Speakers apply morphological dependencies in the inflection of novel forms

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Introduction: What does the title mean?

… morphological dependencies …

- If a Hungarian noun has -ɒk in the plural, it is likely to have -ɒ in the possessive.
- Paradigmatic structure/informativity: the Paradigm Cell Filling Problem (e.g. Ackerman et al., 2009; Ackerman and Malouf, 2013)

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Introduction: Why should we care?

Considerations for theoretical morphology

- Speakers learn morphological dependencies (just like phonological ones)
- Easy to represent generalizations using diacritic features in lexical entries (e.g. Chomsky and Halle, 1968)

Outline

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Arbitrary inflection of lexical items must be somehow *grammatically marked*

One common approach: *morphological features* (e.g. Lieber, 1980; Corbett and Baerman, 2006) that are attached as *diacritics* to lexical entries

Inflection class features: the case of Russian

Russian feminine nouns: class II and III (Corbett and Baerman, 2006)

class *example*	II 'newspaper'	III 'bone'
nominative	gazet-a	kost^{j}
dative	gazet-e	kost^{j}-i
instrumental	gazet-oj	kost^{j}-ju

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Feature-based analysis of Russian

The features II and III are each referenced in *multiple* (DM-style) *vocabulary insertion rules* (see Halle and Marantz, 1993; Müller, 2004; Embick and Marantz, 2008)

(1) *Vocabulary insertion rules for Russian cases*

a.	NOM ↔ a / II ___	d.	NOM ↔ Ø / III ___
b.	DAT ↔ e / II ___	e.	DAT ↔ i / III ___
c.	INS ↔ oj / II ___	f.	INS ↔ ju / III ___

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(2) *Lexical entries for Russian nouns*

a. II: /gazet$_{II}$/ ‘newspaper’, /tʃert$_{II}$/ ‘characteristic’, /dolʲ$_{II}$/ ‘portion’, …

b. III: /kostʲ$_{III}$/ ‘bone’, /tetradʲ$_{III}$/ ‘notebook’, /ploɕːadʲ$_{III}$/ ‘square’, …

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Novel dative [grid^{j}-i] ‘princely retinue’, **what’s the instrumental?**

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The structure of the grammar, with features used in multiple rules, facilitates inference of new forms!

Narrowly tailored features: the case of Hungarian

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Hungarian plural (-ok/-ɒk) and possessive (-ɒ/-jɒ): all four possible combinations (Rácz and Rebrus, 2012)

			"lowering stems"	
noun	dɒl	tʃont	vaːlː	hold
gloss	'song'	'bone'	'shoulder'	'moon'
plural	dɒl-ok	tʃont-ok	vaːlː-ɒk	hold-ɒk
possessive	dɒl-ɒ	tʃont-jɒ	vaːlː-ɒ	hold-jɒ

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Features for the possessive ([±j]) and plural ([lower]) are each referenced in *one rule* (see Siptár and Törkenczy (2000) for an alternate analysis)

(5) *Vocabulary insertion rules for Hungarian plural and possessive*

a. PL ↔ ɒk / [lower] ___

b. PL ↔ ok

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a. [lower]: /vaːlː$_{[\text{lower},-\text{j}]}$/ ‘shoulder’, /hold$_{[\text{lower},+\text{j}]}$/ ‘moon’, /ɟaːr$_{[\text{lower},-\text{j}]}$/ ‘factory’, /ɲaːr$_{[\text{lower},+\text{j}]}$/ ‘poplar’, …

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c. [−j]: /dɒl$_{[-\text{j}]}$/ ‘song’, /vaːlː$_{[\text{lower},-\text{j}]}$/ ‘shoulder’, /kaːr$_{[-\text{j}]}$/ ‘damage’, /ɟaːr$_{[\text{lower},-\text{j}]}$/ ‘factory’, …

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- [lower] in noun's lexical entry ↛ …

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- [lower] in noun's lexical entry ↛ …

  (5c) POSS ↔ jɒ / [+j] ___

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Unlike in Russian, the structure of the grammar, with each feature used in a single rule, **does not** facilitate inference of new forms.

