Allophonic variation and the locality of production planning

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reporting on joint work with:
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Outline

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Sandhi

External Sandhi

Phonological processes in which (part of) the triggering context is not within the same word

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'real friends'

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(1) Liaison in French

a. des vrai~~s~~ copins
b. des vrai[z] amis

'real friends'

(2) Flapping in English

a. A ca[t] meowed!
b. A ca[r] attacked!

Locality

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(Kilbourn-Ceron et al. 2016)

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But **why** do particular processes apply within particular domains?

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(i) **Variability of Application**: Sandhi processes often only apply in a probabilistic way.

(ii) **Variability of Domain**: Sandhi processes often have a variable domain (e.g., locality window widens when speech rate increases, e.g. Kaisse 1985 on fast speech phenomena)

Variability

Current accounts in phonology usually assume the following:

(i) **Variability of Application**: Variable Rules/Variable Constraint Ranking (cf. Anttila, 2002; Coetzee and Kawahara, 2013)

(ii) **Variability of Domain**: Multiple prosodic constituents of a certain type optionally restructure into one constituent of that type or vice-versa.(e.g. Nespor and Vogel, 1986)

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But **why** are sandhi processes often variable?

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The Basic Idea

We need to consider **locality of production planning**.

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- Levelt (1989): phonological detail is planned over a window roughly the size of a **single prosodic word**

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- Planning window also varies depending on cognitive load (Swets et al., 2013).

The Locality of Production Planning

Production Planning Hypothesis (PPH)

Sandhi processes are local and variable because the phonological detail relevant to the process may not have been planned yet in time

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- Why is tapping **variable**?
  - Planning is variable: Scope of planning is affected by many factors

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Evidence for PPH:

Kilbourn-Ceron (2015),Kilbourn-Ceron et al. (2017), Kilbourn-Ceron (2017a), Kilbourn-Ceron (2017b), Kilbourn-Ceron et al. (submitted), Lamontagne and Torreira (2017), Tamminga (2018), Tanner et al. (2015), Tanner et al. (2017), Wagner (2011), Wagner (2012)

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Effects of syntax and prosody

with Oriana Kilbourn-Ceron  & Meghan Clayards 

Kilbourn-Ceron, O., Wagner, M., and Clayards, M. (2017). The effect of production planning locality on external sandhi: A study in /t/. Proceedings CLS, 313–326

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Across Sentences:
It's **late. I'm** leaving. → *(possible but rare: Kahn 76, Nespor & Vogel 86, ..)*

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Two factors affecting tapping:

1. **Strength of a prosodic boundary**: a stronger boundary between the stop and following vowel appear to reduce flapping rate
2. **Strength of syntactic break**: higher level syntactic boundaries appear to reduce flapping rate

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- **Articulatory phonology**: Tapping as the result of gestural undershoot/overlap, which is less likely across junctures

Tapping in English: The PPH

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- ...because we know independently that these factors affect planning scope

Tapping: Production Experiment

Table: A sample item set

Phonology		**Syntax**
	Clause Boundary	*No Clause Boundary*
Consonant	If you **plit**, Alice will be mad.	If you **plit** Alice, John will be mad.
Vowel	If you **plit**, Penny will be mad.	If you **plit** Penny, John will be mad.

Additional manipulation: Speech rate

Tapping: Production Experiment

- 23 participants, 8 different item sets with the 4 conditions
- Participants could familiarize themselves with sentence before recording.
- They were recorded at two speech rates
- Utterances were annotated by RAs, and also forced-aligned
- Acoustic measures were extracted, in particular measures for the vowel preceding the [t] ('final lengthening', Price et al. 1991, and references therein) as a proxy for measuring prosodic boundary strength

Tapping: Production Experiment

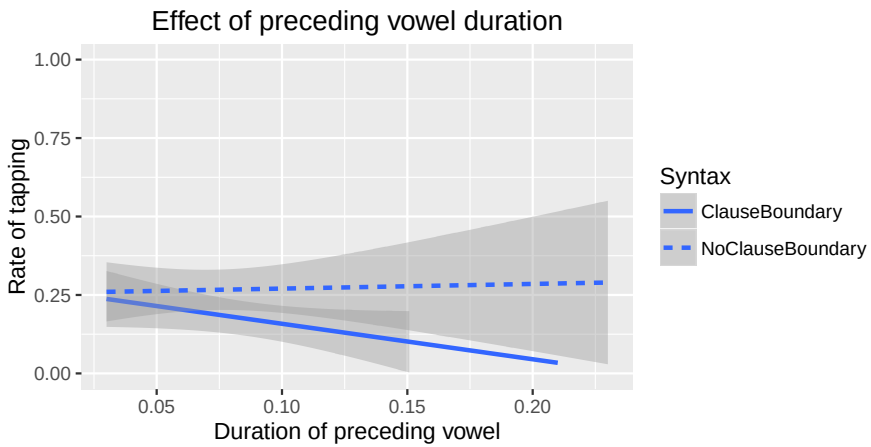

Figure: Percent of tapped [t]s.

