# Phonetic rhythm in *–ization*[*]

Juliet Stanton, NYU • Keio x ICU-LINC Colloquium Series • February 10/11, 2021

## 1 Introduction

- **Commonly assumed**: stress is the manifestation of linguistic rhythm (Liberman & Prince 1977).
- Rhythm implies *alternation*, or the timed succession of weak and strong beats.
  - In English, rhythmic alternation can be found at the phrase level.

    (1) Rhythmic alternation within a phrase (Hayes 1995:28)

    x
    x x x
    x x x x x
    x x x x x x x x x x x
    *twenty-seven Mississippi legislators*

  - Rhythmic alternation is also found at the word level.

    (2) Rhythmic alternation within a word (Hayes 1995:29)

    x
    x x
    x x x
    x x x x x x
    *reconciliation*

- Alternation implies *distance*: weak and strong beats are separated in time.
- **Question**: how do we measure rhythmic distance?
  - The way in which rhythmic distance is measured differs in foot-based and foot-free approaches to stress.
  - Distance, in recent foot-based approaches to stress (e.g. Kager 1999):
    - ≫ Constraints like PARSESYL requires syllables to be parsed into feet.
    - ≫ Constraints on foot form (e.g. IAMB, TROCHEE) and alignment (e.g. ALLFTLEFT) regulate distance between stresses.
  - Distance, in recent foot-free approaches to stress (e.g. Gordon 2002):
    - ≫ Constraints like *LAPSE and *CLASH directly regulate the distance between stressed and stressless syllables.

      (3) *LAPSE assign one * for each sequence of two adjacent stressless syllables.

      (4) *CLASH: assign one * for each sequence of two adjacent stressed syllables.

    - ≫ These constraints are often referred to as *rhythmic* constraints.
- These approaches are superficially different, but share something fundamental: they calculate distance over units of formal structure (syllables and feet).
- **This talk** explores an alternative: rhythm is calculated not over units of formal structure, but over duration, in a more direct way.

**Outline**

- Evidence for this alternative: suffixal stress in American English *-ization* (see also Stanton 2019 for similar evidence from *-ative*).
  - In *-ization*, stress on the inner suffix is variable.
  - **Claim**: this variability is, at least in part, governed by rhythm.
- In *-ization*, inner suffix stress becomes more likely as its distance from the rightmost stem stress increases.
  - Words like *federalization* more likely to bear *-ize* stress than words like *realization* (distance measurable in syllables, duration, or segments).
  - Words like *baptization* more likely to bear *-ize* stress than words like *realization* (distance measurable in duration or segments).
- **Main point**: the metric of distance speakers use references duration in a more direct way than is generally assumed by theories of stress.

[*]Thanks to A. Albright, D. Steriade, and audiences at NYU, AMP 2020, Berkeley, and Cornell.

## 2 Stress in *-ization*

- Our interest: words ending in *-ization* vary in whether or not *-ize* bears stress.

(5) Stress on *-ize-* is variable (Data source: OED)
  a. Stressed *-ize-*: *solarization*, *lemmatization*
  b. Stressless *-ize-*: *fascization*, *functionalization*
  c. Variable: *relativization*, *serialization*

- Necessary to first review more general properties of stress in *-ization* to answer a few questions: what factors favor/disfavor stress on *-ize*?

### 2.1 Background

- It is useful to separate words that end in *-ization* into two domains: the stem (pre-*ization* material) and the suffixal domain (*-ization*).

(6) Division of *–ization* forms into stem and suffixal domains

s o l a r – i z e - a t e - i o n
*stem* *suffixal*

f a s c – i z e - a t e - i o n
*stem* *suffixal*

- We need just a few assumptions, for now, to illustrate why *-ization* stress varies.
  - Stress on *-ize* is compelled by a suffix-specific constraint, STRESS$_{\text{-}ize}$.

(7) STRESS$_{\text{-}ize}$: assign one * if the suffix *-ize* does not bear stress.

  - Stressing *-ize* and *-ate* violates *CLASH; *-ize* destressing can thus be seen as a clash-avoidance strategy.
  - Preference for *-izátion* (vs. *-ization*) due to *LAPSER (Gordon 2002).

(8) *LAPSER: assign one * if neither of the final two syllables is stressed.

  - *LAPSER ≫ STRESS$_{\text{-}ize}$ explains why it's *-ize* stress that varies.

(9)

| sérial-ize-ate-ion | *LAPSER | *CLASH | STRESS$_{\text{-}ize}$ |
|---|---|---|---|
| ☞ a. sèrialìzátion | | * | |
| ☞ b. sèrializátion | | | * |
| c. sérialìzation | *! | | |

### 2.2 Rhythmic effects in *-ization* stress

- **The question**: can we predict when *-ize* is more or less likely to bear stress?
- Corpus study conducted to see if rhythmic factors are implicated in *-ization* stress (cf. Stanton 2019:7.2): all *-ization* forms in the OED as of 2/19 (n=773).
  - Inner suffix counted as "stressed" if *-ize* transcribed as [aɪz].
  - Inner suffix counted as "stressless" if *-ize* transcribed as [ə] or [ɪ].
  - Variable cases are assigned to the "stressed" category (doesn't affect results).
- Results (10) demonstrate a rhythmic effect in *-ization* stress: *-ize* stress is more frequent when it resolves a lapse than when it creates a clash.[1]

(10)

| Effect of *-ize* stress | Stressed *-ize* | Stressless *-ize* | % stressed |
|---|---|---|---|
| *CLASH violation | *còncrètìzátion* (n=59) | *mètronòmizátion* (n=33) | 64.1% (59/92) |
| *LAPSE satisfaction | *chànnelìzátion* (n=529) | *dichòtimizátion* (n=32) | 94.3% (529/561) |
| *EXTLAPSE satisfaction | *fèderalìzátion* (n=202) | *cùlturalizátion* (n=3) | 98.5% (202/205) |