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- plural: lufɒnɒk **(lowering stem)**

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Stats

- 90 participants
- 35–50 trials per participant
- …of which 8–12 lowering stem trials
- 81 stimuli (57 target, 24 filler)
- 2,398 total target trials

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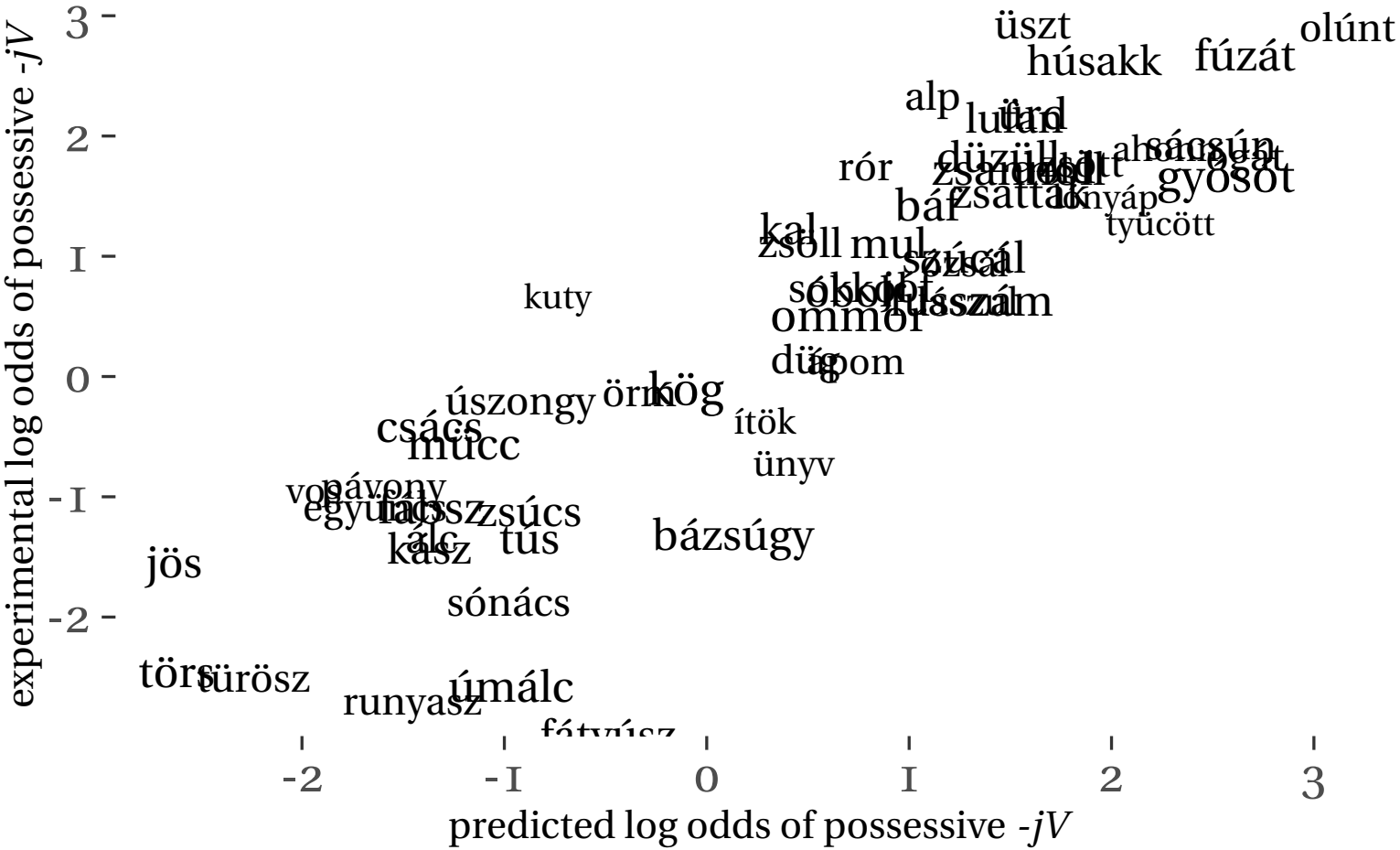

Baseline: the phonological model predicts experimental rate of possessives for *individual nonce words* quite well