Tapping: Production Experiment

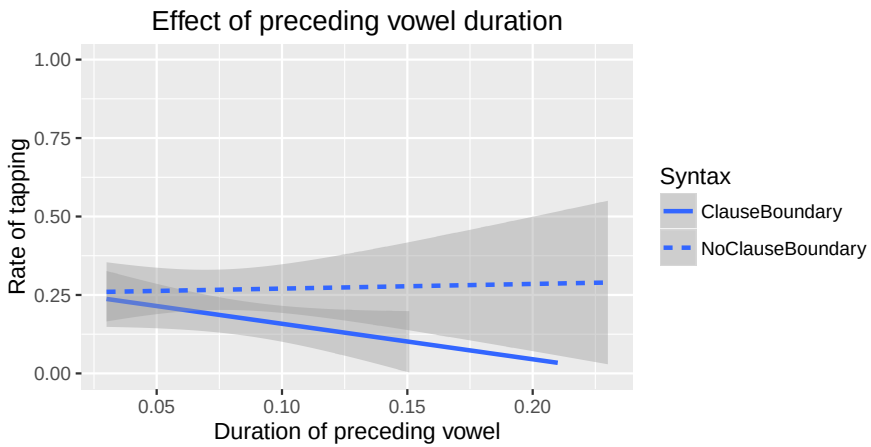

Figure: Percent of tapped [t]s.

- Flapping rate lower when there is a syntactic boundary
- Flapping rate lower when there is a prosodic break...
- ...but only in intransitive case, when there is likely to be a boundary

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- Syntax affects tapping rate significantly even after controlling for prosodic boundary strength
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- Significant interaction between syntax and prosody, and presence syntactic effect after prosody controlled for suggests its not reducible to prosodic effect
  - unexpected for Prosodic Phonology account
- (Also: Effect with nonce-words hard to explain in terms of exemplars or storage of frequently co-occurring bigrams Bybee 2001)

Outline

Effects of Predictability 1: Tapping in Spontaneous speech

with Oriana Kilbourn-Ceron  *& Meghan Clayards* 

Kilbourn-Ceron, O., Wagner, M., and Clayards, M. (2017). The effect of production planning locality on external sandhi: A study in /t/. Proceedings CLS, 313–326

Kilbourn-Ceron, O., Clayards, M., Wagner M. (resubmitted). Predictability modulates pronunciation variants through speech planning effects: A case study on coronal stop realizations. Laboratory Linguistic

Tapping as probabilistic reduction?

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- Tapping is a form of reduction
- Related to reduction of word duration
- Known factor influencing word duration: frequency and predictability
- Common approach to explain this: Information theoretic rationale (cf. Jurafsky et al., 2001; Pluymaekers et al., 2005; Jaeger, 2010, and many others): Less information $\rightarrow$ less oomph

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  - Glottalization: [t/d] $\rightarrow$ ʔ/ __ #
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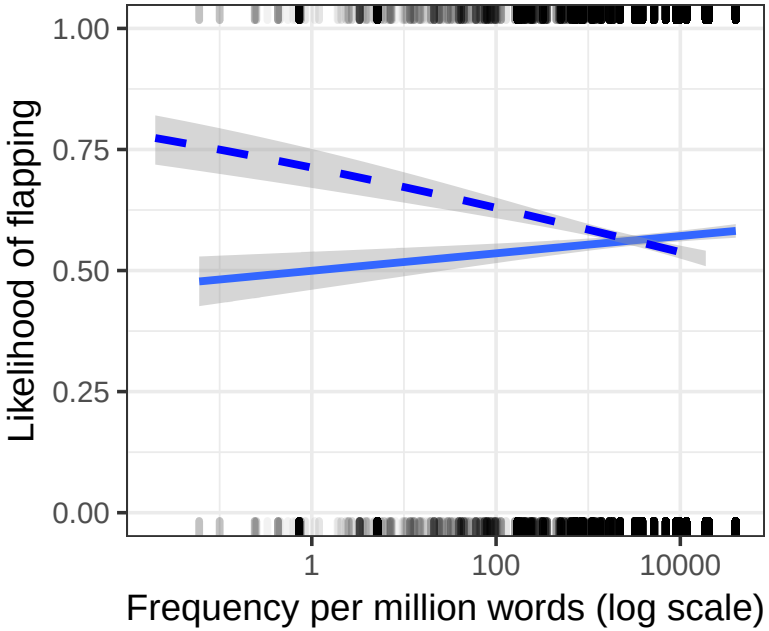
Tapping: Corpus Data

- We look at Buckeye Corpus (Pitt et al., 2007). to look for effect predictability measures
- 11863 tokens with word-findal /t/ or /d/ followed by a vowel-initial word (46.24% were transcribed as flaps).
- Excluded: words followed by disfluency (18.26% of tokens)
- Word frequencies were retrieved from SUBTLEX-US, a database of word frequencies based on film and television subtitles (Brysbaert and New, 2009)

Tapping: Corpus Data

Tapping:



Glottalization:

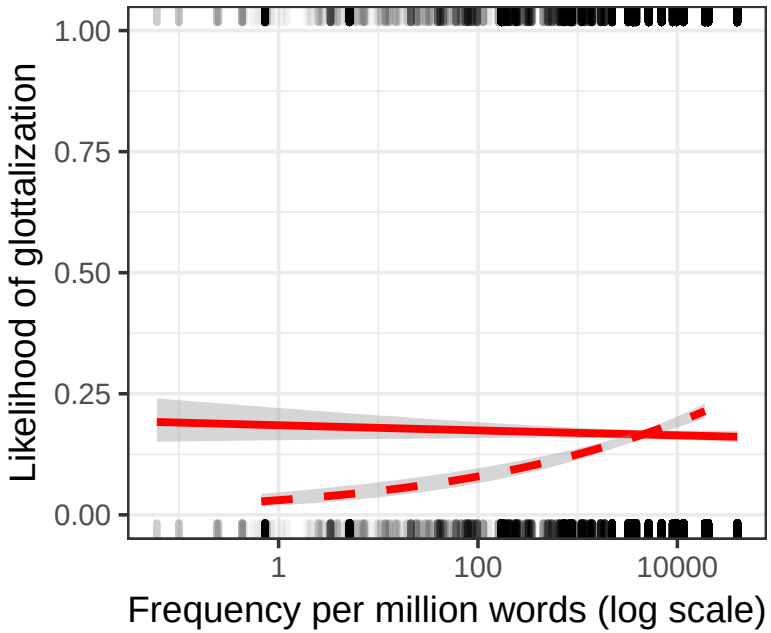


Figure: Relationship between SUBTLEX-US word frequency (per million words) and proportion of tokens transcribed as flaps [dx] (left panel, blue), glottal stops [tq] (right panel, red) in the Buckeye corpus. Solid lines show trigger word frequency, dashed lines show target word frequency, with shading showing 95% confidence intervals of a linear smooth (GLM, logit-link). Rug plot on top and bottom margins represent distribution of tokens.

Tapping & Glottalization: Frequency Effects

- Higher **Target Word Frequency** → less tapping, more glottalization

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The probabilistic reduction account does not explain the differences

Tapping & Glottalization: Conditional probability

The PPH predicts that the **conditional probability** of the second word given the first should be relevant for tapping:

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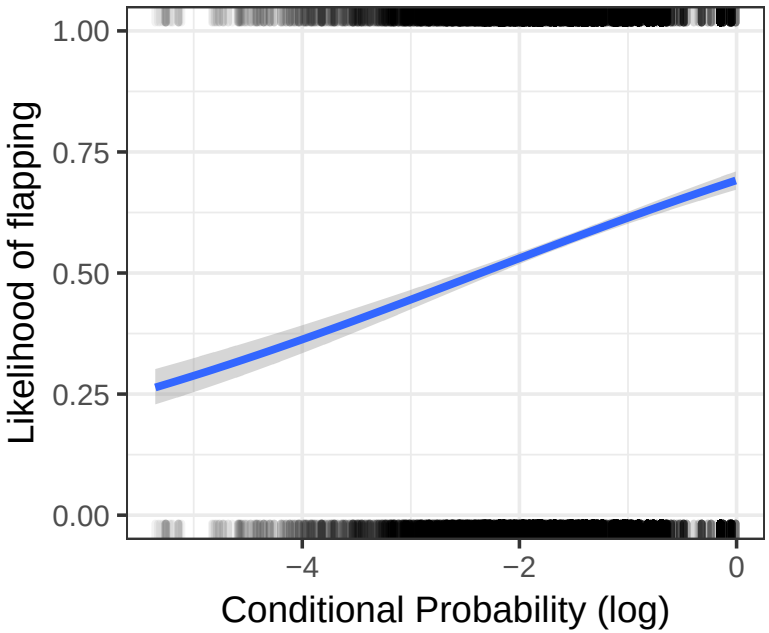

