective in describing trajectory patterns

DISCUSSION

Discrimination of minimal pairs such as *hut/hurt* is most difficult with derhoticised /r/. However, even though MC pairs were easier to distinguish than WC pairs, MC stimuli in the Mixed block were harder to distinguish than in the Single block.

So the answer to the research question is:

Words are harder to distinguish when talkers are heard together

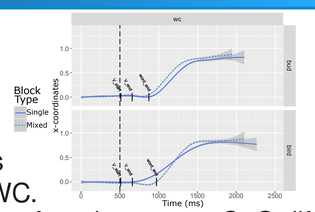
This highlights the difficulty of perceptually switching between speakers with different accents. It also suggests a similar finding as [10 & 11], who found integrated talker & phoneme processing.

ONGOING RESEARCH

This research will answer another question:

At what point does the listener decide what word they are hearing?

Trajectories have been aligned with segment data, enabling real-time comparison of when listeners moved the mouse while hearing stimuli.



Preliminary indications: following fricatives, to a greater degree than stops or nasals, facilitate **earlier discrimination** of e.g. *bu**st**/bur**st*** in MC than in WC. Fricatives can carry information about a preceding segment: spectral analyses found a greater CoG difference between MC /r/ & no-/r/ tokens' fricatives (850Hz), than the difference in WC fricatives (350Hz).

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