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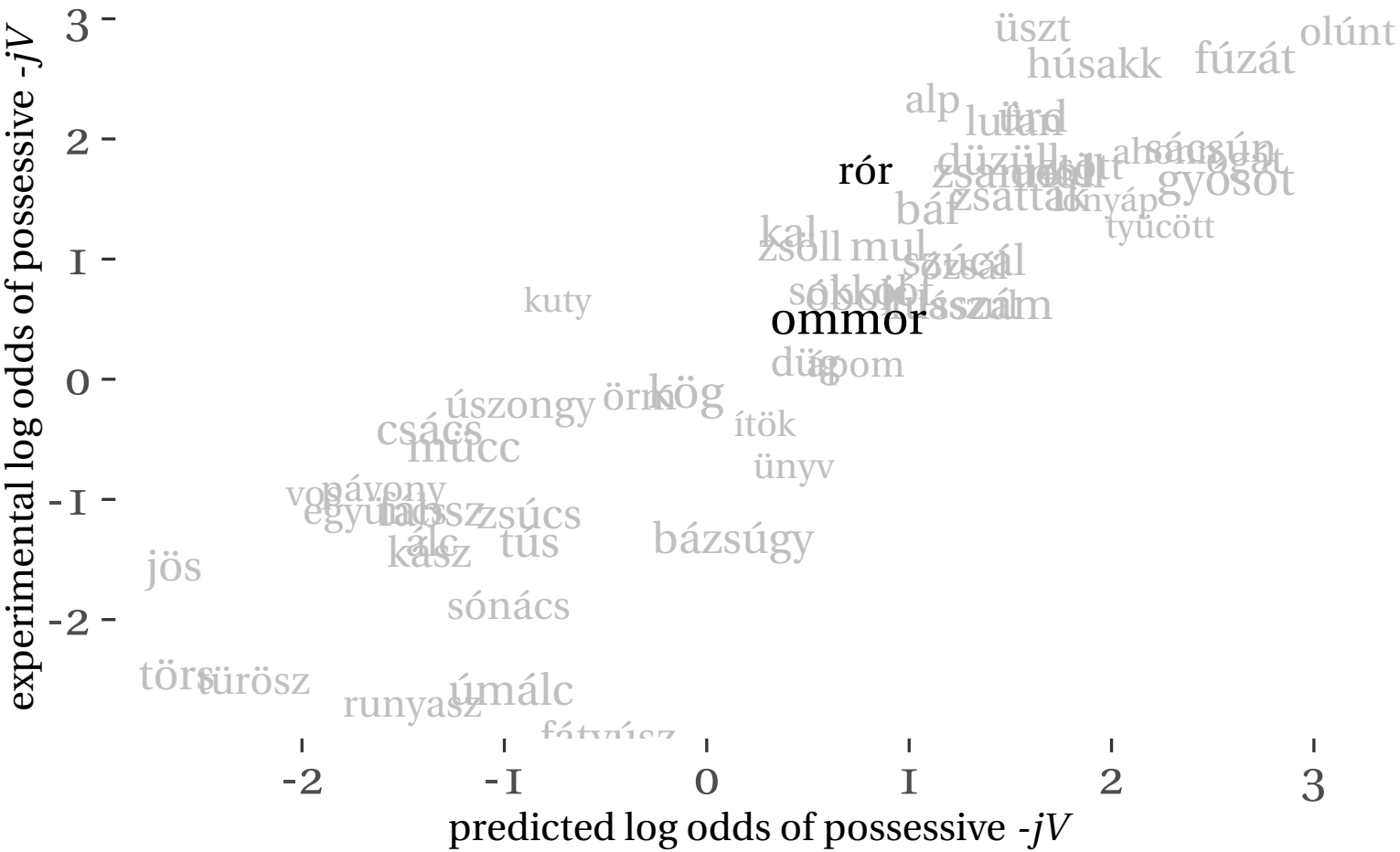