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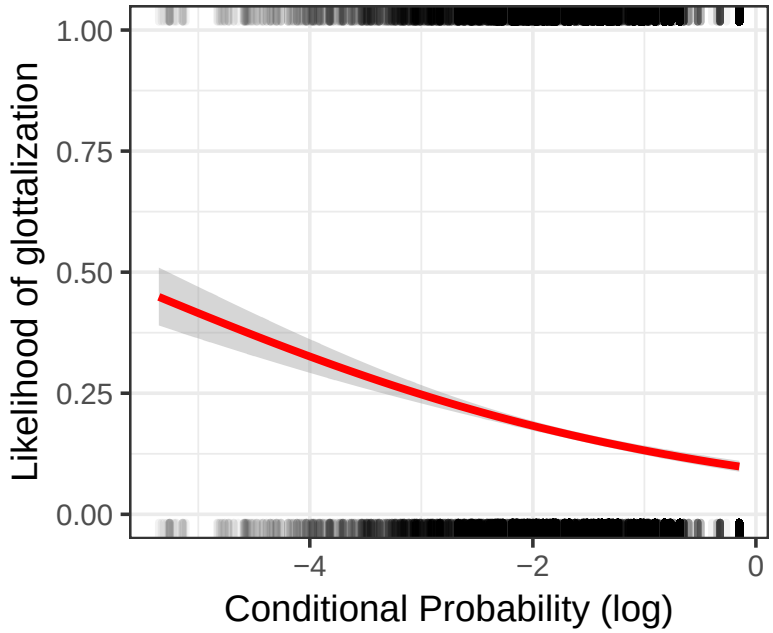
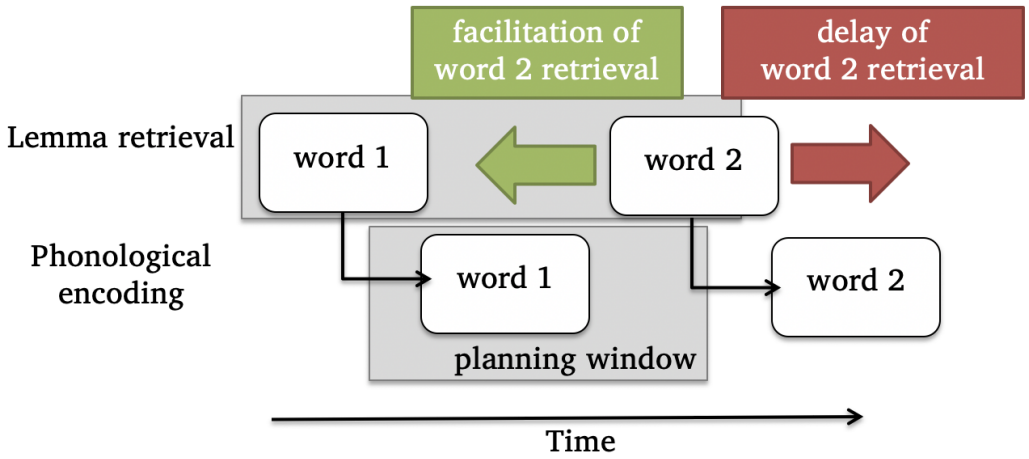


Figure: Relationship between Conditional Probability (of following word given target word) and proportion of tokens transcribed as flaps [dx] (blue, left panel) or glottal stops [tq] (red, right panel) in the Buckeye corpus. Solid lines and shading are linear smooths (GLM, logit-link) with 95% confidence intervals.

Tapping & Glottalization: Frequency Effects

Why negative effect of Target Word Frequency on flapping rate?



There are conflicting results whether high Word1 frequency makes it more or less likely that Word2 is planned at the same time

Effects of predictability 2: [t,d] Deletion in Clusters

with James Tanner  *& Morgan Sonderegger* 

Tanner, J., Sonderegger, M., and Wagner, M. (2015). Production planning and coronal stop deletion in spontaneous speech. In Proceedings of the 18th International Congress of Phonetic Sciences (ICPHS) in Glasgow.

Tanner, J., Sonderegger, M., and Wagner, M. (2017). Production planning and coronal stop deletion in spontaneous speech. Laboratory Phonology, 8 (1): 15:1–3

[t,d] Deletion in Clusters (British English spontaneous speech)

fast ball $>$ **fas' ball**

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PPH: Effect of X should be modulated by **Prosody boundary strength** and **predictability of following word**

[t,d] Deletion in Clusters

Effect of following segment is modulated by strength of boundary:

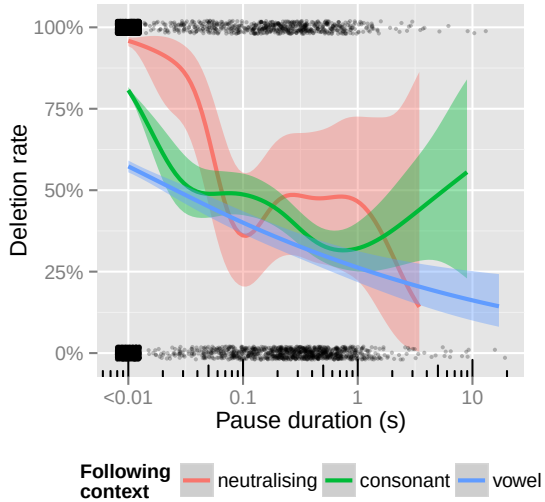

Figure: Deletion rate as a function of pause duration

[t,d] Deletion in Clusters

The higher the **conditional probability**, the bigger the effect of context:

