# Preserving Synchronic Parallelism: Diachrony and Opacity in Polish[*]

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## Goals

- outline a specific case of phonological opacity in Polish that is a problem for strictly parallel Optimality Theory (OT) (Prince and Smolensky 1993)
- provide evidence that this case of opacity is not synchronically productive
- construct an analysis of these data consisting of diachronically ordered strictly parallel phonologies, with the mechanism of Lexicon Optimization (Prince and Smolensky 1993) encoding the output of each historical stage directly into the evolving lexicon
- summarize implications of this analysis and issues for further study

## 1 Data

All data is from Jastrzębska-okoń and Billip 1993, confirmed by a native speaker. Broad IPA is used, with [ɕ] and [ʑ] for orthographic ⟨*ś*⟩ and ⟨*ź*⟩, [ʲ] for other palatalized sounds, and [ʂ], [ʐ], and [tʂ] for ⟨*sz*⟩, ⟨*rz*⟩, and ⟨*cz*⟩. Modern Polish has the vowel inventory in (1). Orthographic ⟨*y*⟩ is fronter and lower, closer to [ɪ], but I use [ɨ] to avoid discussing the evolution of Proto-Slavic [ɨ] to Modern Polish [ɪ].

(1)

| | *oral* | | | | *nasal* | |
|---|---|---|---|---|---|---|
| i | ɨ | u | | | | |
| | ɛ | ɔ | | | ɛ̃ | ɔ̃ |
| | ɑ | | | | | |

Polish generally has a contrast in obstruent voicing, but word-final obstruents must always be voiceless:

(2) klu**p** klu**b**ɨ 'club (SG/PL)'
ɕlɑ**t** ɕlɑ**d**ɨ 'remnant (SG/PL)'
bʐɛ**k** bʐɛ**gʲ**i 'edge (SG/PL)'

[ɔ] is banned before word-final voiced oral consonants; [u] appears instead:

(3) st**u**w st**ɔ**wɨ 'table'
sw**u**j sw**ɔ**jɛ 'pot'
m**u**l m**ɔ**lɛ 'moth'
dv**u**r dv**ɔ**rɨ 'mansion'

The generalizations in (2) and (3) interact opaquely in the data in (4), with the [ɔ]~[u] alternation 'overapplying' where it should not, before (surface) voiceless obstruents:

(4) gr**up** gr**ɔb**ɨ 'grave'
**rut** r**ɔd**ɨ 'family'
st**uk** st**ɔgʲ**i 'stack'

This type of opacity cannot be analyzed in strictly parallel OT:

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(5)
***d#** voiced obstruents cannot appear word-finally
***ɔd#** [ɔ] cannot appear before word-final voiced oral consonants
**ID-hi** do not change vowel height from input to output
**ID-voi** do not change voicing from input to output

(6)

| | /rɔd/ | *d# | ID-voi | *ɔd# | ID-hi |
|---|---|---|---|---|---|
| ☞ a. | rut | | * | | * |
| ☠ b. | rɔt | | * | | |
| c. | rud | * | | | * |
| d. | rɔd | * | | * | |

**Problem:** The opaque ☞ candidate [rut] (6a) is harmonically bounded by the ☠-marked transparent candidate [rɔt] (6b). Thus, no constraint ranking can get the opaque output as the winner.

Various analyses have been proposed to solve this type of problem in OT: sympathy (McCarthy 1999), turbidity (Goldrick and Smolensky 1998, Goldrick 2000), multiple levels (Goldsmith 1993, Inkelas and Orgun 1995, Kiparsky in press), etc. The common assumption (and motivating factor) behind these analyses is that opacity can be synchronically productive (non-OT analyses with this same assumption include Gussman 1980, Rubach 1984, and Kenstowicz 1994).

**Proposal:** Following the predictions of strictly parallel OT, assume opacity cannot be synchronically productive. Instead, opacity arises via a series of diachronically ordered parallel phonologies. The results of each stage of the grammar are encoded in the lexicon, and opacity is thus lexically memorized and never productive.

## 2 Productivity

There are two ways to test productivity: find lexical exceptions (especially in loanwords) and examine the phonology of nonsense words.