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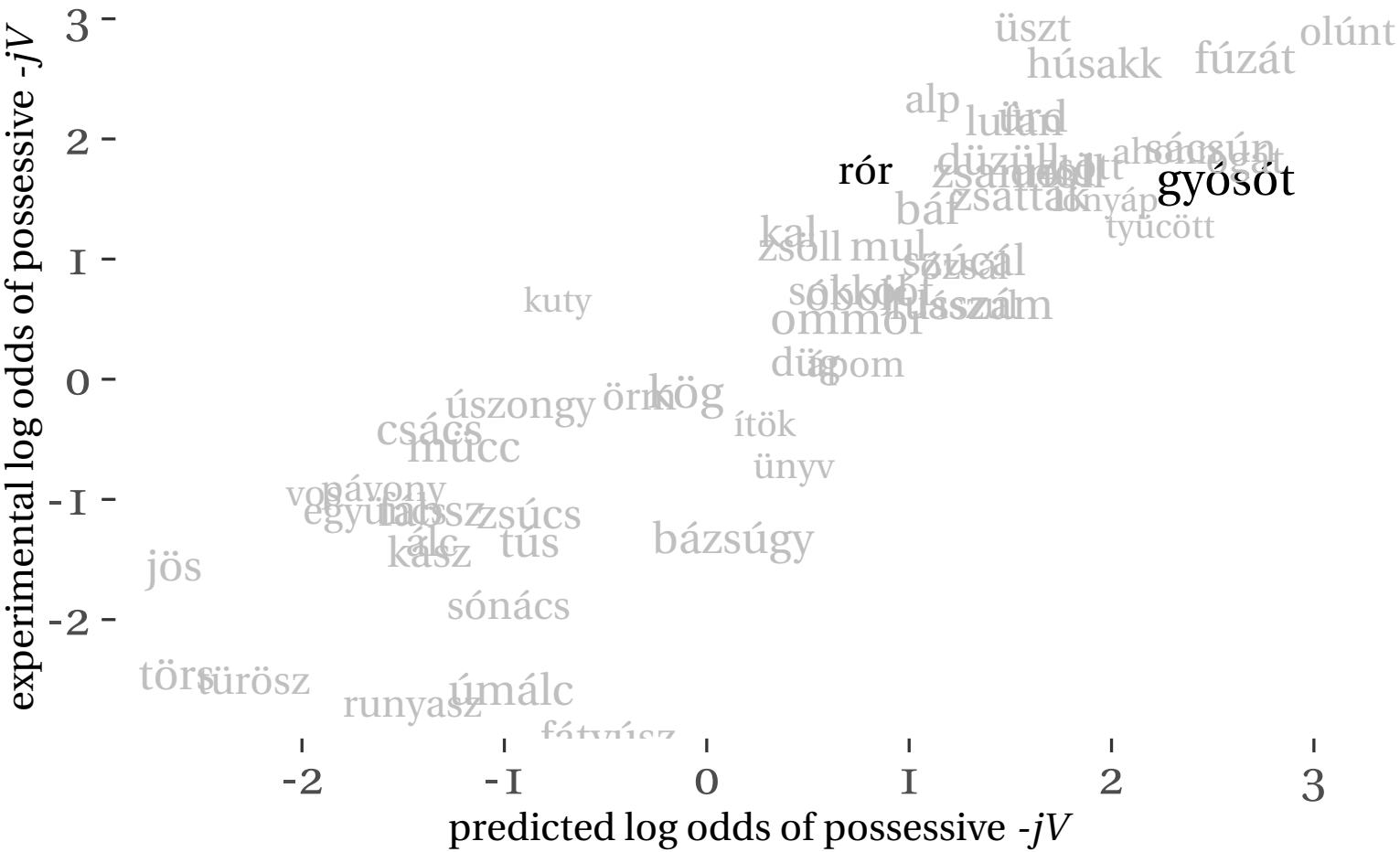