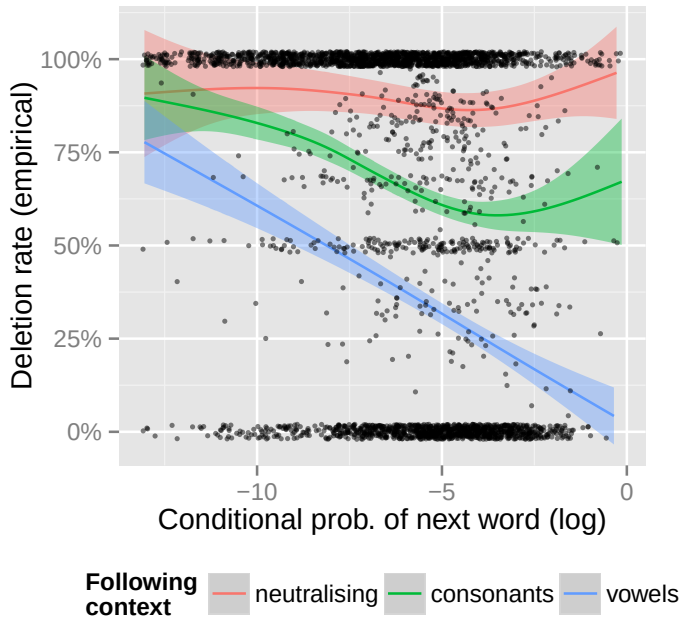

Figure: Deletion rate as a function of conditional probability

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- We tried to control for this by adding duration measures to model
- ...but we could get more direct evidence by looking at **non-reductive** process

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- **Probabilistic reduction:** More predictable information is **reduced** for probabilistic/information-theoretic reasons (cf. Jurafsky et al., 2001; Pluymaekers et al., 2005; Jaeger, 2010, and many others)

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- We found that reduction through glottalization works differently, which suggests that this explanation is not sufficient
- ...but again, by looking at **non-reductive processes** we could avoid similarity in predictions

Outline

Effects of predictability in non-reductive processes: Liaison

with Oriana Kilbourn-Ceron  *& Josiane Lachapelle* 

Corpus Study: Kilbourn-Ceron, Oriana (2016). Speech production planning affects variability in connected speech. Proceedings of AMP, USC

Experimental study: Kilbourn-Ceron, Oriana, Josiane Lachapelle, Michael Wagner (in prep)

Liaison: Latent consonant appears before vowel initial word

Un peti[t] ami

cf. un peti[ ] chapeau

Des vrai[z] amis

cf. des vrai[ ] chatons

Liaison

Different from tapping: Syntactic/Morphological Interactions (Côté, 2013, 157):

	Singular	*Plural*	
Adj + N:	le gros [z] enjeu	les gros [z] enjeux	'the big stake(s)'
N + Adj:	le pas *[z] enjoué	les pas [z] enjoués	'the cheerful step(s)'
N + Verb:	le pas *[z] endort	les pas *[z] endorment	'the step(s) send(s) to sleep'

Liaison

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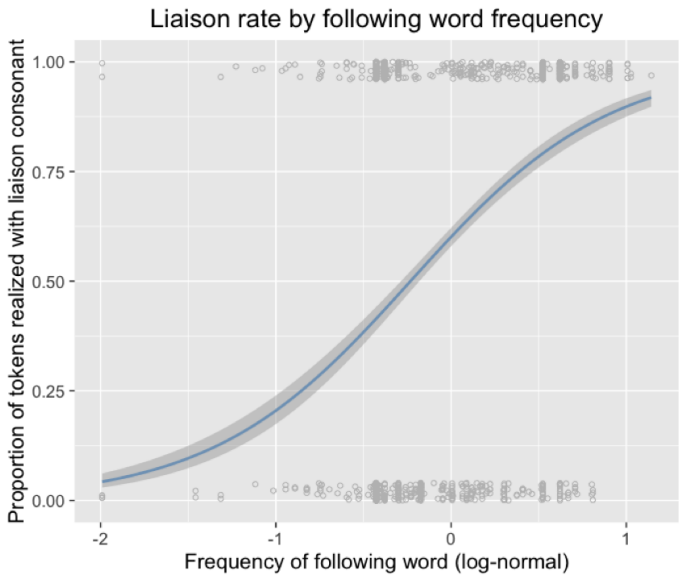
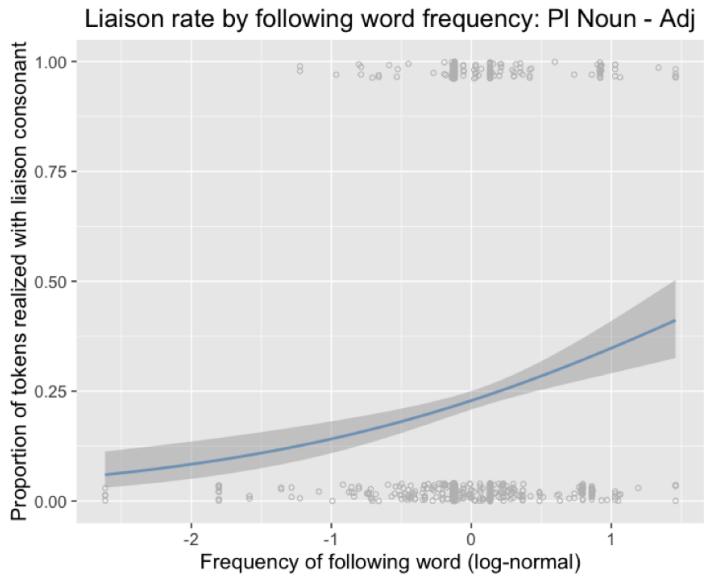
- For predictability effects, PPH makes **same** predictions as for reductive process