  - A logistic regression finds a significant difference between the *CLASH and *LAPSE contexts, as well as the *LAPSE and *EXTLAPSE contexts.
  - Factors not included in the model:
    - ≫ Derivative (*-ization*) and base (*-ize*) frequency: $\chi^2$ (2) = 1.51, $p$ = .47
    - ≫ Identity of final segment (/s/ vs. others): $\chi^2$ (1) = .00, p = .99
- A detailed look at the data shows variance within some rhythmic categories.
  - In the *CLASH context, rate of *-ize* stress varies with interstress material.[2]

(11)

| Interstress seg(s). | Stressed *ize* | Stressless *ize* | % stressed |
|---|---|---|---|
| Sonorant (R) | *xè**n**ìzátion* (n=17) | *rèa**l**izátion* (n=15) | 53.1% (17/32) |
| Obstruent (O) | *stỳlò**p**ìzátion* (n=17) | *fàs**c**izátion* (n=11) | 60.7% (17/28) |
| Cluster (CC) | *bà**pt**ìzátion* (n=20) | *òbjè**ct**izátion* (n=6) | 76.9% (20/26) |

  - The rate of *-ize* stress does not vary noticeably within the *LAPSE and *EXTLAPSE resolution contexts; the numbers are close to ceiling.

[1] Numbers in (10) adds up to more than 773 because some stems have two stress patterns, e.g. *multimer-ization* can be 202-?10 or 020-?10. In such cases, variants are counted as separate stems.

[2] A logistic regression finds that neither the R vs. O nor the O vs. CC comparisons are significant. In addition, there are 6 cases where a vowel-final stem takes *-ization* (e.g *Maoization*). In 5/6, *-ize* is reported to at least variably bear a stress. Because the number of such forms is small, and it is possible that there are additional constraints on V́V hiatus, I do not include these forms here.

## 2.3 Hypothesis

- **Hypothesis**: *-ize* stress is sensitive to duration. The longer the distance between the rightmost stem stress and *-ize*, the more likely *-ize* is to be stressed.
- Analytically: *-ize* stress is governed by a phonetic version of *CLASH.
  - If this is correct: as the number of syllables between the rightmost stem stress and *-ize* increases, so should the duration (expected given (10)).

    (12) Different interstress durations (in black) in *-ization* forms
    a. V̀ $C_0$ -ìzátion (*fa**sc**ization*) : shortest
    V̀ [ $C_0$ ] *ìzátion*
    b. V̀ $C_0$V $C_0$ -ìzátion (*cha**nnel**ization*): longer
    V̀ [ $C_0$V $C_0$ ] *ìzátion*
    c. V̀ $C_0$V $C_0$V $C_0$ -ìzátion (***federal**ization*): longest
    V̀ [ $C_0$V $C_0$V $C_0$ ] *ìzátion*

  - ⪰ Seems obvious: more syllables should mean more duration.
  - ⪰ However, Nespor & Vogel (1989:102) hint at the existence of lapse compression in English, so this prediction should be verified.
  - Given (11), we might also expect for clashes with sonorants to be shorter than those with obstruents, which might be shorter than those with clusters.

    (13) Different clash lengths in *-ization* forms (clash is in black)
    a. V̀ ***R*** -ìzátion (*xe**n**ization*: shortest
    V̀ [ ***R*** ] *ìzátion*
    b. V̀ ***O*** -ìzátion (*stylo**p**ization*): longer
    V̀ [ ***O*** ] *ìzátion*
    c. V̀ ***CC*** -ìzátion (*ba**pt**ization*): longest
    V̀ [ ***CC*** ] *ìzátion*

- We need to know whether or not trends in the dictionary data correlate with trends in duration, and whether or not speakers' preferences match these trends.

# 3 Experimental support

- To test the hypothesis, I conducted a forced-choice task (*-izátion* vs. *-ìzátion*; Section 4.2) and a production task (Section 4.3).
- **Overall**: both sets of results converge on the same conclusion. Speakers are sensitive to duration and use this when producing or judging an *-ization* form.

Table 1: *-ization* items, by rhythmic profile and interstress C(s)

| *CLASH (n=10) Interstress C(s) | *LAPSE (n=10) Interstress C(s) | *EXTLAPSE (n=10) Interstress C(s) |
|---|---|---|
| *Pràgueizátion* [g] | *Ègyptizátion* [dʒ], [pt] | *Pròvidenceizátion* [v], [d], [ns] |
| *Quebècizátion* [k] | *Wyòmingizátion* [m], [ŋ] | *Sènegalizátion* [n], [g], [l] |
| *Chàdizátion* [d] | *Cùbanizátion* [b], [n] | *Ìndianàpolisizátion* [n], [p], [l] |
| *Ròmeizátion* [m] | *Bròoklynizátion* [kl], [n] | *Antàrcticanizátion* [ɪ(k)t], [k], [n] |
| *Japànizátion* [n] | *Àustinizátion* [st], [n] | *Blòomingtonizátion* [m], [ŋt], [n] |
| *Brònxizátion* [ŋks] | *Tèxasizátion* [ks], [s] | *Mèxicanizátion* [ks], [k], [n] |
| *Vermòntizátion* [nt] | *Phòenixizátion* [n], [ks] | *Mìchiganizátion* [ʃ], [g], [n] |
| *Frànceizátion* [ns] | *Alàskanizátion* [sk], [n] | *Òberlinizátion* [b], [ɪl], [n] |
| *Bàsqueizátion* [k] | *Rùssianizátion* [ʃ], [n] | *Màdisonizátion* [d], [s], [n] |
| *Mìnskizátion* [nsk] | *Ìcelandizátion* [sl], [nd] | *Ròchesterizátion* [tʃ], [st], [ɪ] |

## 3.1 Items and acoustic analysis

- For the experiment, I recorded one speaker producing *-ìzátion* and *-izátion* variants of forms that ended in *-ization*, all placenames or demonyms (Table 1).
  - Ten items where *-ize* stress would violate *CLASH, and ten where *-ize* stress would satisfy *LAPSE, and ten where *-ize* stress would satisfy *EXTLAPSE.
  - Within categories, segmentals following the rightmost stem stress differed.
- Durational properties of these forms are in line with the predictions above.
  - Distance from the rightmost stem stress to the *-ize* suffix is shortest in the *CLASH context, longer in *LAPSE, and longest in *EXTLAPSE (Fig. 1).[3]
  - Sonorants between two stresses are shorter than obstruents (though not by much), which are shorter than clusters (Fig. 2).
- First part of the hypothesis is plausible: broad trends discovered in the dictionary study correlate with properties of the productions.