There are many lexical exceptions for the ban on [ɔ] before sonorants (7) and before voiceless obstruents which are voiced when non-final (8):

| | | | | | |
|---|---|---|---|---|---|
| (7) | ɔɕ**ɔ**w | *ɔɕ**u**w | 'donkey' | | |
| | ɑnʲ**ɔ**w | *ɑnʲ**u**w | 'angel' | | |
| | kɔvb**ɔ**j | *kɔvb**u**j | 'cowboy' | | |
| | x**ɔ**l | *x**u**l | 'lobby' | | |
| | pɑrɑs**ɔ**l | *pɑrɑs**u**l | 'umbrella' | | |
| | p**ɔ**r | *p**u**r | 'leek' | | |
| | kɔl**ɔ**r | *kɔl**u**r | 'card suit' | | |
| (8) | gl**ɔ**p | *gl**u**p | 'globe' | *cf.* gl**ɔ**bɨ | 'globes' |
| | sn**ɔ**p | *sn**u**p | 'snob' | *cf.* sn**ɔ**bɨ | 'snobs' |
| | ɛpʲiz**ɔ**t | *ɛpʲiz**u**t | 'episode' | *cf.* ɛpʲiz**ɔ**dɨ | 'episodes' |
| | k**ɔ**t | *k**u**t | 'code' | *cf.* k**ɔ**dɨ | 'codes' |
| | nɛkrɔl**ɔ**k | *nɛkrɔl**u**k | 'obituary' | *cf.* nɛkrɔl**ɔ**gʲi | 'obituaries' |
| | prɔl**ɔ**k | *prɔl**u**k | 'prologue' | *cf.* prɔl**ɔ**gʲi | 'prologues' |
| | x**ɔ**wt | *x**u**wt | 'homage' | *cf.* x**ɔ**wdɨ | 'homages' |
| | rɛk**ɔ**rt | *rɛk**u**rt | 'record' | *cf.* rɛk**ɔ**rdɨ | 'records' |
| | fʲ**ɔ**rt | *fʲ**u**rt | 'fjord' | *cf.* fʲ**ɔ**rdɨ | 'fjords' |
| | tʂ**ɔ**wk | *tʂ**u**wk | 'tank' | *cf.* tʂ**ɔ**wgʲi | 'tanks' |

Additionally, I conducted experiments in which two native speakers produced singulars from plurals (9). The results were similar to (8), with no [ɔ]~[u] alternation (further details in Appendix):

| | | | | | | |
|---|---|---|---|---|---|---|
| (9) | ʑnɑb**ɔ**t | *ʑnɑb**u**t | *from* ʑnɑb**ɔ**dɨ | ɕrɑb**ɔ**k | *ɕrɑb**u**k | *from* ɕrɑb**ɔ**gʲi |
| | pʂɑk**ɔ**t | *pʂɑk**u**t | *from* pʂɑk**ɔ**dɨ | ʂlɑp**ɔ**k | *ʂlɑp**u**k | *from* ʂlɑp**ɔ**gʲi |
| | ʂtɑp**ɔ**t | *ʂtɑp**u**t | *from* ʂtɑp**ɔ**dɨ | smɑt**ɔ**k | *smɑt**u**k | *from* smɑt**ɔ**gʲi |

This lexical and experimental evidence suggest that the [ɔ]~[u] alternation is not synchronically productive. But this alternation *is* prevalent in the lexicon, so it must still be accounted for diachronically.

## 3 Diachronic analysis

(10)

| | | | | | |
|---|---|---|---|---|---|
| pre-Polish | 12th century | V > Vː before word-final voiced C | rɔd | > | rɔːd |
| Old Polish | 14th century | word-final obstruents devoice, and *ɔː, ɛː > ɔ̣ː, ɛ̣ː* | rɔːd | > | rɔ̣ːt |
| Middle Polish | 16th century | Vː > V everywhere | rɔ̣ːt | > | rɔ̣t |
| modern Polish | 18th century | *ɔ̣ > u* (but note *ɛ̣ > ɛ*) | rɔ̣t | > | rut |

(based on Stieber 1968 and Gotteri 1998)

The exact quality of Middle Polish [ɔ̣] is debatable (similarly for [ɛ̣]). What is known is that it was somewhere between [ɔ] and [u]. For the purposes of this analysis, I assume that [ɔ], [u], and [ɔ̣] all differ from each other in height, and thus a change from one to another incurs a violation of ID-hi.