Liaison

Liaison rate in Adjective-Noun (left) and Noun-Adjective (right) Cases:





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- Modulation by syntax also as expected (see also Tamminga, M. (2018, *Glossa*) on [t/d]-deletion)
- (Note that the observed frequency effects are also compatible with storage of larger-sized units, Bybee 2001; Côté 2013)

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- Also manipulated: speech rate, repetition, word frequencies, conditional probability of upcoming word, syntax (adjective-noun vs. noun-adjective contexts)

Liaison: Production experiment

(4) Adjective-Noun ('obligatory' liaision context)

a. Low conditional probability;shortword1;shortword2:

Elle discute avec les derniers élèves.
she discusses with the last students

'She is talking with the latest students.' slow; fast

b. High conditional probability,longword1;shortword2:

Vous regrettez vos dernières années.
you regret your last years

'You regret the previous years.' slow; fast

(5) Noun-Adjective ('optional' liaision context')

a. Low conditional probability;shortword1;longword2:

Ils construisent des douches intérieures.
they construct of douches interior

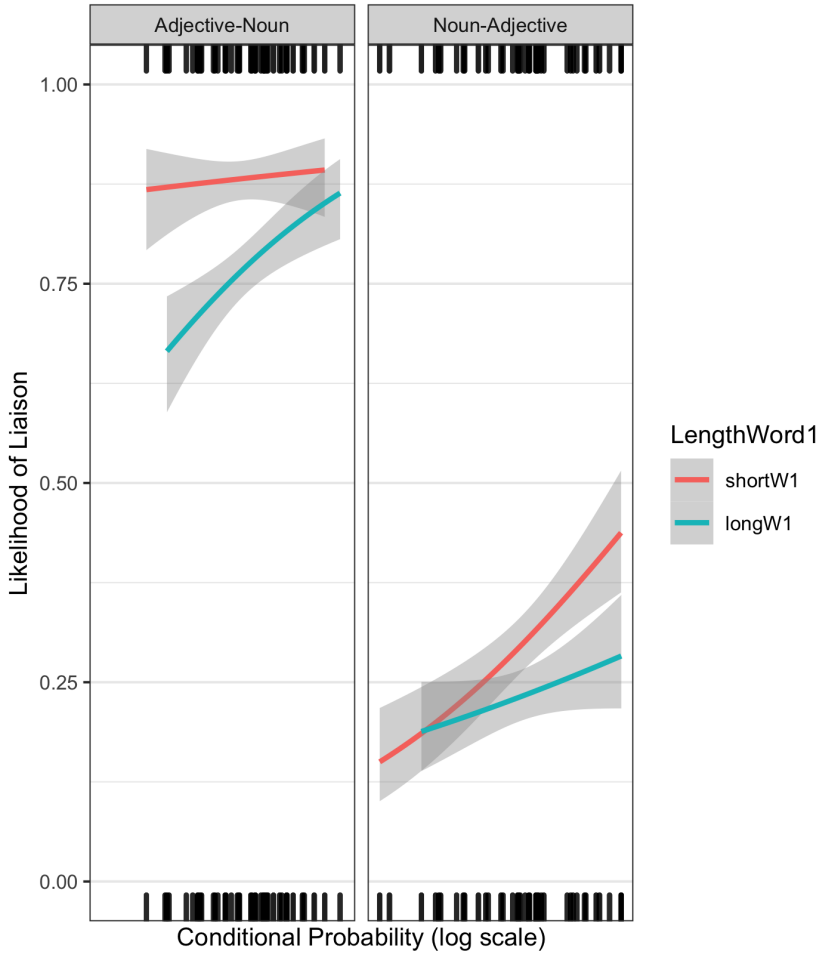
'They are constructing interior showers.' slow; fast

b. High conditional probability;shortword1;shortword2:

Mathilde regarde ses dessins animés.
Mathilde watches her drawing animated

'Mathilde is reading comic books.' slow; fast

Liaison: Production experiment



Plot of the effect of conditional probability, syntax, and length of word1

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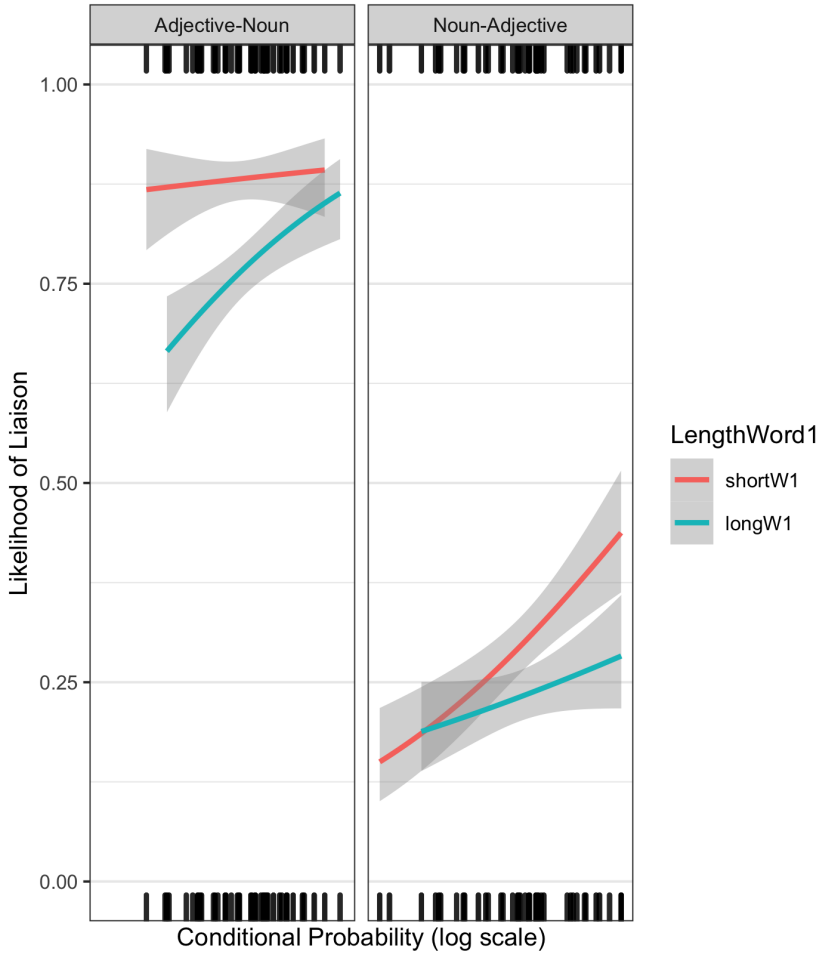

Plot of the effect of conditional probability, syntax, and length of word2

- The longer word1 was, the lower the liaison rate (this has not previously been shown for liaison, as far as we know)

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- No effect of Repetition
- No effect of Speech rate (already observed in Kaisse)
  - Why is it not like tapping in this respect? Does liaison operate at a different level of representation than tapping?

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- The PPH (correctly) makes the *opposite* prediction

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- This result contradicts the PPH! But there are potential confounds...
- The PPH predicts predictability effect irrespective of their adaptiveness from an information-theoretic point of view
- (although which patterns 'survive' and are grammaticalized might still depend on their utility for message-retrieval)

Outline

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It may be a bit of both... but mostly it's just an empirical hypothesis...

Toward a predictive theory of locality & variability in phonology

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Why do these processes differ in their locality and variability?

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- Taiwanese
  - every non-final word within a domains undergoes tone sandhi;
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More predictions: Influence of prior vs. upcoming information in vowel coalescence (Lamontagne and Torreira, 2017)

Locality and Variability

Can we make predictions about Locality?

Maybe yes: When a process relies on phonological information about an upcoming word, it should necessarily be local; when it depends on phonological information about a previous word, or on higher level information, it does not need to be local.

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Can we make predictions about variability?

Maybe yes: If a process relies on phonological information contained in an upcoming word, it necessarily has to be variable, but not if it relies on information from preceding word.

Thanks!

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Anttila, A. (2002). Variation and phonological theory. In The handbook of language variation and change, pages 206–243. Wiley-Blackwell, Oxford.

Browman, C. P. and Goldstein, L. (1990). Tiers in articulatory phonology, with some implications for casual speech. Papers in laboratory phonology I: Between the grammar and physics of speech, pages 341–376.

Brysbaert, M. and New, B. (2009). Moving beyond Kučera and Francis: A critical evaluation of current word frequency norms and the introduction of a new and improved word frequency measure for american english. Behavior research methods, 41(4):977–990.

Bybee, J. (2001). Frequency effects on French liaison. In Bybee, J. and Hopper, P., editors, Frequency and the emergence of linguistic structure, pages 337–359. John Benjamins.

Byrd, D. and Saltzman, E. (2003). The elastic phrase: Modeling the dynamics of boundary-adjacent lengthening. Journal of Phonetics, 31:149–180.

Chen, M. (2000). Tone sandhi: Patterns across Chinese dialects. Cambridge Univeristy Press.

Chen, M. Y. (1987). The syntax of Xiamen tone sandhi. Phonology Yearbook, 4:109–49.

Coetzee, A. W. and Kawahara, S. (2013). Frequency biases in phonological variation. Natural Language & Linguistic Theory, 31(1):47–89.

Cooper, W. E. and Paccia-Cooper, J. (1980). Syntax and Speech. Harvard University Press, Cambridge, Mass.

Côté, M.-H. (2013). Understanding cohesion in french liaison. Language Sciences, 39:156–166.

Currie Hall, K., Hume, E., Jaeger, T. F., and Wedel, A. (2016). The message shapes phonology. Ms. Univ. of British Columbia, Univ. of Canterbury, Univ. of Rochester, Univ. of Arizona.

