Phonetic rhythm in *–ization*[*]

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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 (following Stanton 2019:7.2).[1]
  - Corpus: all relevant *-ization* forms in the OED as of 2/2019 (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.[2]

(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)

  - Factors included in a statistical model: rhythmic context.
  - Factors not included in the model:
    - ≫ Derivative (*-ization*) and base (*-ize*) frequency: χ^2 (2) = 1.51, p = .47
    - ≫ Identity of final segment (/s/ vs. others): χ^2 (1) = .00, p = .99
- Available evidence suggests that speaker productions mirror the OED trends.
  - Productions are from `forvo.com`, a pronunciation dictionary.
  - Dictionary was searched (in 2/2019) for all *-ization* words in (10). Native speaker status and *-ize* stress were determined by ear.

(11)

Effect of *-ize* stress	Stressed *-ize*	Stressless *-ize*	% stressed
*CLASH violation	*rèalizátion* (n=4)	*tàblòidizátion* (n=21)	19% (4/25)
*LAPSE satisfaction	*fòssilizátion* (n=49)	*demòbilizátion* (n=151)	24.5% (49/200)
*EXTLAPSE satisfaction	*àctualizátion* (n=21)	*lábializátion* (n=51)	29.2% (21/72)

[1] For the OED: a logistic regression finds a significant comparison between *LAPSE vs. *CLASH (p < .001) and *LAPSE vs. *EXTLAPSE (p < .05). For Forvo: a logistic regression finds a significant comparison between *LAPSE vs. *EXTLAPSE contexts (p < .01) but not *LAPSE vs. *CLASH.

[2] 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.

- A more detailed look at the OED data shows that there is variance within some of these rhythmic categories.
  - Focusing on the cases where *-ize* stress results in a *CLASH violation (12), we see that the rate of *-ize* stress varies with the interstress material.[3]

(12)

Interstress seg(s).	Stressed *ize*	Stressless *ize*	% stressed
Sonorant (R)	*xèn**i**zátion* (n=17)	*rèal**i**zátion* (n=15)	53.1% (17/32)
Obstruent (O)	*stỳlòp**i**zátion* (n=17)	*fàsc**i**zátion* (n=11)	60.7% (17/28)
Cluster (CC)	*bàpt**i**zátion* (n=20)	*òbjèct**i**zátion* (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.

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 gradient 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 (10-11)).

(13) Different interstress durations (in black) in *-ization* forms

a. V̀ C_0 -ìzátion (*fa**sc**ization*) : shortest
   V̀ [***C*₀**] *ìzátion*

b. V̀ C_0V C_0 -ìzátion (*cha**nnel**ization*): longer
   V̀ [***C*₀*V* *C*₀**] *ìzátion*

c. V̀ C_0V C_0V 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.

[3] 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 ÝV hiatus, I do not include these forms here.

  - Given (12), we might also expect for clashes with sonorants to be shorter than those with obstruents, which might be shorter than those with clusters.

(14) 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.

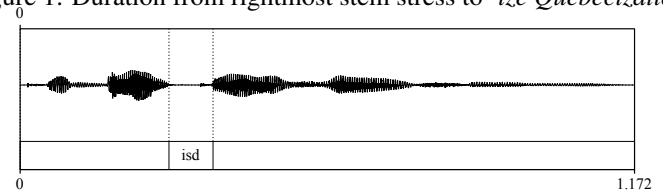
3 Experimental support

- To test the hypothesis, I conducted a forced-choice task (*-ization* 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.
- Analysis of the experimental items supports predictions in (13-14).

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.
- Duration between the rightmost stem stress and *-ize* measured as in Fig. 1.[4]

Figure 1: Duration from rightmost stem stress to *-ize Quebècìzátion*



[4] All acoustic analysis was done in Praat (Boersma & Weenink 2017).

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

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

- Durational properties of these forms are in line with the predictions above.
  - Distance from the rightmost stem stress is shortest in the *CLASH context, longer in *LAPSE, and longest in *EXTLAPSE (Fig. 2).[5]
  - Sonorants between two stresses are shorter than obstruents (though not by much), which are shorter than clusters (Fig. 3).
- First part of the hypothesis is plausible: broad trends discovered in the dictionary study correlate with properties of the productions.

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!*).