The following markedness constraints are relevant to this analysis:

(11) **CUE-voi** voicing must be adequately cued: (i) contemporaneous with or followed by a sonorant, (ii) preceded by a long vowel if word-final (perception; cf. Steriade 1997)
***Vː** long vowels are marked (articulatory effort)
***ɔː** [ɔː] is marked (articulatory effort: lax+length is bad? perceptual? Note that this constraint should apply to [ɛː] as well, since [ɛː] and [ɔː] both change in Old Polish)
***ɔ̣** [ɔ̣] is marked (*ɔ̣ ≫ *ɔ ≫ *u; universal markedness; cf. Archangeli and Pulleyblank 1994, where [ɔ̣] = [o])

The following input-output faithfulness constraints are also required:

(12) **ID-hi** do not change vowel height
**ID-voi** do not change voicing
**ID-μ** do not change vowel length

The main example word used in this analysis is Proto-Slavic *rɔdʊ* 'family', which becomes *rɔd* after final jers delete ('the fall of the jers', circa 1000 AD for Polish). Other hypothetical inputs will also be used to justify particular constraint rankings as needed. I begin my analysis around the 12th century, when the innovation of vowel lengthening before word-final voiced consonants seems to have been added.

### 3.1 L1 acquisition and diachronic sound change

**Richness of the Base (RotB)** (Prince and Smolensky 1993): multiple possible inputs are posited for the same desired output; these inputs are tested against current constraint hierarchy, with reranking occurring if necessary to ensure outputs for all inputs are grammatical.

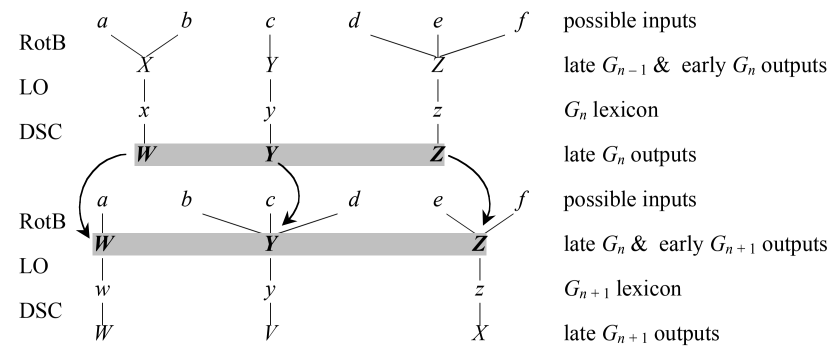
**Lexicon Optimization (LO)** (Prince and Smolensky 1993; see also Kiparsky 1968 for a prescient version of LO): after the RotB phase, in which a stable constraint hierarchy is created, LO allows those inputs which are most faithful (i.e. identical) to their output to be stored in the lexicon as URs. Weak LO of Prince and Smolensky 1993 further requires that each morpheme only be associated with one lexical entry (e.g. the root), while I assume a stronger version of LO that stores entire words, even if it means multiple lexical entries (e.g., singular and plural) for the same morpheme.

**Diachronic sound change (DSC):** productive, regular deviations in the sound pattern of the language, achieved in this analysis through reranking within the constraint hierarchy after LO has occurred. The outputs of DSC become the set of forms that the next generation uses for RotB. This next generation then in turn lexicalize these forms via LO, encoding historical innovations directly into their current lexicon.



I use the term 'early' to indicate the period of time in a historical stage of a language prior to the relevant DSC(s) in that stage. Analogously, the term 'late' is used to indicate the period of time after the DSC(s).