Griffin, Z. (2003). A reversed word length effect in coordinating the preparation and articulation of words in speaking. Psychonomic Bulletin and Review, 10:603–609.

Jaeger, T. (2010). Redundancy and Reduction: Speakers Manage Syntactic Information Density. Cognitive Psychology, 61(1):23–62.

Jurafsky, D., Bell, A., Gregory, M., and Raymond, W. D. (2001). Probabilistic relations between words: Evidence from reduction in lexical production. In Bybee, J. and Hopper, P., editors, Frequency in the Emergence of Linguistic Structure, pages 229–254. John Benjamins, Amsterdam.

Kaisse, E. M. (1985). Connected Speech. The interaction between syntax and phonology. Academic Press, Orlando, Flo.

Kilbourn-Ceron, O. (2015). The influence of prosodic context on high vowel devoicing in spontaneous Japanese. In Proceedings of the 18th International Congress of Phonetic Sciences (ICPHS) in Glasgow.

Kilbourn-Ceron, O. (2017a). Speech production planning affects phonological variability: a case study in French liaison. In Proceedings of the Annual Meeting on Phonology 2016, October 21-23, 2016. University of Southern California, Los Angeles, CA.

Kilbourn-Ceron, O. (2017b). Speech production planning affects variation in external sandhi. PhD thesis, McGill University.

Kilbourn-Ceron, O., Clayards, M., and Wagner, M. (submitted). Predictability modulates pronunciation variants through speech planning effects: A case study on coronal stop realizations. Laboratory Linguistics.

Kilbourn-Ceron, O., Wagner, M., and Clayards, M. (2017). The effect of production planning locality on external sandhi: A study in /t/. In Proceedings of the 52nd Annual Meeting of the Chicago Linguistic Society, pages 313–326.

Krivokapić, J. and Byrd, D. (2012). Prosodic boundary strength: An articulatory and perceptual study. Journal of phonetics, 40(3):430–442.

Lamontagne, J. and Torreira, F. (2017). Production planning effects in sandhi: A corpus study using automated classification. Talk presented at New Ways of Analyzing Variation 46, Madison, Wisconsin.

Miozzo, M. and Caramazza, A. (2003). When more is less: a counterintuitive effect of distractor frequency in the picture-word interference paradigm. Journal of Experimental Psychology: General, 132(2):228.

Nespor, M. and Vogel, I. (1986). Prosodic Phonology. Foris, Dordrecht.

Odden, D. (1990). Syntax, lexical rules and postlexical rules in Kimatuumbi. In Inkelas, S. and Zec, D., editors, The phonology-syntax Connection, pages 259–278. CSLI and CUP.

Pak, M. (2008). The postsyntactic derivation and its phonological reflexes. PhD thesis, University of Pennsylvania.

Pitt, M. A., Dilley, L., Johnson, K., Kiesling, S., Raymond, W., Hume, E., and Fosler-Lussier, E. (2007). Buckeye corpus of conversational speech (2nd release). Columbus, OH: Department of Psychology, Ohio State University.

Pluymaekers, M., Ernestus, M., and Baayen, R. (2005). Articulatory planning is continuous and sensitive to informational redundancy. Phonetica, 62(2-4):146–159.

Selkirk, E. (1986). On derived domains in sentence phonology. Phonology Yearbook, 3:371–405.

Selkirk, E. (2011). The syntax-phonology interface. In Goldsmith, J., Riggle, J., and Yu, A., editors, The Handbook of Phonological Theory, pages 435–484. Blackwell, Oxford, 2nd edition.

Swets, B., Jacovina, M. E., and Gerrig, R. J. (2013). Effects of conversational pressures on speech planning. Discourse Processes, 50(1):23–51.

Tamminga, M. (2018). Modulation of the following segment effect on english coronal stop deletion by syntactic boundaries. Glossa.

Tanner, J., Sonderegger, M., and Wagner, M. (2015). Production planning and coronal stop deletion in spontaneous speech. In Proceedings of the 18th International Congress of Phonetic Sciences (ICPHS) in Glasgow.

Tanner, J., Sonderegger, M., and Wagner, M. (2017). Production planning and coronal stop deletion in spontaneous speech. Laboratory Phonology, 8 (1): 15:1–39.

Temple, R. (2014). Where and what is (t,d)? a case study in taking a step back in order to advance sociophonetics. In Calamai, C. C. . S., editor, Advances in Sociophonetics, pages 97–136. John Benjamins, Amsterdam.

Turnbull, R., Seyfarth, S., Hume, E., and Jaeger, T. F. (2018). Nasal place assimilation trades off inferrability of both target and trigger words. Laboratory Phonology: Journal of the Association for Laboratory Phonology, 9(1).

Wagner, M. (2011). Production-planning constraints on allomorphy. volume 39, pages 160–161.

Wagner, M. (2012). Locality in phonology and production planning. In Proceedings of Phonology in the 21 Century: Papers in Honour of Glyne Piggott, Montréal. McGill Working Papers.