The Role of Context Sonority
in the typology and perceptibility of geminate consonants.

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Geminate Consonants across the World

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Typology of Geminates

Contextual Restrictions

- Geminate consonants do not appear in various contextual positions with equal frequency.
- *Intervocalic* geminates are by far the most common across languages.
- This restriction arises as categorical or gradient:
  - Some languages categorically restrict geminates to the intervocalic environment: Bengali, Somali, Maranungku.
  - In others, geminates are statistically more common between vowels (Italian, Finnish) or resist neutralization in the intervocalic context (Iraqi Arabic, Syrian Arabic, Russian, Hungarian).

Typology of Geminates

Contextual Restrictions

- There are reasons to believe that at the source of this restriction is the sonority of adjacent segments:
  - Adjacent vowels provide a high sonority context.
  - Some languages allow consonant-adjacent geminates, provided the consonants are sonorants:

    Finnish: *kartta* ‘map’, *vintti* ‘attic’ (Karlsson, 1999, p. 13)
    Italian: *soffrire* ‘to suffer’, *applicare* ‘to apply’
  - Sonorant-adjacent concatenated geminates resist degemination in Hungarian and Russian (Pycha, 2010; Siptar and Torkenczy, 2000, p. 291-292; Kasatkin and Choj, 1999).

Context Sonority

Perceptual Aspect

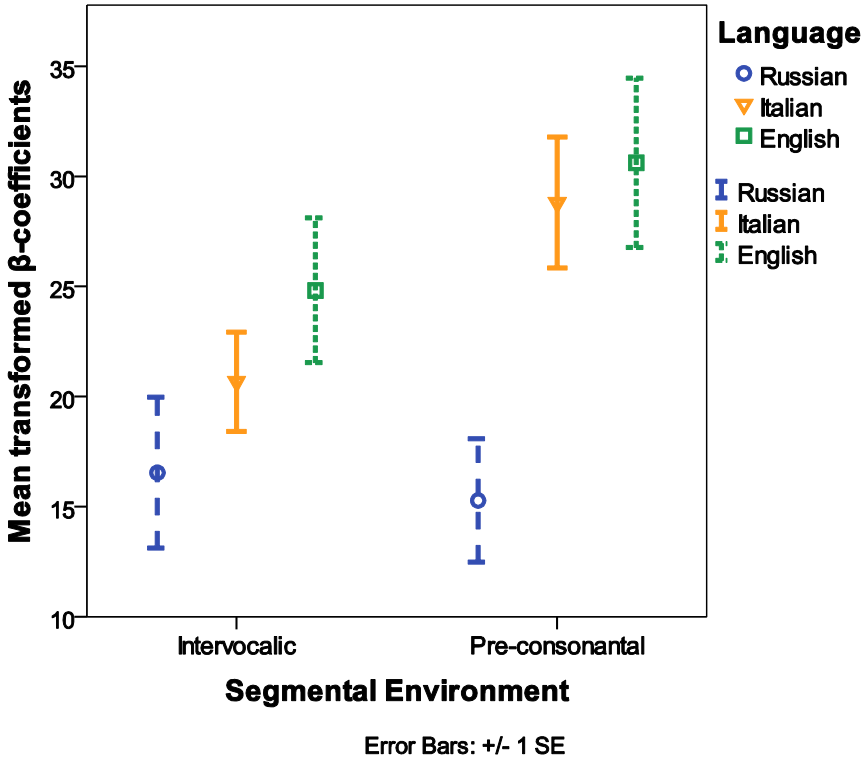
- What is the reason for the crosslinguistic preference for geminates in high-sonority contexts?
- Padgett (2003), following Bradley (2001), hypothesized that the acoustic property of *duration* is more perceptible in high sonority environment:
    - High-sonority sounds, such as vowels, provide clear perceptual reference points for the beginning and the end of the target segment.
    - Which facilitates the task of estimating target's duration.
- This hypothesis can be tested in a perceptual identification or discrimination experiment.

Context sonority

Prior Experimental Results

- Duration categorization of consonants in the intervocalic and pre-consonantal environments in non-words (Dmitrieva, 2012):

- Targets: coronal fricative [s]
- Following consonants: [l] or [m]
- Forced choice identification: *short* or *long*.
- Dependent variable: Reciprocally transformed β-coefficients of the identification functions (related to the steepness of the curve).
- The <u>steeper</u> is the curve – the more <u>successful</u> is the categorization.