(13) acquisition and sound change for *n*th and (*n* + 1)th generations, $G_n$ and $G_{n+1}$




### 3.2 Pre-Polish vowel lengthening (12th c.?)

Early pre-Polish allowed voiced codas, so ID-voi ≫ CUE-voi. Vowels were not yet required to lengthen to cue voicing in early pre-Polish, so *Vː ≫ CUE-voi:

(14)

| /rɔd/ | ID-voi | *Vː | CUE-voi |
|---|---|---|---|
| ☞ a. rɔd | | | ** |
| b. rɔːd | | *! | * |
| c. rɔt | *! | | |

There are no long vowels in early pre-Polish, so ID-μ must be low-ranked (hypothetical input /nɑːk/):

(15)

| /nɑːk/ | *Vː | ID-μ |
|---|---|---|
| ☞ a. nɑk | | * |
| b. nɑːk | *! | |

Finally, the marked [ɔ̣] does not appear in pre-Polish, so *ɔ̣ ≫ ID-hi. Since [ɔ] and [u] both appear, *ɔ and *u must be ranked below ID-hi (hypothetical /nɔ̣kɔt/):

(16)

| /nɔ̣kɔt/ | *ɔ̣ | ID-hi | *ɔ | *u |
|---|---|---|---|---|
| ☞ a. nukɔt | | * | * | * |
| b. nɔkɔt | | * | **! | |
| c. nukut | | ***! | | ** |
| d. nɔ̣kɔt | *! | | * | |

Because *Vː is inviolable in early pre-Polish, the more specific constraint *ɔː cannot play a role and thus is unranked. The final constraint ranking for early pre-Polish is:

(17) ID-voi, *Vː ≫ CUE-voi, ID-μ; *ɔː; *ɔ̣ ≫ ID-hi ≫ *ɔ ≫ *u

By RotB, various inputs will be submitted to (17). In particular, the input /rɔd/ will emerge as [rɔd] (14). Since the input and output are identical, this input will be stored via LO as the UR for [rɔd] ‘family’. This UR will be the input for the DSC of late pre-Polish.

In late pre-Polish, long vowels emerged as a cue to word-final voicing. No other DSCs occurred. This DSC requires the reranking CUE-voi ≫ *Vː,*ɔː.

(18)

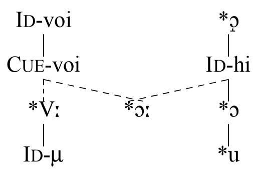
| /rɔd/ | ID-voi | CUE-voi | *Vː | *ɔː |
|---|---|---|---|---|
| ☞ a. rɔːd | | * | * | * |
| b. rɔd | | **! | | |
| c. rɔt | *! | | | |

In addition, raising of [ɔː] must be prevented by ID-hi ≫ *ɔː.

(19)

| /rɔd/ | *ɔ̣ | ID-hi | *ɔː | *ɔ | *u |
|---|---|---|---|---|---|
| ☞ a. rɔːd | | * | * | * | |
| b. ruːd | | **! | | | |
| c. rɔt | *! | | | | |

The constraint hierarchy for late pre-Polish is given below, with DSC-related rerankings shown with dotted lines. I assume that all other constraint rankings from early pre-Polish still hold:

(20)



Note that the plural form *rɔdɨ* undergoes no change at all because it satisfies all of the relevant high-ranked constraints:

(21)

| /rɔdɨ/ | ID-voi | CUE-voi | ID-hi | *ɔː | *Vː | ID-μ |
|---|---|---|---|---|---|---|
| ☞ a. rɔdɨ | | | | | | |
| b. rɔːdɨ | | | | *! | *! | * |

### 3.3 Old Polish devoicing and 1st vowel raising (14th century)

The RotB phase operating on pre-Polish outputs derives the same hierarchy as in (20).

The input /rɔːd/ outputs as [rɔːd] and is more faithful (identical, in fact) to [rɔːd] than any other input which outputs as [rɔːd], so by strong LO, /rɔːd/ is selected as the UR for [rɔːd]. Crucially, the plural UR is /rɔdɨ/, without underlying length (again, identical to the output). Weak LO would store this pair as /rɔd/ and /rɔdɨ/, with underlying identity.