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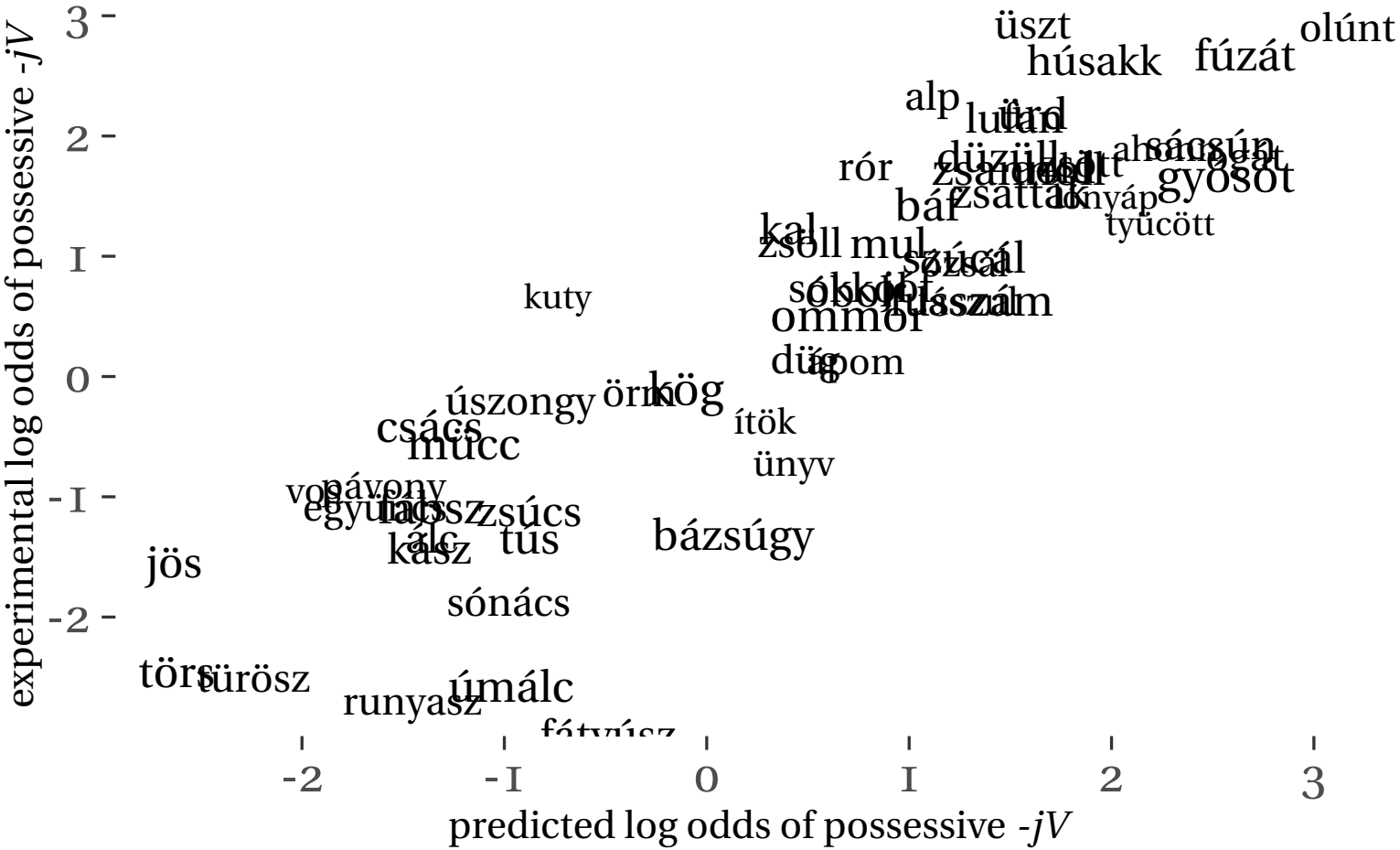

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Baseline: phonological model trained on corpus of monomorphemic words from Papp (1969)

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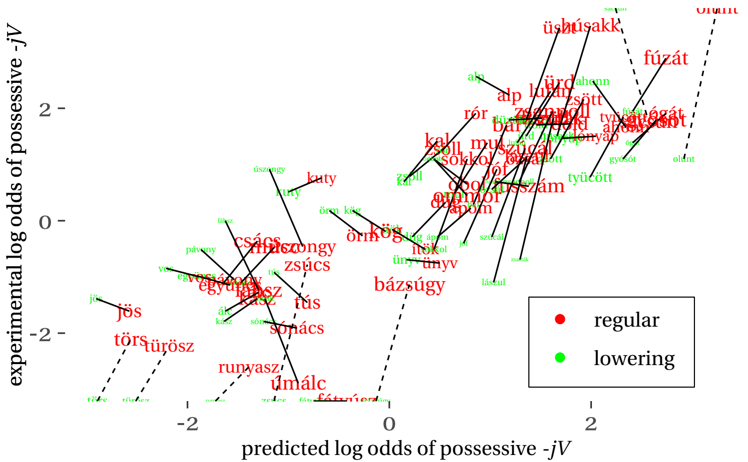
- final C manner + final C place + harmony class + final V height + final V length + final coda complexity + word length