Context sonority

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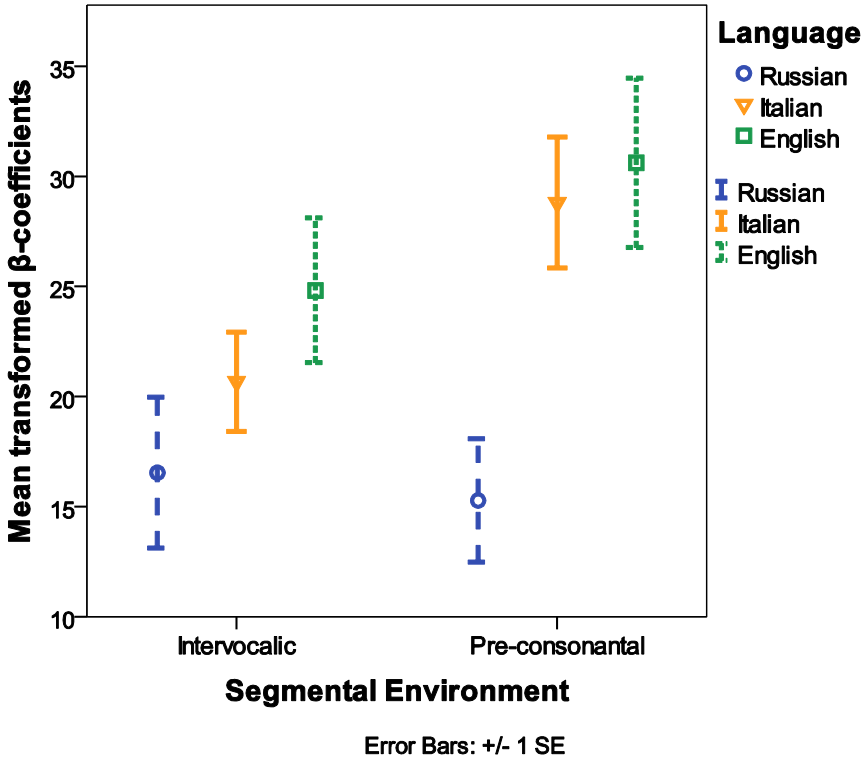


Categorization was more successful in the intervocalic context.

The Present Study

Motivation

- Previous design compared only *intervocalic* and *pre-sonorant* contexts.
- However, the sonorant-advantage hypothesis predicts a truly gradient dependency between context sonority and duration perceptibility.
- A more detailed comparison between contexts of varying sonority can test this prediction:

Perceptibility of duration will deteriorate with decreasing context sonority

The Present Study

Stimuli

- Non-words, recorded by a male native speaker of American English
- Target consonant: alveolar stop [t] with a closure duration of 100 or 200 ms
- Structure: V(C)__V or V__(C)V
- Preceding or following consonants: [l], [n], [s], [f], or [p].

	V_V	L	N	S	F	P
Onset	a.ta	al.ta	an.ta	as.ta	af.ta	ap.ta
Coda	---	at.la	at.na	at.sa	at.fa	at.pa