[3] Figure 3 and all other plots were produced with R's ggplot2 (Wickham 2016).

Figure 1: Interstress duration by the number of interstress syllables

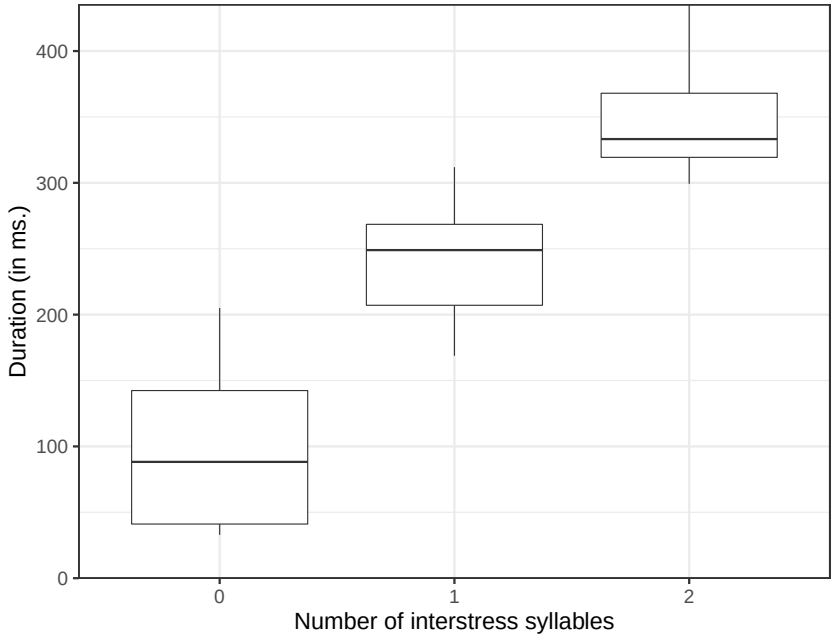
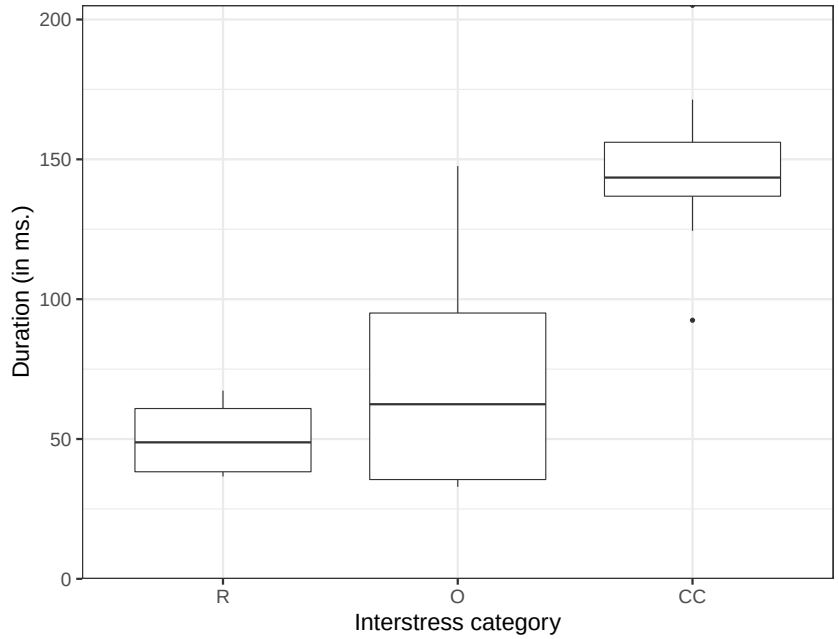



Figure 2: Interstress duration by the type of interstress consonant(s)




## 3.2 Forced-choice task

### 3.2.1 Design

- Stimuli were created from the forms in Table 1, differing only in suffixal stress (examples: *Quebècizátion-Quebècizátion*, *Mèxicanizátion-Mèxicanizátion*).
- Participants were told they were helping a travel company pronounce words in new slogans (*Prepare for the **Quebecization** of your vacation!*).
- Participants heard a recording of the placename (e.g. *Quebec*). They chose between two possible pronunciations of the derivative (e.g. *Quebecization*).[4]

### 3.2.2 Participants

- Fifty participants recruited using Mechanical Turk. All indicated that they are native U.S. speakers of English. None were excluded; all were compensated.