Then: predict experimental results from phonological model **and stem class**

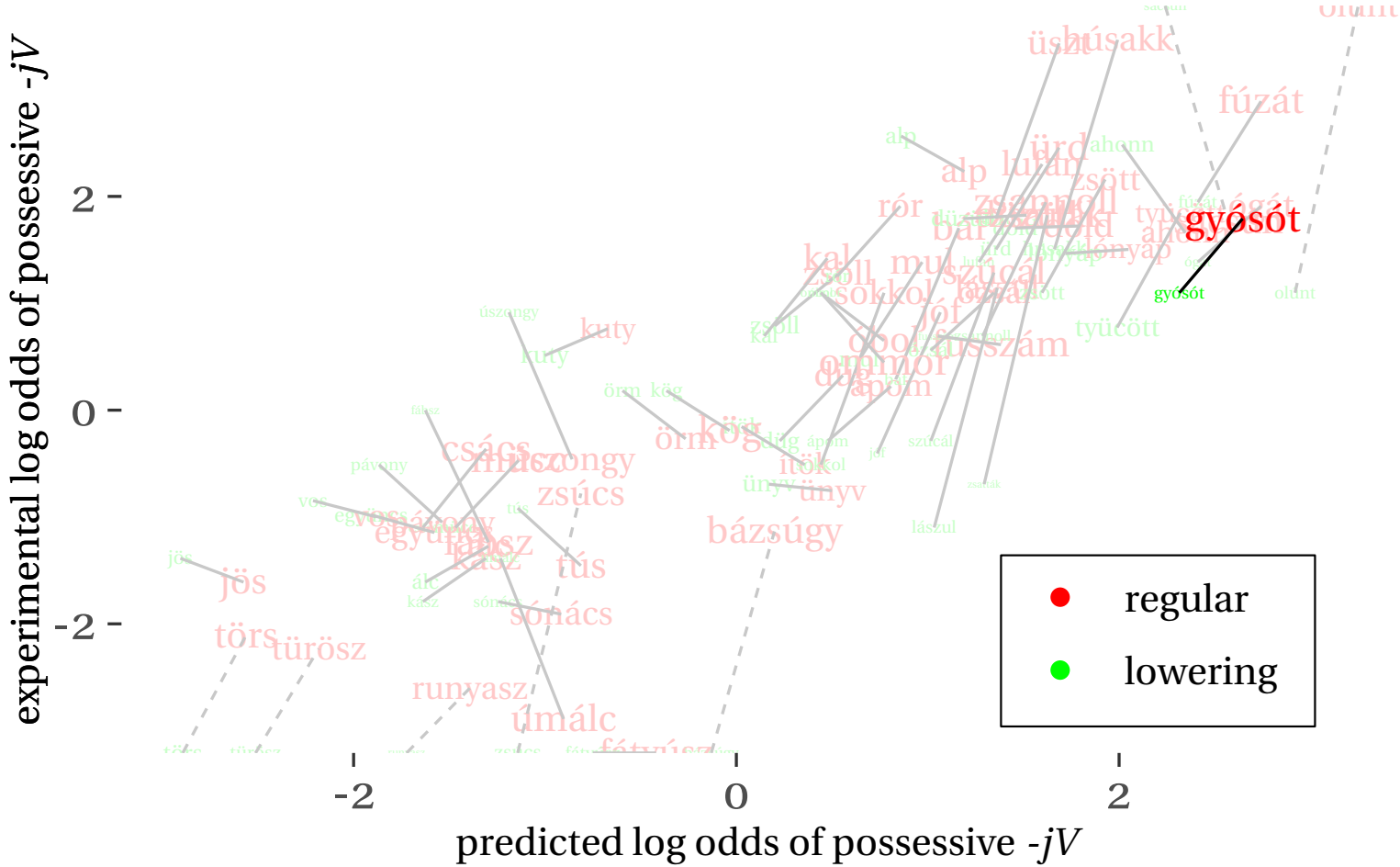
- Given nonce word phonology **and plural** and participant, predicts odds of -jɒ
- (1 | participant) + phon_odds **+ plural**

Results: sensitivity to morphology



Target condition: most nonce words had a *lower* rate of -jɒ when presented as lowering stems