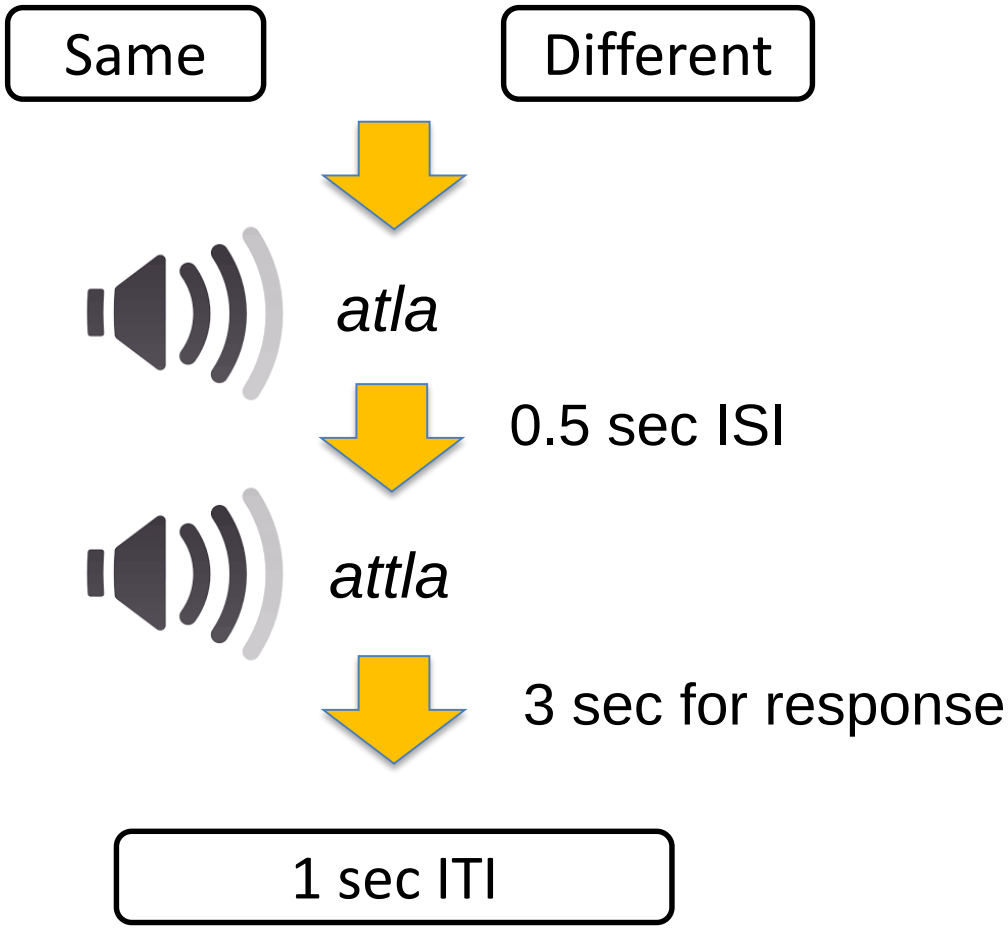
The Present Study

Procedure

- AX discrimination task: Participant listened to pairs of stimuli and attempted to detect a difference.
- Duration was not mentioned in the instructions.
- Pair types: *atla-attla* (different, short first)
  attla-atla (different, long first)
  atla-atla (same, both short)
  attla-attla (same, both long)
- Each pair presented 10 times, equal # of same and different pairs.
- Total of 440 pairs presented to each participant, overall duration ~40 min.
- Reponses were entered via a button-box, response options order was counterbalanced across participants.

The Present Study

Procedure: E-Prime



The Present Study

Participants

- Eighteen (18) monolingual native speakers of American English, Mid-Western dialect.
- Recruited on the campus of Purdue University.
- Undergraduate students enrolled at Purdue (age 18-22), mostly from rural Indiana and neighboring states.
- Paid for participation.