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

Figure 2: Interstress duration by the number of interstress syllables

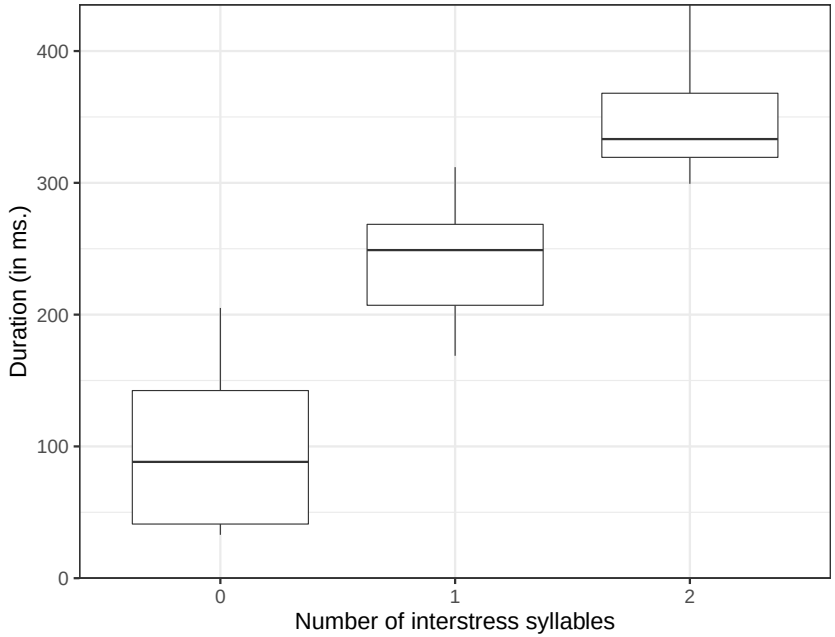
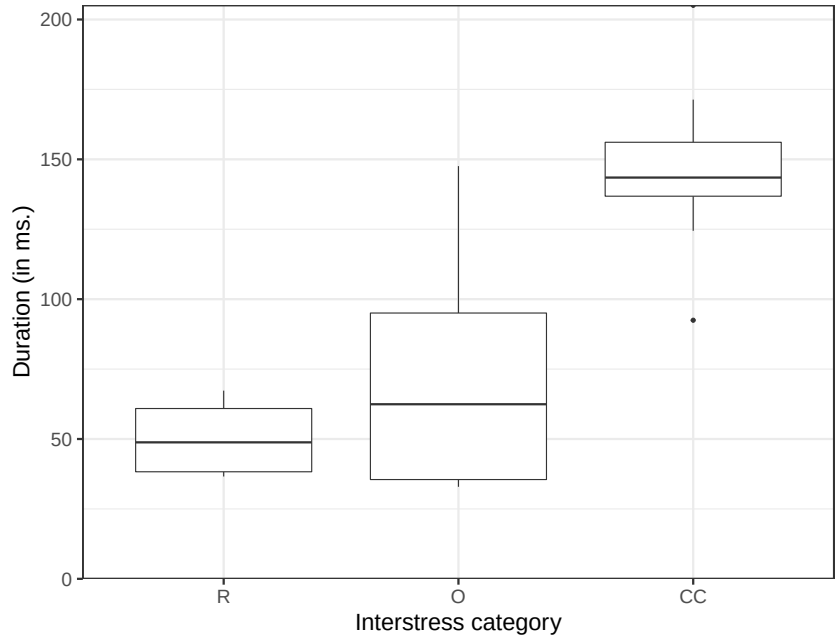


Figure 3: Interstress duration by the type of interstress consonant(s)



- First, participants heard a recording of the placename (e.g. *Quebec*).
- They then chose between two possible pronunciations of the bolded and italicized word (e.g. *Quebecization*), which they could listen to twice.[6]

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 4).
- 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).[7]

(15) Model with duration as fixed effect

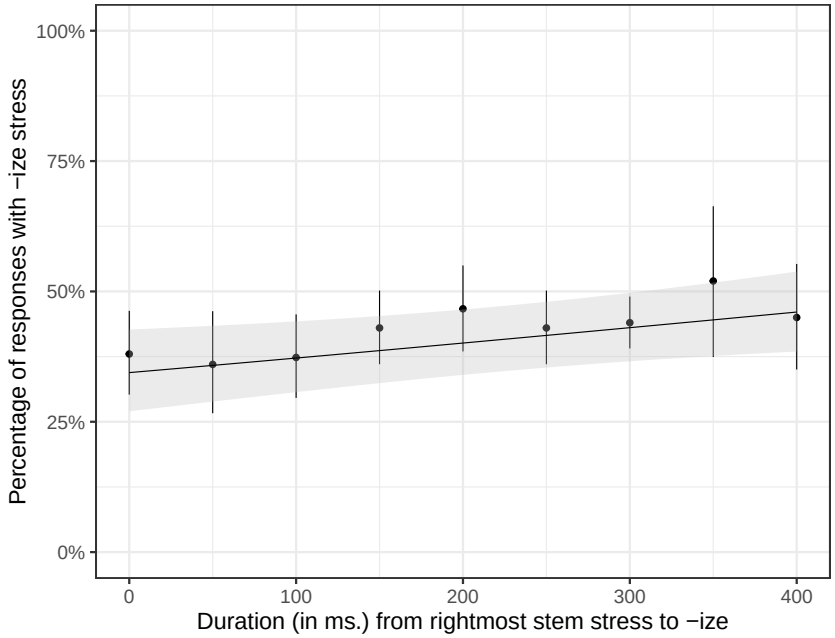
Factor	Coefficient	z value	Significant?
(Intercept)	-0.70	–	
Duration	1.21	2.36	Yes ($p < .05$)
Final /s/	0.32	2.17	Yes ($p < .05$)

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

[6] 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).