Results: sensitivity to morphology



predicted: ɟoːsoːtok, ɟoːsoːtjɒ > ɟoːsoːtɒk, ɟoːsoːtjɒ

actual: ɟoːsoːtok, ɟoːsoːtjɒ > ɟoːsoːtɒk, ɟoːsoːtjɒ

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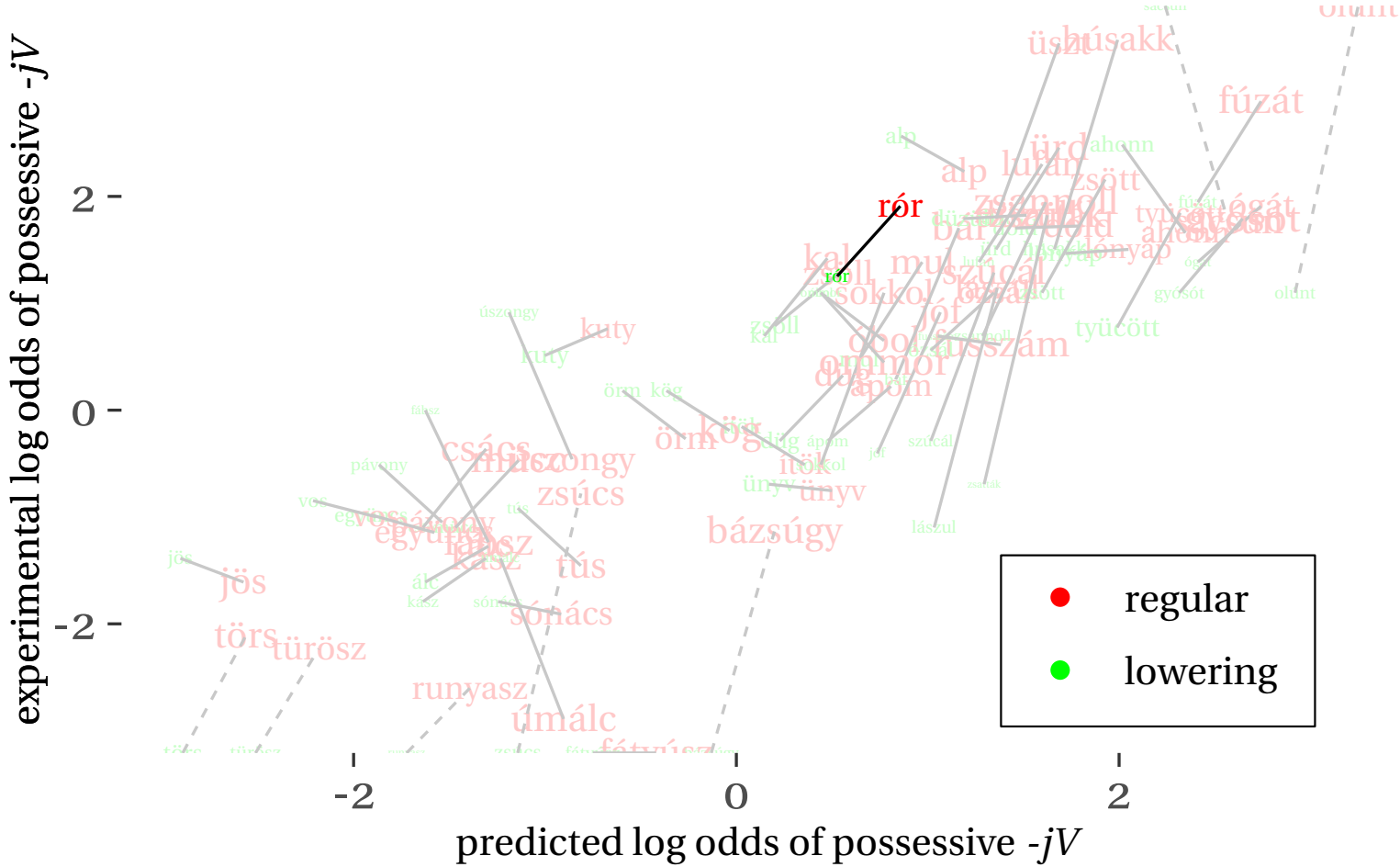
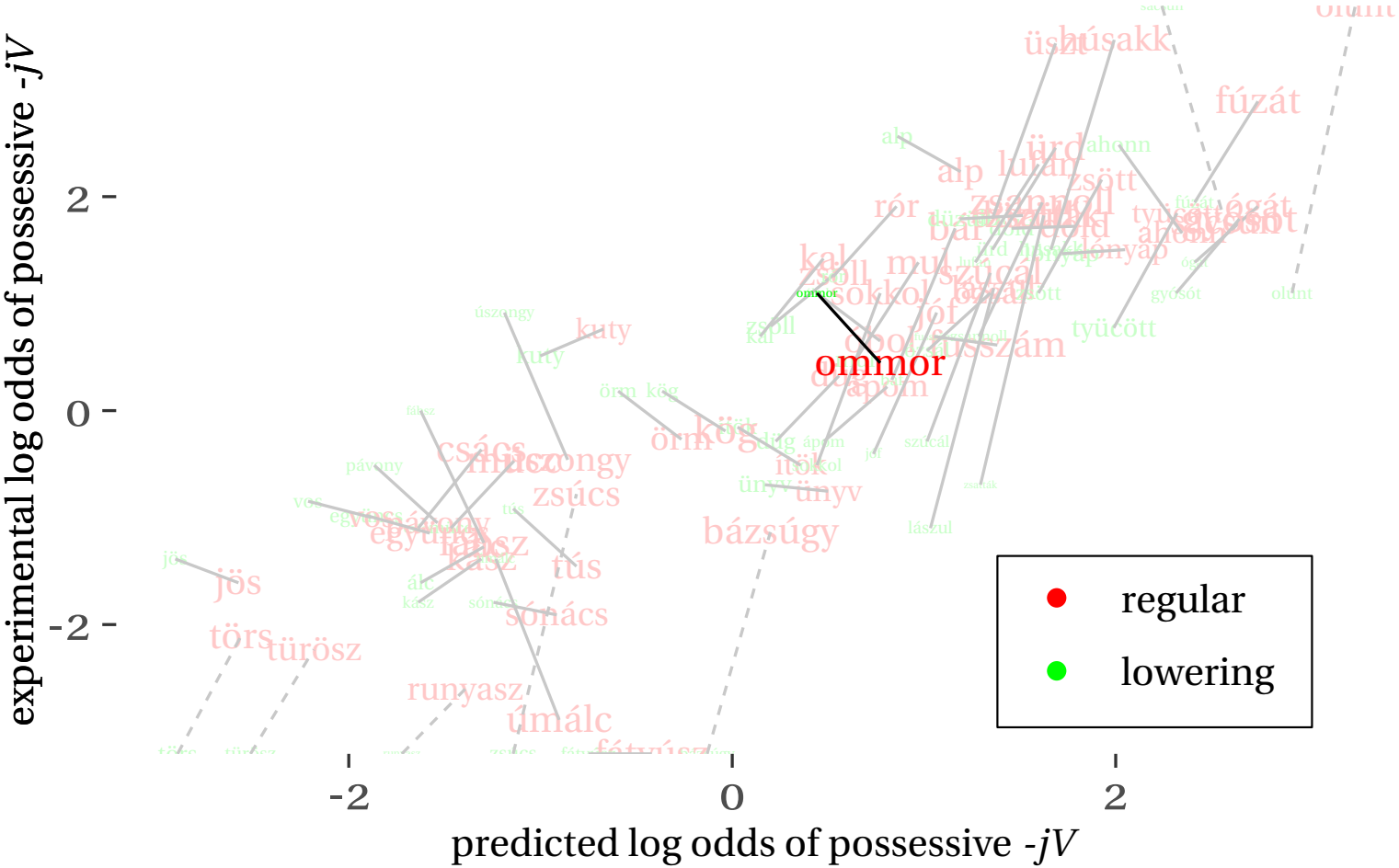