In late Old Polish, two DSCs occurred: devoicing of word-final obstruent and raising of long mid vowels. CUE-voi reranked over ID-voi forces word-final obstruent devoicing:

(22)

| /rɔːd/ | CUE-voi | ID-voi |
|---|---|---|
| ☞ a. rɔ̣ːt | | * |
| b. rɔ̣ːd | *! | |
| c. rɔ̣d | **! | |

Raising of [ɔː] to [ɔ̣ː] requires numerous rerankings in late Old Polish:

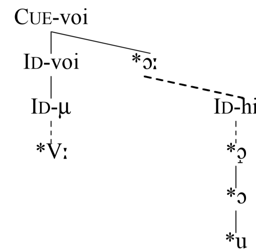


• *ɔː ≫ ID-hi, *ɔ̣ (to allow raising to occur at all);
• ID-μ ≫ *Vː (to preserve underlying length from surfacing); and
• ID-hi ≫ *ɔ̣ (to prevent [ɔː] from raising all the way to [uː]):

(23)

| /rɔːd/ | *ɔː | ID-μ | *Vː | ID-hi | *ɔ̣ | *ɔ | *u |
|---|---|---|---|---|---|---|---|
| ☞ a. rɔ̣ːt | | | * | * | * | | |
| b. ruːt | | | * | **! | | | * |
| c. rɔt | | *! | | | | * | |
| d. rɔːt | *! | | * | | | * | |

The constraint hierarchy for late Old Polish is:

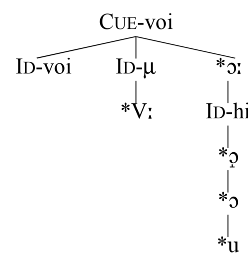
(24)



### 3.4 Middle Polish vowel shortening (16th century)

The language learner hears both [rɔt] and [rɔ̣ːt] (early pre-Polish *rɔt* and *rɔd*) with no surface environment to trigger length. Thus, underlying long vowels must be allowed to surface, so ID-μ ≫ *Vː.

Voicing is maximally cued, so CUE-voi ≫ *ɔː, ID-voi, ID-μ (note that the late pre-Polish ranking between ID-voi and ID-μ does not exist in early Middle Polish because it is not necessary; the ranking in late pre-Polish is merely a holdover from the earlier, pre-DSC pre-Polish grammar).

One step raising of [ɔː] is obligatory in early Middle Polish, so *ɔː ≫ ID-hi ≫ *ɔ̣ ≫ *ɔ ≫ *u still holds:

(25)



LO operates just as before, with the input identical to its output being stored as the UR. Thus, /rɔ̣ːt/ is stored as the UR for ‘family’.

In late Middle Polish, all long vowels shortened. This DSC requires *Vː to rerank over CUE-voi to prevent vowel lengthening before sonorants (hypothetical UR /dɑːr/):

(26)

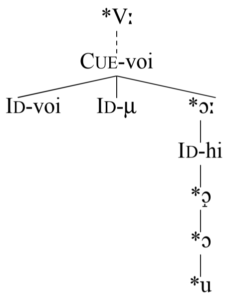
| /dɑːr/ | *Vː | CUE-voi |
|---|---|---|
| ☞ a. dɑr | | * |
| b. dɑːr | *! | |

Because CUE-voi was already ranked over ID-µ, *Vː transitively outranks ID-µ as well:

(27)

| /rɔ̣ːt/ | *Vː | CUE-voi | ID-µ |
|---|---|---|---|
| ☞ a. rɔ̣t | | | * |
| b. rɔ̣ːt | *! | | |

(28)




### 3.5 Modern Polish 2nd vowel raising (18th century)

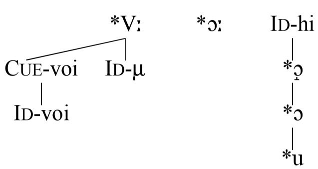
As in early Middle Polish, RotB in early Modern Polish results in a slightly different grammar than its predecessor (27). The language learner hears no short vowels, so *Vː >> CUE-voi, Id-µ.