### 3.2.3 Results

- Patterns in the data suggest that the hypothesis is correct.
  - Distinctions among rhythmic categories are what we would expect, given the dictionary data and acoustic results.
    - ⩾ For the *CLASH context (*Quebecization*), 34.9% prefer *-ize* stress.
    - ⩾ For the *LAPSE context (*Austinization*), 39.4% prefer *-ize* stress.
    - ⩾ For the *EXTLAPSE context (*Mexicanization*), 40.2% prefer *-ize* stress.
  - The positive correlation between *-ize* stress and interstress duration is also expected: the worse the clash, the more likely *-ize* destressing (Figure 3).
- Interestingly, the statistics indicate that only duration (and *not* rhythmic category) played a role in participants' responses.
  - The best-fit mixed-effects logistic regression model finds a significant effect for duration and for the identity of the final segment (/s/ vs. others).[5]

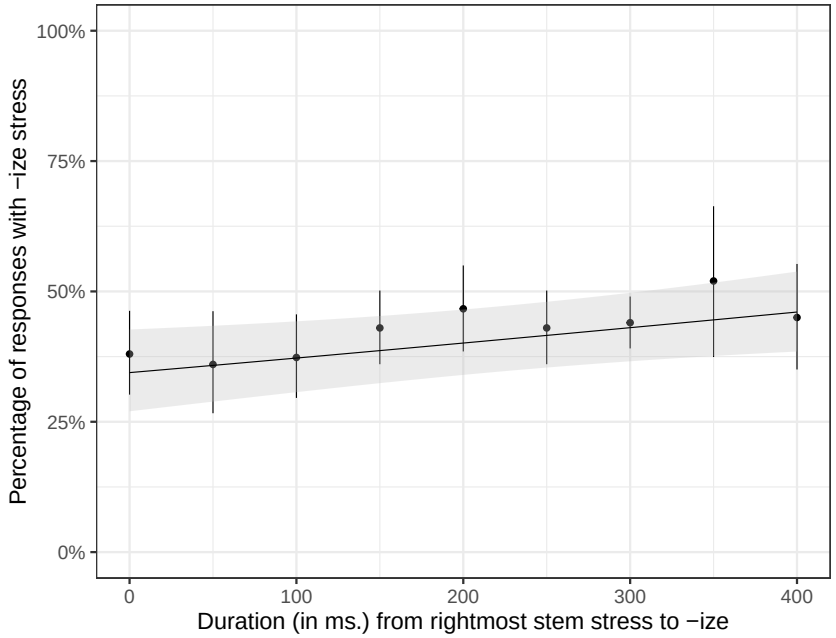
(14) Model with duration as fixed effect

| Factor | Coefficient | *z* value | Significant? |
|---|---|---|---|
| (Intercept) | -0.70 | – | |
| Duration | 1.21 | 2.36 | Yes ($p < .05$) |
| Final /s/ | 0.32 | 2.17 | Yes ($p < .05$) |

[4]The order of stressed and stressless *-ization* was randomized by item and participant; item order was randomized by participant. Experiments were made with Experigen (Becker & Levine 2013).

[5]All models were fitted using the glmer function of R's lme4 (Bates & Maechler 2011) and include a random intercept for participant. Significance values are from lmerTest (Kuznetsova et al. 2016).

Figure 3: Preference for *-ize* stress by interstress duration




- As with the corpus data, frequency of the *-ization* derivative and its *-ize* base don't play a role in speaker responses ($\chi^2$ (2) = 4.37, $p$ = .11).
- Adding a predictor for rhythmic category does not improve the fit of the model ($\chi^2$ (2) = .16, $p$ = .93), nor does adding an interaction.
- ((14) also has a lower AIC/BIC than a model with rhythmic context.)

- What we can take away from these results:
  - Phonetic rhythmic information plays a role in speakers' judgments about whether or not to destress *-ize* in *-ization*.
  - It's the *duration* between the last stem stress and *-ize* that matters. The rhythmic category the form belongs to (*CLASH, *LAPSE, *EXTLAPSE) only matters insofar as these categories are shorthand for duration.

## 3.3 Production study

### 3.3.1 Design

- Stimuli were identical to those in the forced-choice task.
- Participants were told they were helping a travel company pronounce words in new slogans (*Prepare for the **Quebecization** of your vacation!*).
- Participants heard a recording of the placename (e.g. *Quebec*). After this, they pronounced the slogan aloud.

### 3.3.2 Participants

- Fifty-seven participants were recruited over Craiglist, Facebook, and Twitter[6]. All but one indicated that they were native speakers of English from the U.S.
  - One speaker was excluded for being a native speaker of Canadian English.
  - Six additional speakers were excluded; while they claimed to be monolingual speakers of English from the U.S., I don't think they were being truthful.
- The experiment took place over the Zoom webconferencing platform. Participants were recorded to the Cloud and compensated for their time.

### 3.3.3 Results

- Most productions (992/1495) did not involve rhythmic modification of the item (e.g. *Quebècizátion*). I'll refer to these as the 'default' productions.
- I grouped non-default productions into four categories: addition, deletion, stress shift, and *-ize* stress. Ultimately, we're interested in deletion/*-ize* stress.
- Note that a single form can belong to more than one category: it's possible to exhibit e.g. deletion and *-ize* stress at the same time (e.g. *Ìndianàpolìzátion*).

**Addition**

- Addition: material is added to either stem or suffixal domain.
  - Examples: *Franceizization* (suffix doubled), *Romanization* (demonym).
  - The 61 items exhibiting addition were not evenly distributed (15) by rhythmic context; most (51/61) additions happened in the *CLASH context.

(15) Addition by rhythmic context

| Rhythmic context | No addition | Addition | % addition |
|---|---|---|---|
| *CLASH | *Bronxization* (n=445) | *Bronx**in**ization* (n=51) | 10.3% (51/496) |
| *LAPSE | *Egyptization* (n=491) | *Egypt**iz**ization* (n=9) | 1.8% (9/500) |
| *EXTLAPSE | *Michiganization* (n=1) | *Michigan**if**ication* (n=498) | .002% (1/499) |

[6]Thanks to Lisa Davidson for posting my ad to her Twitter account.

- This is independently interesting, for rhythmic reasons.
  - Addition doesn't make sense, from a rhythmic perspective: it takes a form that could exhibit perfect alternation and gives it a lapse.
  - Rhythmic distribution suggests a sensitivity to the length of a stress lapse.
  - The suggestion: lapse creation is okay, but lapse elongation is not.
- Within the *CLASH context, addition is likely not rhythmically conditioned: *Romanization* (an existing demonym) is the most frequent error.