The Present Study

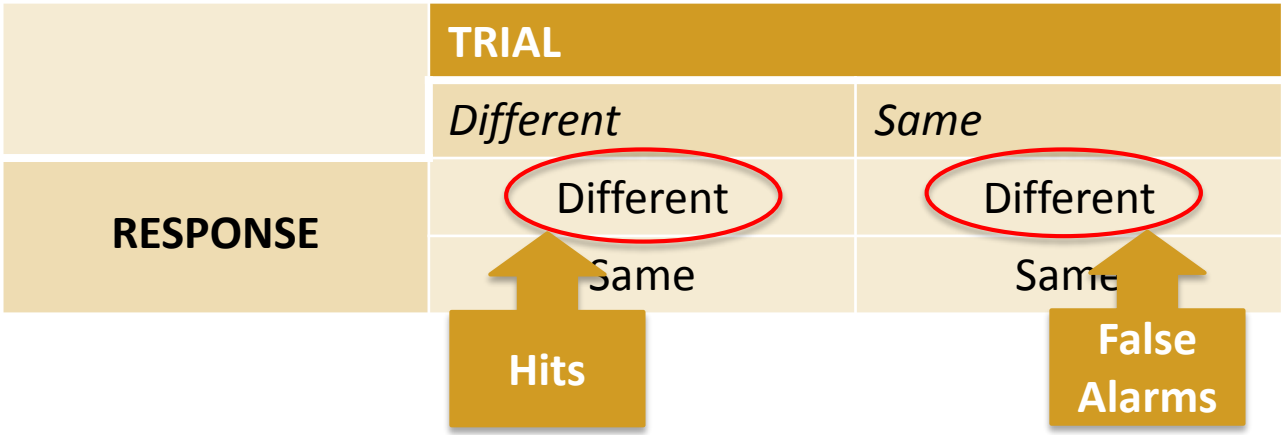
Analysis

	TRIAL	
	Different	*Same*
RESPONSE	Different	Different
	Same	Same

1. Measure of sensitivity to difference: d’ – the difference between z-transforms of Hit rates and False Alarm rates

The Present Study

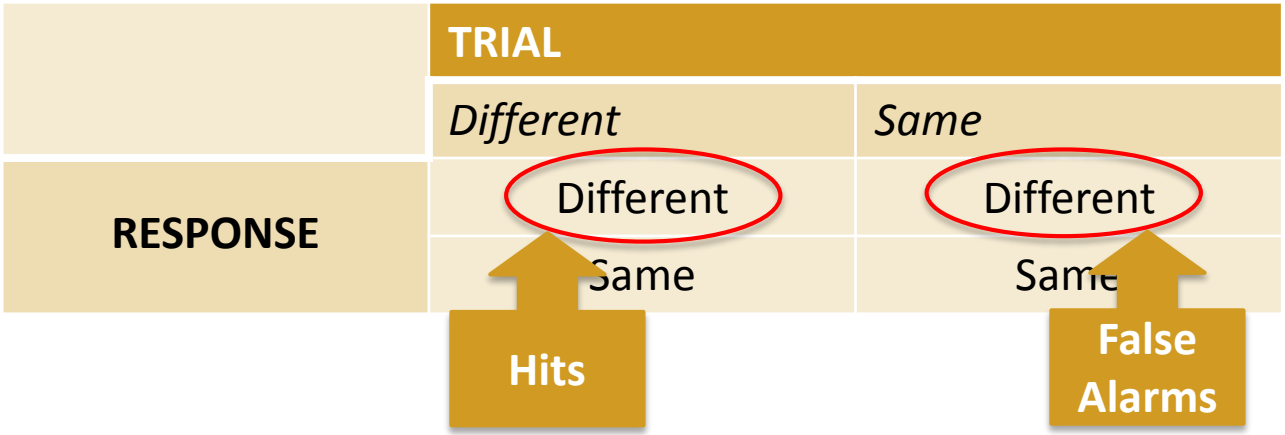
Analysis



1. Measure of sensitivity to difference: d' – the difference between z-transforms of Hit rates and False Alarm rates
    - The higher absolute values of d' indicate a greater sensitivity to the presence of duration difference

The Present Study

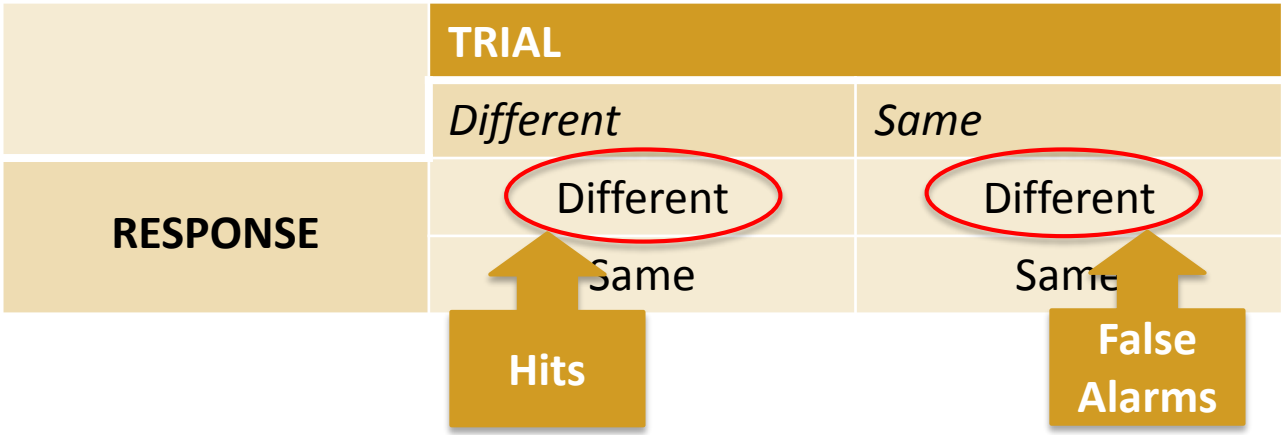
Analysis



1. Measure of sensitivity to difference: d' – the difference between z-transforms of Hit Rates and False Alarm rates
2. Measure of bias: c = -0.5[z(H)+z(FA)]. More difficult conditions are expected to elicit a higher 'same' bias.
   - c > 0 indicates a tendency to say 'same' more than 'different', c < 0 indicates a tendency to say 'different' more than 'same'.