Word-final devoicing is still productive, so CUE-voi >> ID-voi.

Finally, since the language learner hears both [rɔt] and [rɔ̣t], early Modern Polish must have ID-hi >> *ɔ̣ >> *ɔ >> *u to allow [ɔ̣] to surface.

Since *Vː is unviolated, *ɔː again plays no role and is unrankable.

(29)




By LO, the UR for [rɔ̣t] 'family' will be the input identical to it: /rɔ̣t/.

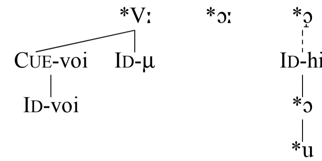
Late Middle Polish introduces further vowel raising as a DSC, changing /ɔ̣/ into [u] (in some dialects, this has not occurred, and [ɔ̣] is still distinct from [ɔ] and [u]). This DSC requires reranking ID-hi over *ɔ̣ (universal ranking of *ɔ over *u ensures that raising, not lowering, will satisfy *ɔ̣):

(30)

| /rɔ̣t/ | *ɔ̣ | ID-hi | *ɔ | *u |
|---|---|---|---|---|
| ☞ a. rut | | * | | * |
| b. rɔt | | * | *! | |
| c. rɔ̣t | *! | | | |

The final constraint ranking for late Modern Polish is:

(31)




As expected, underlying /rɔd/ does not emerge with devoicing and full raising as [rut] with this constraint ranking. Rather, it is rendered transparently as [rɔt]. The opacity rampant in the lexicon is not synchronically productive (cf. (6)):

(32)

| /rɔd/ | *Vː | ID-µ | CUE-voi | ID-voi | *ɔ̣ | ID-hi |
|---|---|---|---|---|---|---|
| ☞ a. rɔt | | | | * | | |
| b. rut | | | | | | **! |
| c. rɔ̣t | | | | | *! | * |
| d. rɔːd | *! | *! | * | | | |

### 4 Summary and some areas for further study

- Opacity in Polish involving [ɔ]~[u] alternation and word-final obstruent devoicing should not be a problem for synchronic parallel phonology since the [ɔ]~[u] alternation seems not to be productive.
- The framework of diachronically ordered parallel phonologies developed in this talk can be used to account for general historical sound change but is specifically well-suited for explaining historical opacity that is no longer synchronically productive.
- I have used this framework to analyze a purported case of opacity in Polish, showing how a series of sound changes and regular lexicon optimization have led to opacity being encoded directly into the lexicon but being rendered synchronically unproductive, matching lexical and experimental results.

**Raising?** In late Modern Polish, *ɛ̣ > ɛ*, lowering instead of raising like its back counterpart [ɔ̣]. This difference in mid vowel behavior could be related to the migration of Proto-Slavic [ɨ] to Modern Polish [ɪ], which crowded the front vowel space and may have forced [ɛ̣] to lower in order to be more perceptually distinct from [ɪ].

**Nasal codas?** Nasals do not trigger [ɔ]~[u] alternation, though they triggered vowel lengthening in pre-Polish. The vowel was probably also nasalized. Due to resonance in the unchanging nasal cavity, all nasal segments have a fixed nasal formant, $F_N$, higher than, but close to, F1 for mid vowels. There is perceptual blurring of F1 and $F_N$, with F1 sounding higher, which means the vowel sounds lower. This lowering effect may have shielded the vowels from Old Polish raising.

**Nasal vowels?** There is an alternation between ⟨ą⟩ and ⟨ę⟩, as in *ząb~zęby* 'tooth (SG/PL)', in many of the same environments as the [ɔ]~[u] alternation. Proto-Slavic distinguished front and back nasal vowels, but these vowels eventually merged into one, often written as ⟨ϕ⟩. Like all vowels, ⟨ϕ⟩ lengthened before word-final voiced consonants. This long ⟨ϕϕ⟩ eventually became a back nasal vowel (Modern Polish ⟨ą⟩) while short ⟨ϕ⟩ fronted to Modern Polish ⟨ę⟩. This alternation is opaque, like the [ɔ]~[u] alternation, and it should be possible to analyze it within this framework.