[7] 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 4: Preference for *-ize* stress by interstress duration



- What we can take away from these results:
  - Gradient 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!*).
- First, participants heard a recording of the placename (e.g. *Quebec*).
- They then pronounced the slogan aloud.

3.3.2 Participants

- Fifty-seven participants were recruited over Craiglist, Facebook, and Twitter[8]. 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. *Quebecization*). I'll refer to these as the 'faithful' productions.
- I grouped unfaithful productions into four categories: addition, deletion, stress shift, and *-ize* stress. Ultimately, we're interested in deletion and *-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 (16) by rhythmic context; most (51/61) additions happened in the *CLASH context.

(16) 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)

- 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* (17).

(17) 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, *Vermont*	48	2	4%
Antarctica, *Austin*	49	1	2%
Mexico	48	1	2%
Michigan, *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%).

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

- *-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=33) or consistent non-stressers (n=2), 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 (18) and *CLASH.

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

(19)

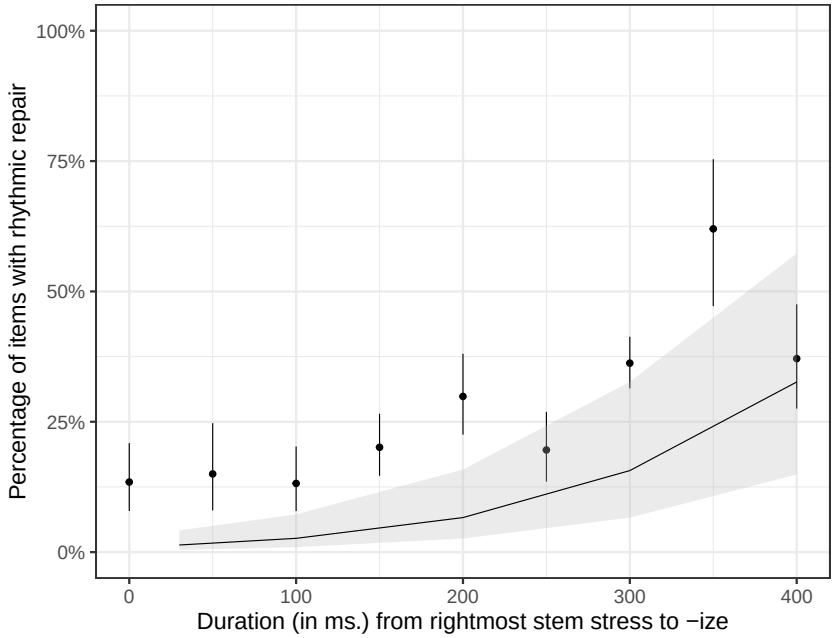
	Màdison-iz-at-ion	*EXTLAPSE	*CLASH	MAX
☞	a. Màdison-ìz-át-ion		*	
☞	b. Màdon-iz-át-ion			**
	c. Màdison-iz-átion	*!		

  - 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.
- They also track duration: the longer the distance from the rightmost stem stress to the righmost stem boundary, the more likely rhythmic repair (Figure 5).
- 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.

(20) 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 ($p < .01$)

Figure 5: Rhythmic repair by interstress duration



  - Adding a predictor to this model for rhythmic context does not result in an improvement of fit (χ^2 (2) = 3.25, p = .20), nor does adding an interaction.
  - ((20) 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:
  - Corpus data (from the OED and from Forvo) which demonstrate 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 gradient 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 fairly 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)	*LAPSE (n=5)	*EXTLAPSE (n=5)
Interstress C(s)	Interstress C(s)	Interstress C(s)
Quebècizátion	*Ègyptizátion*	*Ròchesterizátion*
[k]	[dʒ], [pt]	[tʃ], [st], [ɪ]
Chàdizátion	*Cùbanizátion*	*Sènegalizátion*
[d]	[b], [n]	[n], [g], [l]
Ròmeizátion	*Àustinizátion*	*Ìndianàpolisizátion*
[m]	[st], [n]	[n], [p], [l]
Brònxizátion	*Tèxasizátion*	*Antàrcticanizátion*
[ŋks]	[ks], [s]	[ɪ(k)t], [k], [n]
Bàsqueizátion	*Phòenixizátion*	*Mèxicanizátion*
[sk]	[n], [ks]	[ks], [k], [n]

- For this experiment, two versions of each item were used.
  - The first version: both forms were presented at the normal speech rate.
  - The second version: both forms were artificially slowed by 20%, using 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.