The Present Study

Analysis



1. Measure of sensitivity to difference: d' – the difference between z-transforms of Hit Rates and False Alarm rates
2. Measure of bias: c = -0.5[z(H)+z(FA)]. More difficult conditions are expected to elicit a higher 'same' bias
3. Reaction Times (on correct responses only)

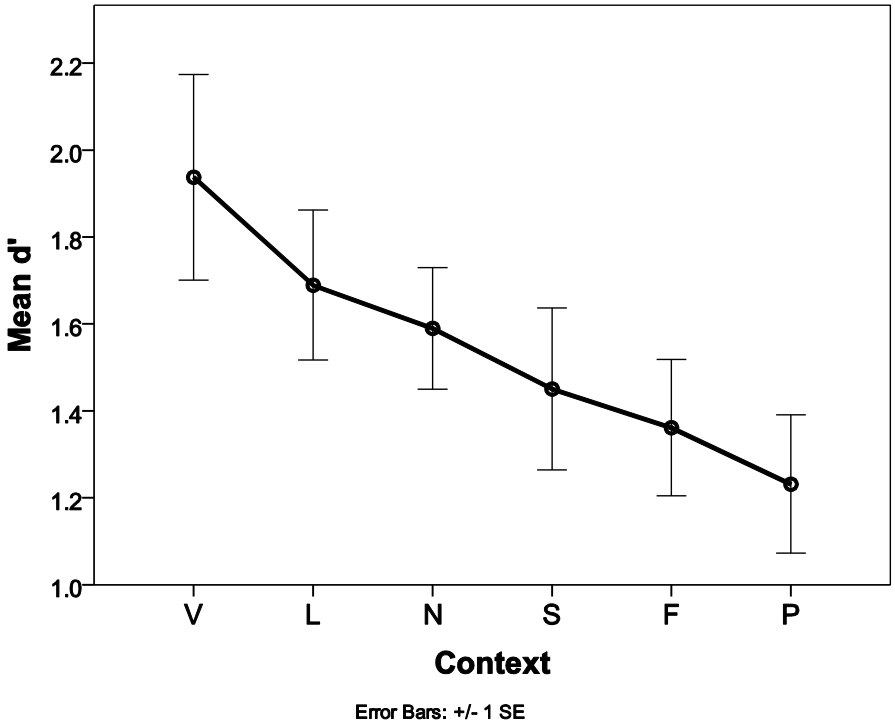
The Present Study

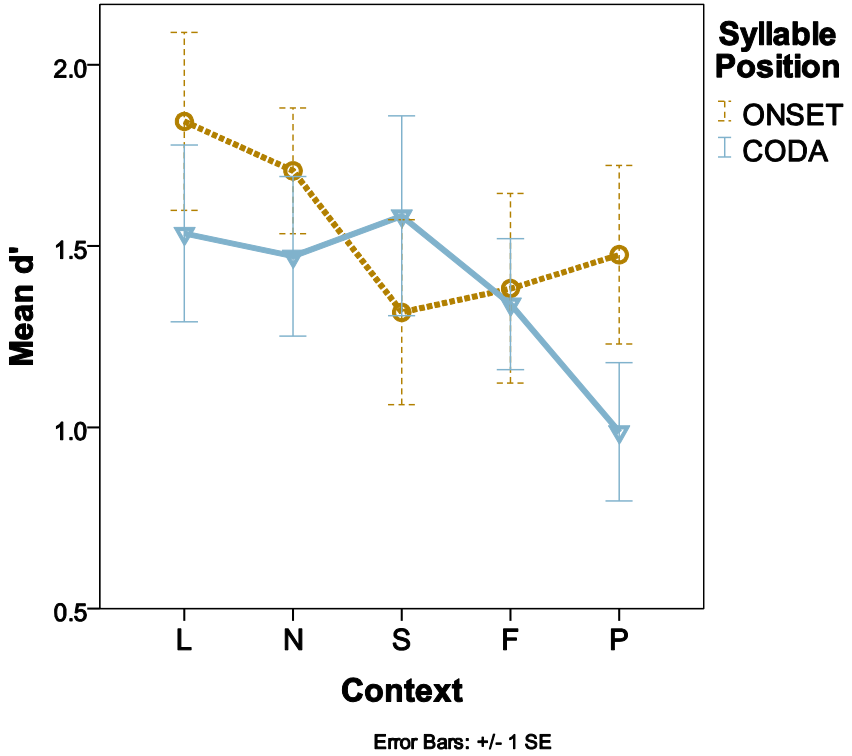
Analysis

- These measures were submitted to repeated measures ANOVAs with Context and Syllable Position as independent variables.
    - The effect of Context (6 levels) is analyzed across syllable positions in a one-way ANOVA.
    - And together with the Syllable Position factor in a two-way ANOVA. In this analysis, the intervocalic condition is omitted since it is available in onset position only.
    - Multiple pair-wise comparisons are not reported for the sake of time economy - more statistical details are available upon request.

Sensitivity Measure: d’