## Appendix

The two subjects who have taken part in this experiment so far are: MJ, a male in his mid-30s of unconfirmed dialect, who has been in the United States for over 10 years; and KN, a female teenager from Warsaw, who had been in the United States for approximately three months at the time of the experiment.

The subjects were given 3 repetitions each of the following types of sentences (spoken by a female native speaker of Polish in her 20s of unconfirmed dialect), in which the underlined word, a nonsense noun in the masculine nominative plural, was the only variable:

(33) Bardzo ładne <u>cztapody</u> dały Jankowi kawę, nie herbatę.
Bardzo ładne <u>smatogi</u> dały Jankowi kawę, nie herbatę. (etc.)
'The very pretty cztapuds (smatogs, ...) gave John coffee, not tea.'

The subjects were asked to say the following sentence three times, with the appropriate form of the nonsense word in the blank:

(34) Jeden bardzo ładny ______ pożyczył Jankowi i pieniądze, i koszulę.
'One very pretty ______ lent John both money and a shirt.'

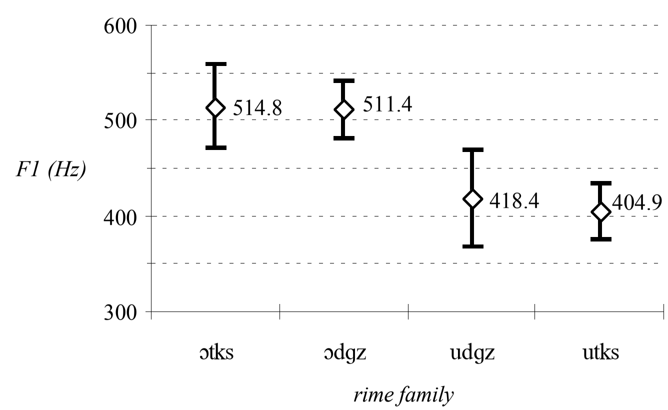
The valid form to go in the blank is the masculine nominative singular, which drops the vowel ending of the plural, and creates the environment for both raising of [ɔ] to [u] and for devoicing. Thus, these forms should be opaque if this case of opacity is productive.

F1, the phonetic correlate of height, was measured for the final vowel of all of MJ's tokens of the relevant nonsense words. These measurements were grouped into four rime families:

(35) ɔtks /ɔ/ followed by a voiceless obstruent
ɔgdz /ɔ/ followed by a voiced obstruent = should output with [u]
utks /u/ followed by a voiceless obstruent
udgz /u/ followed by a voiced obstruent

The following graph shows the mean and standard deviation of each family:

(36)






The data from the four families were subjected to the Tukey method of multiple comparison to test whether the differences between the means are statistically significant. The relevant statistic, the Studentized range statistic $q$, for each pairwise comparison of families is:

(37)

| | ɔtks | ɔdgz | udgz | utks |
|---|---|---|---|---|
| ɔtks | 0.000 | 0.367 | 10.278 | 11.717 |
| ɔdgz | 0.367 | 0.000 | 9.910 | 11.350 |
| udgz | 10.278 | 9.910 | 0.000 | 1.439 |
| utks | 11.717 | 11.350 | 1.439 | 0.000 |

The critical value for $q$ is approximately 5.6, based on 72 data points, 4 families, and a confidence interval of $\alpha = 0.001$ (Glass and Hopkins 1996 give the critical value to be 5.05, but I believe this to be a misprint; regardless, the results are the same with $q_{crit} = 5.05$ or 5.6). If the value of $q$ is greater than the critical value, the families are statistically different (that is, we can reject $H_0$ = 'the two families in the pair are identical') with 99.9% confidence. It is clear that the ɔtks family and (crucially) the ɔdgz family are both statistically different from utks and udgz families. Thus, for nonsense words, [ɔ] does not alternate with [u] in the expected environment, so this case of opacity is not synchronically productive for MJ.

Measurements for KN are incomplete. Impressionistically, the results for KN are the same as for MJ, and early computations support the ɔdgz family being statistically different from the utks and udgz families.

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