**Stress shift**

- Stress shift: stress in the *-ization* stem is realized differently than in isolation.
  - Example: *Egỳptizátion*, instead of *Ègyptizátion*.
  - The 101 tokens exhibiting stress shift are concentrated in four items: *Egyptization*, *Icelandization*, *Rochesterization*, and *Japanization* (16).

(16) Rates of stress shift by item

| Item | No stress shift | Stress shift | % stress shift |
|---|---|---|---|
| *Egyptization* | 17 | 33 | 66% |
| *Japanization* | 27 | 23 | 46% |
| *Icelandization* | 35 | 15 | 30% |
| *Rochesterization* | 38 | 12 | 24% |
| *Senegal* | 46 | 4 | 8% |
| *Quebec* | 46 | 3 | 6% |
| *Providence* | 48 | 2 | 4% |
| *Vermont* | 48 | 2 | 4% |
| *Antarctica* | 49 | 1 | 2% |
| *Austin* | 49 | 1 | 2% |
| *Mexico* | 48 | 1 | 2% |
| *Michigan* | 49 | 1 | 2% |
| *Oberlin* | 49 | 1 | 2% |
| *Phoenix* | 49 | 1 | 2% |

  - Why these items?
    - ≥ *Jàpanizátion*: existence of *-ize* base with this stress.
    - ≥ *Egỳptizátion* and *Ìcelàndizátion*: relative (*Egyptian*, *Icelandic*) with this stress (see Steriade 1999, Stanton & Steriade in prep on these effects).
    - ≥ *Rochèsterizátion*: secondary stress in that position, for some speakers.
- Stress shift is interesting but orthogonal; it's not governed by rhythm.

**Deletion and *-ize* stress**

- Deletion: deletion of stem or suffixal material.
  - Examples: *Madonization* (stem deletion), *Madisonation* (suffix deletion).
  - Deletion was relatively frequent (160/1495 items, or 10.7%).
- *-ize* stress: pronunciation of *-ize* as [aɪz].
  - Most frequent change, occurring in 243/1495 (16.3%) of the tokens.
  - Most speakers were either consistent *-ize* stressers (n=2) or consistent non-stressers (n=33), with fewer (n=15) showing variation.
- Deletion and *-ize* stress are part of a conspiracy: both reduce the amount of material between the rightmost stem stress and the suffixal stress.
  - In an OT analysis, we can view the variation between them as variation in the ranking of MAX (17) and *CLASH.

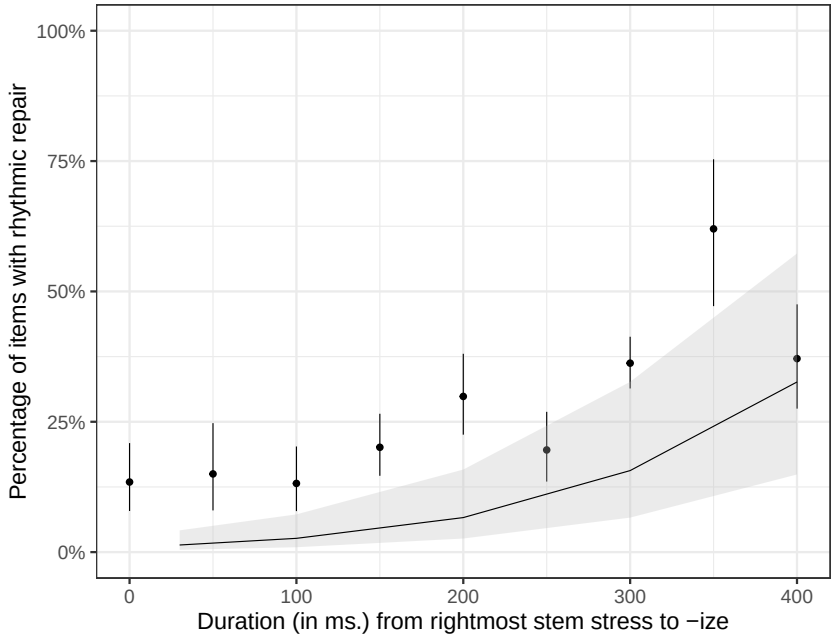
(17) MAX: assign one * for each input segment that lacks an output correspondent.

(18)

| | Màdison-iz-at-ion | *EXTLAPSE | *CLASH | MAX |
|---|---|---|---|---|
| ☞ | a. Màdison-ìz-át-ion | | * | |
| ☞ | b. Màdon-iz-át-ion | | | ** |
| | c. Màdison-iz-átion | *! | | |

  - If *CLASH ≫ MAX, we get deletion; if the reverse, we get *-ize* stress.
- Because of their similarity, I'll refer to these together as *rhythmic repair*.
- Rhythmic repair is distributed unevenly across rhythmic contexts.
  - In the *CLASH context (*Quebecization*): 8.5% of tokens exhibit it.
  - In the *LAPSE context (*Austinization*): 15.3% of tokens exhibit it.
  - In the *EXTLAPSE context (*Mexicanization*): 23.8% of tokens exhibit it.
- It also tracks duration: the longer the distance from the rightmost stem stress to the righmost stem boundary, the more likely rhythmic repair (Figure 4).
- As with the forced-choice task, the statistics indicate that duration is a better model of participants' behavior than rhythmic context.
  - The best-fit model finds significant effects for duration, identity of the final segment, frequency of the base, and frequency of the derivative.