Figure 6: Preference for *-ize* stress by duration (faceted by speech rate)

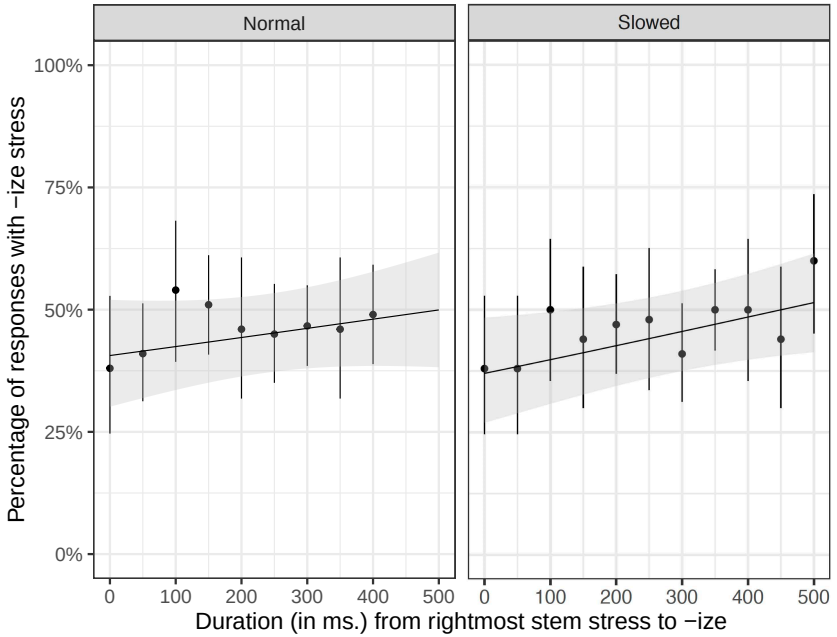
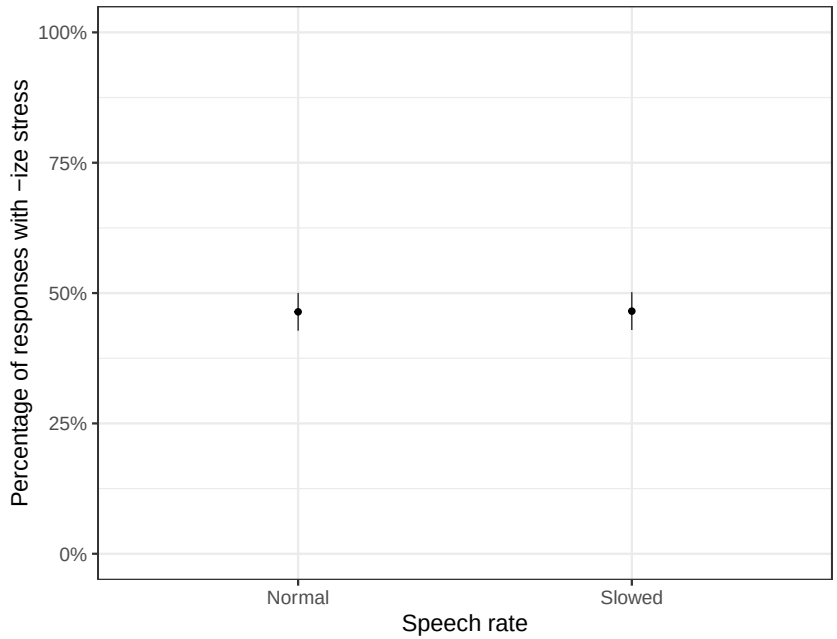


Figure 7: Preference for *-ize* stress by speech rate



- 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 (21). Trend is visible in both the normal and slowed forms (Fig. 6).

(21) 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 (χ^2 (2) = 4.58, p = .1), nor does adding base/derivative frequency or identity of the final segment.[9]
  - Unsurprisingly, item type (slowed vs. not slowed) is not a significant predictor; adding it to the model also does not improve fit (χ^2 (1) = .72).
- **The takeaway**: gradient rhythmic constraints likely assess violations at a more abstract level than raw duration.

4.2 Defining gradient rhythmic constraints

- Results of the above experiment limit the hypothesis space as to how gradient *CLASH is 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.
- Further work is required to further narrow down this hypothesis space!

[9] As is true for the preceding models, the AIC/BIC for (21) are lower than the AIC/BIC for an otherwise equivalent model that includes rhythmic context.

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 gradient 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 gradient 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 gradient *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).

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