Results



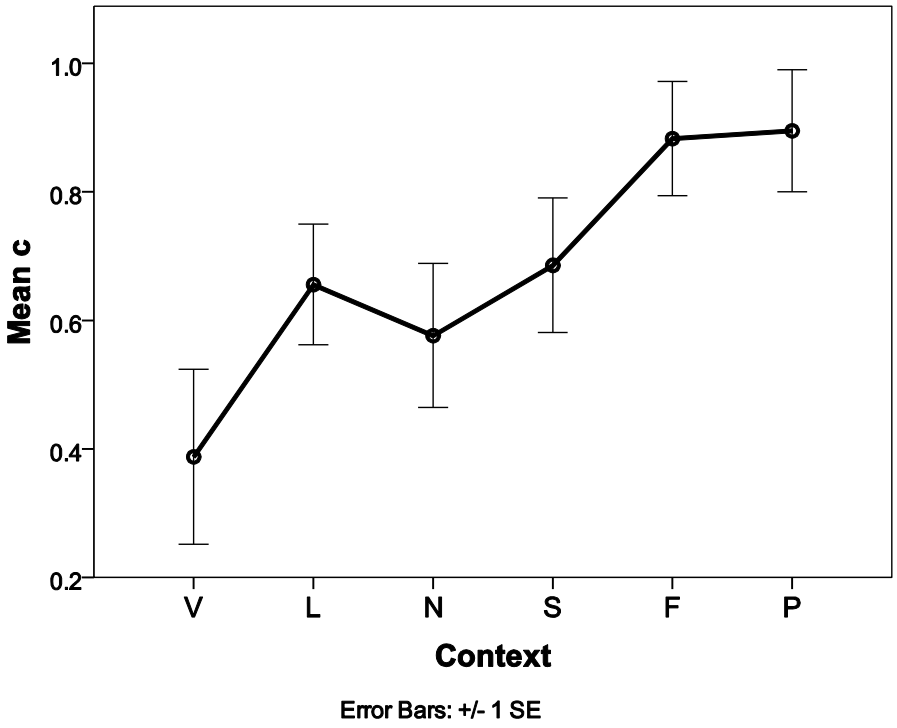


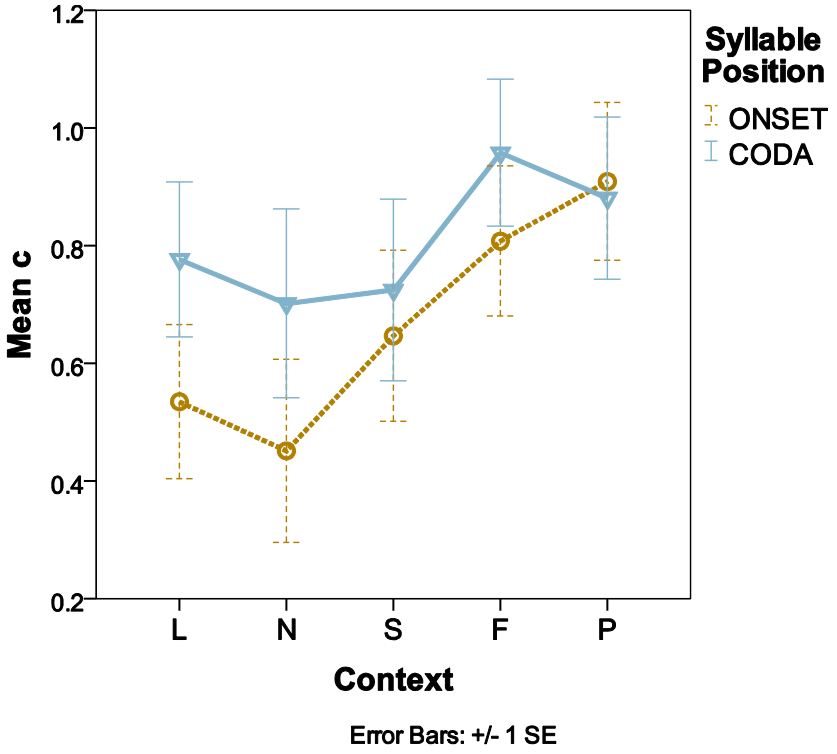
- A significant effect of **Context**
- A significant effect of **Context**, **Syllable Position + Interaction**

Sensitivity to duration differences decreases with context sonority. Sensitivity is higher in onset positions.