Figure 4: Rhythmic repair by interstress duration




(19) Model with duration as fixed effect

| Factor | Coefficient | $z$ value | Significant? |
|---|---|---|---|
| (Intercept) | -4.93 | – | |
| Duration | 10.00 | 9.34 | Yes ($p < .001$) |
| Final /s/ | 1.61 | 6.98 | Yes ($p < .001$) |
| Derivative Freq. | -0.80 | -3.27 | Yes ($p < .01$) |
| Base Freq. | 0.60 | 2.81 | Yes ($p < .01$) |

- Adding a predictor to this model for rhythmic context does not result in an improvement of fit ($\chi^2$ (2) = 3.25, $p$ = .20), nor does adding an interaction.
- ((19) also has a lower AIC/BIC than a model with rhythmic context.)

### 3.4 Interim conclusions

- **Conclusion**: *-ize* stress in *-ization* forms is rhythmically conditioned.
- **Importantly**: rhythmic constraints must be defined in a more fine-grained way than is typically assumed in theories of stress.
- Sources of evidence for these conclusions:
  - Dictionary data (from the OED) that demonstrates rhythmic effects, both across and within rhythmic categories.
  - Results from a forced-choice task, which show that participants' judgments are influenced by duration and not categorical rhythmic information.
  - Results from a production study, which show the same.

## 4 Towards an analysis

- Results from Section 3 support the hypothesis: the longer the distance between the rightmost stem stress and *-ize*, the more likely *-ize* is to be stressed.
- Analytically speaking: these results support the addition of phonetic rhythmic constraints, defined over duration, to CON.
- But how should these constraints should be defined, and what kinds of representations do they evaluate?
  - Concrete definition: constraints evaluate milliseconds (Stanton 2019).
  - Abstract def.: constraints evaluate normalized duration, segment type…
- Results from a second judgment task suggest a more abstract definition is appropriate; I sketch a possible one, based on these results, in Section 4.2.

### 4.1 Another forced-choice task

- The second forced-choice task used half of the *-ization* items from the original task (Table 2). It was in all other ways identical.

Table 2: Experiment 1 items, by rhythmic profile and interstress C(s)

| *CLASH (n=5) Interstress C(s) | *LAPSE (n=5) Interstress C(s) | *EXTLAPSE (n=5) Interstress C(s) |
|---|---|---|
| *Quebècizátion* [k] | *Ègyptizátion* [dʒ], [pt] | *Ròchesterizátion* [tʃ], [st], [ɪ] |
| *Chàdizátion* [d] | *Cùbanizátion* [b], [n] | *Sènegalizátion* [n], [g], [l] |
| *Ròmeizátion* [m] | *Àustinizátion* [st], [n] | *Ìndianàpolisizátion* [n], [p], [l] |
| *Bròmxizátion* [ŋks] | *Tèxasizátion* [ks], [s] | *Antàrcticanizátion* [ɪ(k)t], [k], [n] |
| *Bàsqueizátion* [sk] | *Phòenixizátion* [n], [ks] | *Mèxicanizátion* [ks], [k], [n] |

Figure 5: Preference for *-ize* stress by duration (faceted by speech rate)

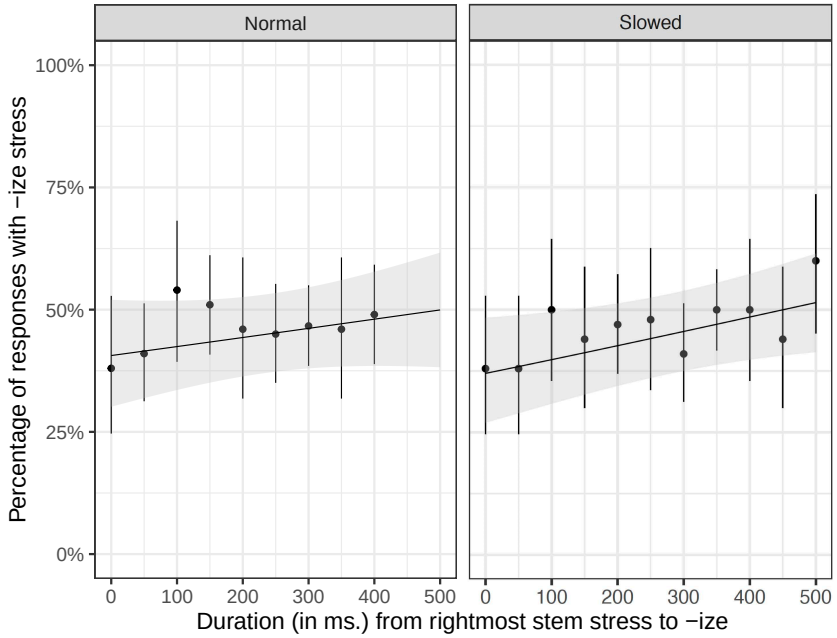
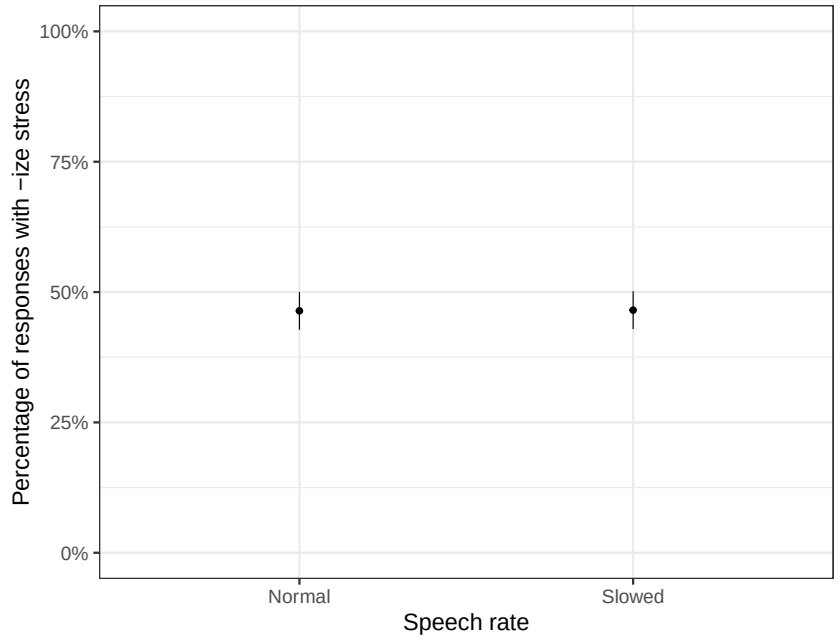



