Testing the perceptual basis of laryngeal metathesis and rarity of preaspirated stops

Madeline Gilbert

Laboratoire de Phonétique et Phonologie, UMR 7018, CNRS/Sorbonne Nouvelle

madeline-besse.gilbert@sorbonne-nouvelle.fr

I. Introduction

- Observations about [hC] and [Ch] sequences:
  1. Cross-linguistically, postaspirated stops are more common than preaspirated stops (Silverman 2003)

     [Ch] > [hC]

     ~ 25% of languages have postaspirated stops (UPSID)

     <1% have preaspirated stops (Clayton 2010)

  2. Laryngeal metathesis often results in [h] 'docking' on the stop release (Yoon 2012)

     [hCV], [CVh] → [ChV]

     /pasta/: [pa**h**ta] → [pat**h**a]   Sevillian Spanish
     (Torreira 2006; Ruch 2013; Gilbert 2022)

     Also: Cayuga (Foster 1982), Cherokee (Flemming 1996), Balangao (Hume 2002), Cebuano (Wolff 1972) (non-exhaustive)

- Asymmetries argued to be driven by differences in perceptual strength of [h] in different contexts (Bladon 1986; Kingston 1990; Flemming 1996; Steriade 2001; Cho 2012; Yoon 2012)
  - Pre-stop coda [h] is perceptually weak
    - Low intensity
    - Formant structure in same regions as preceding vowel = perceptual 'masking'
  - Post-stop [h] is perceptually stronger
    - Stop release is high-intensity, high-volume, noisy
    - Increased auditory nerve sensitivity after silence (stop closure)

- Some experimental work supports the perceptual difficulty of [h] in [hC] sequences (Mielke 2003), but not all (Clayton 2010)

- **Goal**: Test perception of [h] in HC and CH contexts by listeners of different language backgrounds
  - → Is [h] more difficult to hear before a stop than after a stop?
  - → Is this universally true, or does native language experience affect perception?

II. Experiment Design

- ABX discrimination task
  - Trisyllabic nonce words with /aCa/ sequences
  - 3 conditions (C, HC, CH)
    - Acoustically manipulated to match within word sets (intonation contour, duration of [h])

	C	HC	CH
/apa/	fam**apa**	fam**ahpa**	fam**apha**
/ata/	lam**aka**	lam**ahka**	lam**akha**
/aka	lan**ata**	lan**ahta**	lan**atha**

  - Recorded by male native speaker of Turkish (has both CH and HC sequences)

- Presented in all orders (ABA, ABB, BAA, BAB) with ISI of 500ms

	Comparison type	Example
How perceptible is [h] before a stop?	HC/C	lan**ah**ta-lan**a**ta-lan**ah**ta (ABA)
How perceptible is [h] after a stop?	CH/C	lan**atha**-lan**a**ta-lan**atha** (ABA)

- 20 native-speaker listeners of Arabic (Levantine varieties), English (U.S.) and French (France), recruited on Prolific (4 excluded for low accuracy on controls)
  - Languages differ in **presence** and **phonological status** of HC and CH sequences

Language	HC	CH
Arabic	Yes - /h/	No
English	No	Yes – Asp. Stop
French	No	No

Hypothesis 1: Perceptual optimization	Hypothesis 2: Language-specificity
• [h] is perceptually weaker before a stop than after a stop	• Perception of [h] depends on native language experience (e.g., Werker & Tees 1984; Dupoux et al. 1999) • Listeners perceive sequences that exist in their language better than sequences that do not

Selected References

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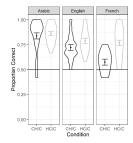
III. Results

- Linear mixed-effects models (posthoc tests with *emmeans* [Lenth 2020])

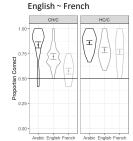 Accuracy ~ Language (Arabic, English, French)*Condition (HC/C, CH/C)

Language group x Condition
- Arabic: HC/C ~ CH/C
- English: HC/C ~ CH/C
- French: HC/C > CH/C

Condition x Language group
- CH/C: Arabic > English > French
- HC/C: Arabic > French
  - Arabic ~ English
  - English ~ French

- Results are **contrary** to those expected under the perceptual optimization hypothesis

> [h] is either:
> (a) easier to hear *before* a stop than *after* a stop (French)
> (b) equally perceptible in both locations (Arabic, English)

- Results support **language-specific perception**

Language	Properties	Result	Explanation
Arabic	• Phonemic /h/ as a coda • No CH sequences, but /h/ occurs after many other consonants	HC/C ~ CH/C	Familiarity with both types of sequences, with /h/ as a contrastive phoneme
English	• /h/ is phonemic, not allowed as coda • Voiceless stops are allophonically aspirated (CH)	HC/C ~ CH/C	Experience with aspirated stops helps perception of CH sequences, but not enough to put them above HC sequences Maybe: Presence of aspirated stops **and** /h/ makes [h] difficult to hear in CH sequences, because must decide about phonological status of [h]
French	• Has neither CH nor HC sequences • Surprisingly high accuracy	HC/C > CH/C	Maybe: Mapped [h] to phonemic French /ʁ/ → good discrimination, since contrast interpreted as /ʁC/-/C/ (Perceptual Assimilation Model, Best & Tyler 2007)

IV. Discussion & Conclusions

- High accuracy on HC sequences for all groups, contrary to findings in Mielke (2003) (methodological differences?)
- In line with other recent studies on [h] perception
  - **Clayton (2010)**: [h] is not harder to perceive in HC than in CH for Gaelic (has HC and CH) or Polish (has neither HC or CH) listeners
    - Only English listeners have more difficulty with HC than CH (word-medially)
  - **Hejná & Kimper (2018)**: British English listeners use preaspiration (**H**C) as cue to fortis-lenis contrast in stops, suggesting it is salient enough to be useful

- Cross-linguistic preference for postaspiration > preaspiration and directionality of HC → CH metathesis is not just perceptual
  - Preaspiration may be rare because it is rarely innovated (Clayton 2010)
  - Preaspiration often strengthened by adding oral stricture (Silverman 2003)
  - Metathesis may favor CH sequences because their gestural timing is more stable than HC sequences (Parrell 2012), or because laryngeal articulation prefers to 'bind' to stop release (Kingston 1990)
  - Subtle perceptual factors not captured here (e.g., poor listening conditions affect HC more than CH)?

- Outstanding questions on [h] in HC sequences
  - How do other cues interact in HC sequences to affect perception?
    - [h] in HC sequences is highly variable in production; variability absent from my stimuli
    - Breathy transition (Ní Chasaide 1985), preceding vowel duration, stop closure duration (Helgason 2002; Silverman 2003; O'Neill 2009; Clayton 2010) may provide additional cues to [h] in HC sequences
  - How does the *status* of [h] in HC sequences affect production/perception?
    - Status of preaspiration differs cross-linguistically: variable/optional (e.g., Italian [Stevens & Reubold 2014]) vs. obligatory (e.g., Faroese [Helgason 2002])
    - In metathesis, [h] is adjacent to the stop, but does not featurally *belong* to it