Response bias: c

Results



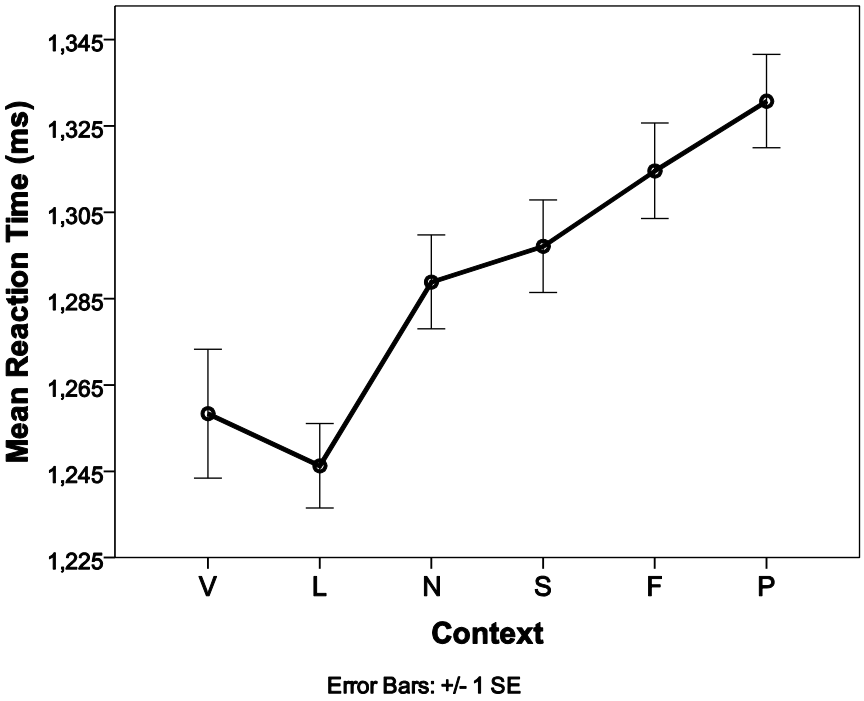


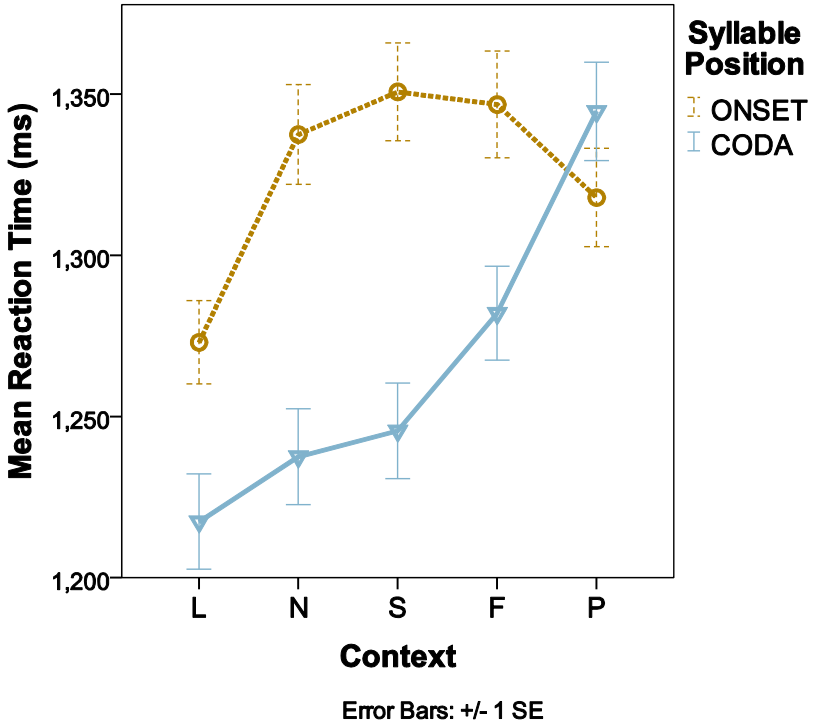
- A significant effect of **Context**
- A significant effect of **Context** and **Syllable Position**

'Same' bias increases as context sonority decreases.
'Same' bias is higher in coda positions.

Reaction Times

Results





- A significant effect of **Context**
- A significant effect of **Context**, **Syllable Position + Interaction**

Reaction time increases as context sonority decreases.
Reaction time is higher in onset positions.

Summary

Context Sonority

- The results confirm the hypothesis that perceptibility of duration deteriorates in lower sonority contexts:
  - **Sensitivity** to duration differences *decreased* with the sonority of adjacent segments.
  - **Bias** to respond ‘same’ *increased* as context sonority decreased.
  - **Reaction times** *increased* as context sonority decreased.

Summary

Syllable Position

- The results showed that, overall, perceptibility of duration was better when the target consonant was in the onset position:
  - **Sensitivity** to duration differences was *higher* in onsets.
    - Except in fricative contexts, especially [s], where the effect seemed to be reversing.
  - **'Same' bias** was *lower* in onsets.
    - More so for sonorants than for obstruents.
  - However, **reaction times** were actually *higher* for onset targets.
    - Possibly, because onset targets become available later in time than coda targets: *at.la* vs. *al.ta.*

Discussion

Syllable Position

- These results add to the body of research which demonstrates perceptual advantage of onset position for other contrasts, such as voicing, place, and manner of articulation in consonants (Miller and Nicely, 1955; Fujimura et al., 1978; Ohala, 1990; Benki 2003, inter alios).
- This suggests that non-intervocalic medial geminates should be found more often in *post-consonantal* than in *pre-consonantal* positions: VC.GV > VG.CV
- This prediction is to be addressed in future typological work.

Discussion

Context Sonority