Figure 6: Preference for *-ize* stress by speech rate




- For this experiment, two versions of each item were used.
  - First version: both forms presented at the normal speech rate.
  - Second version: forms slowed by 20% (Praat Vocal Toolkit, Corretge 2012).
- **The prediction:** if phonetic *CLASH is defined in terms of milliseconds, we should find a stronger preference for *-ize* stress in the slowed items.
- The results are clear, and do not support this prediction.
  - First, a sanity check: does the result from Experiment 1 replicate?
    - ⩾ Yes: duration is a significant predictor of *-ize* stress (20). Trend is visible in both the normal and slowed forms (Fig. 5).

(20) Model with duration as a fixed effect

| Factor | Coefficient | *z* value | Significant? |
|---|---|---|---|
| (Intercept) | -0.66 | – | |
| Duration | 0.99 | 2.26 | Yes ($p < .05$) |

    - ⩾ Adding rhythmic context doesn't improve fit ($\chi^2$ (2) = 4.58, $p$ = .1), nor does adding base/derivative frequency or identity of the final segment.[7]
  - Unsurprisingly, item type (slowed vs. not slowed) is not a significant predictor; adding it to the model also does not improve fit ($\chi^2$ (1) = .72).
- **The takeaway**: phonetic rhythmic constraints likely assess violations at a more abstract level than raw duration.

## 4.2 Defining phonetic rhythmic constraints

- Results of the above experiment limit the hypothesis space as to how phonetic rhythmic constraints are defined, but the hypothesis space is still large.
  - A possibility: each segment is associated with an idealized duration, stored as milliseconds. Rhythmic constraints reference idealized duration.
  - Another possibility: segments are split up into durational categories. Rhythmic constraints reference durational categories.
- For the sake of analysis, I'll pursue this second possibility, though further work is necessary to verify that this is the correct way to go.

[7] As is true for the preceding models, the AIC/BIC for (20) are lower than the AIC/BIC for an otherwise equivalent model that includes rhythmic context.

#### 4.2.1 Defining phonetic *CLASH

- For the purposes of this talk, I'll define phonetic *CLASH as the following.

(21) *CLASH: for each pair of stressed vowels $\acute{V}_1$ and $\acute{V}_2$, assign a base violation score of 1. For each segment between $\acute{V}_1$ and $\acute{V}_2$, multiply the violation score by 1/*x*, where *x* is valued according to (a-b).

a. Sonorant consonants = 2
b. Obstruent consonants = 3

- For *Quebècizátion*, violation score is 2/3 (1/3 (k) + 1/3 (z)).
- For *Tèxasìzátion*, it's 10/27 (1/3 (k) * 1/3 (s) * 1/3 (s) + 1/3 (z)).

#### 4.2.2 Defining phonetic *LAPSE

- In addition to phonetic *CLASH, we should also consider the possibility that phonetic *LAPSE plays a role in speakers' judgments.
  - Argued in Stanton (2019) that phonetic *LAPSE is active in English.
  - For *Tèxasizátion* vs. *Mèxicanizátion*, possible that the preference for more *-ize* stress on the latter is due to phonetic *LAPSE.

(22) *LAPSE: for each pair of stressed vowels $\acute{V}_1$ and $\acute{V}_2$, assign a base violation score of 1. For each segment between $\acute{V}_1$ and $\acute{V}_2$, multiply the violation score by *x*, where *x* is valued according to (a-b).

a. Sonorant consonants = 2
b. Obstruent consonants = 3

- For *Quebècizátion*, violation score is 6 (3 (k) + 3 (k)).
- for *Tèxasizátion*, it's 30 (3 (k) * 3 (s) * 3 (s) + 3 (z)).

#### 4.2.3 Analysis

- Where is the evidence that we need to define these constraints with reference to the identity of segments, rather than just the number of segments?
  - Sporadic evidence that R vs. O matters: in the *LAPSE context, for example, *Texasization* has a higher rate of *-ize* stress (48%) than *Austinization* (40%).
  - Evidence is more consistent for *-ative*, where the segmentals of experimental stimuli were more tightly controlled. See (Stanton, 2019).
- What's important here is the idea: the strength of violation is correlated with the distance between two stresses. These precise formulations can be revised.
- To demonstrate how a partial analysis of these data could work, I consider four items and their realizations from the forced-choice task: *Quebècizátion*, *Fràncеizátion*, *Tèxasizátion*, and *Mèxicanizátion*.
- For an analysis of these results, I include the following constraints:

(23) STRESS-*ize*: assign one * if the suffix *-ize* doesn't bear stress.

(24) *CLASH: as in (21).

(25) .*LAPSE: as in (22).

- I used the Maxent grammar tool (Hayes et al. 2009) to find weights for the above constraints, given the candidates and violation scores in Table 3.

Table 3: Candidates and violations fed to the Maxent grammar tool

| | STRESS-*ize* | *CLASH | *LAPSE |
|---|---|---|---|
| a. *Quebècizátion* | | 2/3 | 6 |
| b. *Quebècizátion* | 1 | 1/9 | 9 |
| c. *Fràncеizátion* | | 1/2 | 9 |
| d. *Fràncеizátion* | 1 | 1/18 | 18 |
| e. *Tèxasizátion* | | 10/27 | 12 |
| f. *Tèxasizátion* | 1 | 1/81 | 81 |
| g. *Mèxicanizátion* | | 19/54 | 57 |
| h. *Mèxicanizátion* | 1 | 1/162 | 162 |

- The tool finds the weights in (26), and makes the predictions in (27).