- The context sonority results are compatible with the hypothesis that geminates' preference for high-sonority contexts may be due to the *perceptual advantage* such contexts provide.
- The question: Why do languages mostly choose the vocalic context for geminates, and not, e.g., vowels + sonorants?

Discussion

Remaining Questions

- What is the mechanism behind the advantage provided by high sonority context?
- The answer may lie in the amount of acoustic differences between high sonority sounds and target consonants:
    - High sonority vowels are maximally acoustically different from obstruent geminates, both in spectral properties and overall intensity.
    - Kato et. al. (1997) shows that amplitude changes may assist listeners in defining boundaries of segments.
- Perceptibility may be determined by the *interaction* between the target and the context sonority: Low sonority targets (e.g. obstruents) are optimal in high sonority contexts (e.g. vowels).

Discussion

Remaining Questions

- There are in fact reports which suggest that obstruent geminates are more common than sonorant geminates (Podesva, 2000, 2002, Kawahara, 2007).
    - Languages which restrict their geminates to *intervocalic obstruents* may be zooming in on optimal conditions for the perception of duration.
- The requirement for some minimal sonority difference between target and context also predicts more complex phonotactic patterns:
    - E.g., nasal geminates only between vowels, but obstruent geminate next to sonorants.
- The exact nature of the interaction between target and context sonority in determining the perceptibility of duration is to be established in future research.

Conclusions

- Duration perceptibility as function of context sonority appear to be a promising direction for explaining the typological preferences for intervocalic geminates.
- Much work remains to be done in obtaining necessary experimental and typological data and addressing the discrepancies between them.

THANK YOU!

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