(26)

| Constraint | Weight |
|---|---|
| *CLASH | 2.52 |
| STRESS-*ize* | 0.574 |
| *LAPSE | 0.006 |

(27)

| Form | Rate of *-ize* stress | |
|---|---|---|
| | Predicted | Observed |
| *Quebècizátion* | 31% | 30% |
| *Fràncеizátion* | 38% | 40% |
| *Tèxasizátion* | 52% | 48% |
| *Mèxicanizátion* | 58% | 60% |

- **The main takeaway**: phonetic versions of *CLASH and *LAPSE play a role in judgments of *-ize* stress. Rhythm drives variation.

# 5 Discussion

- **In short**: gradient, phonetically informed versions of *LAPSE and *CLASH are necessary to account for the full range of rhythmic effects in English.
  - Supporting evidence: stress in English words ending in *-ization* (and *-ative*, Stanton 2019, which shows similar effects).
  - Why have we focused on this small slice of the lexicon?
    - ⪰ Words ending in *-ative* and *-ization* are perhaps the two corners of the English lexicon where evidence for phonetic rhythm is most easily available.
    - ⪰ Clashes and lapses are in principle allowed in these forms: *-ative* and *-ization* are largely stress-preserving (Stanton & Steriade in prep).
    - ⪰ Both of the inner suffixes, *-ate* and *-ize*, have stressed and stressless forms. Their realization can depend on rhythmic context.
- Words in *-ative* and *-ization* are infrequent; must be the case that evidence for phonetic rhythm is more widespread in English than we've seen here.
  - One potential source of evidence: English post-tonic syncope (Hooper 1978, Polgárdi 2015), i.e. *separate* (v.) vs. *separate* (adj.).
  - Another source: the English rhythm rule (Hayes 1986, Beames 2020).

## 5.1 Conclusion

- These results add to a growing base of evidence that rhythmic constraints pay greater attention to duration than is commonly assumed. A couple of examples:
  - Secondary stress in Russian compounds
    - ⪰ Gouskova & Roon (2013): the further away the secondary stress from the primary stress (counting by syllables), the more acceptable the compound.
    - ⪰ Additional work (done by me in 2018) found that replacing the number of syllables with the duration of the interstress interval improves model fit.
  - Secondary stress in Finnish
    - ⪰ Karvonen (2008): for long odd-parity words, secondary stress on antepenult if words ends in *-ia* (*érgonòmia*), penult otherwise (*kólesteròli*).
    - ⪰ Potentially understandable as an effect of phonetic *LAPSER: maybe stress wants to be a consistent distance from the edge, and *-ia* is short.
- All work discussed here is consistent with a broader view in which stress placement is directly informed by phonetics (e.g. Lunden 2013, 2014; Ryan 2014).

# References


Bates, Douglas & Martin Maechler (2011). Package 'lme4'. R.

Beames, Samantha (2020). Experimental Evidence for the Rhythm Rule in English. B.A. thesis, New York University.

Becker, Michael & Jonathan Levine (2013). Experigen – an online experiment platform. Available at http://becker.phonologist.org/experigen.

Corretge, Ramon (2012). Praat Vocal Toolkit. http://www.praatvocaltoolkit.com/index.html.

Gordon, Matt (2002). A factorial typology of quantity insensitive stress. Natural Language and Linguistic Theory 20, 491–552.

Gouskova, Maria & Kevin Roon (2013). Gradient clash, faithfulness, and sonority sequencing effects in Russian compound stress. Laboratory Phonology 4, 383–434.

Hayes, Bruce (1986). Assimilation as Spreading in Toba Batak. Linguistic Inquiry 17, 467–499.

Hayes, Bruce (1995). Metrical Stress Theory: Principles and Case Studies. The University of Chicago Press, Chicago/London.

Hayes, Bruce, Colin Wilson & Ben George (2009). Maxent grammar tool. Software package.

Hooper, Joan B. (1978). Constraints on schwa-deletion in american english. Fisiak, Jacek (ed.), Recent developments in historical phonology, Mouton, The Hague, 183–207.

Kager, René (1999). Optimality Theory. Cambridge University Press, Cambridge.

Karvonen, Daniel (2008). Explaining nonfinality: Evidence from Finnish. Proceedings of the 26th West Coast Conference on Formal Linguistics, Cascadilla Proceedings Project, Somerville, MA, 306–314.

Kuznetsova, Alexandra, Per Bruun Brockhoff & Rune Haubo Bojesen Christensen (2016). Package 'lmertest'. R.

Liberman, Mark & Alan Prince (1977). On stress and linguistic rhythm. Linguistic Inquiry 8, 249–336.

Lunden, Anya (2013). Renanalyzing final consonant extrametricality. The Journal of Comparative Germanic Linguistics 16, 1–31.

Lunden, Anya (2014). Motivating stress system asymmetries. Invited talk at the Conference on Stress and Accent, University of Leiden.

Nespor, Marina & Irene Vogel (1989). On clashes and lapses. Phonology 6, 69–116.

Polgárdi, Krisztina (2015). Syncope, syllabic consonant formation, and the distribution of stressed vowels in English. Journal of Linguistics 51, 383–423.

Ryan, Kevin M. (2014). Onsets contribute to syllable weight: Statistical evidence from stress and meter. Language 90, 309–341.

Stanton, Juliet (2019). Phonetic lapse in American English -ative. Glossa 4, 1–37.

Stanton, Juliet & Donca Steriade (in prep). English stress and the cycle. Ms., NYU and MIT.

Steriade, Donca (1999). Lexical Conservatism. Linguistics in the Morning Calm, Selected Papers from SICOL 1997, Linguistic Society of Korea, Hanshin Publishing House, 157–179.

Wickham, H. (2016). ggplot2: Elegant Graphics for Data Analysis. Spring-Verlag, New York.