predicted: roːrok, roːrjɒ > roːrɒk, roːrjɒ

actual: roːrok, roːrjɒ > roːrɒk, roːrjɒ

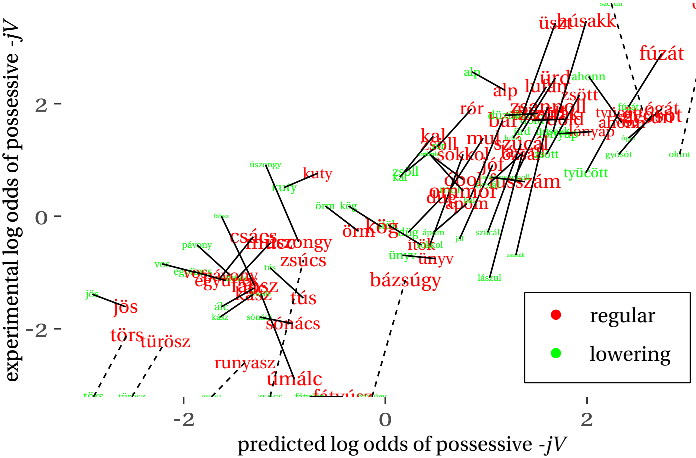
Results: sensitivity to morphology



predicted: om:orok, om:orjɒ > om:orɒk, om:orjɒ

actual: om:orok, om:orjɒ < om:orɒk, om:orjɒ

Results: sensitivity to morphology



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Results: summary

- Participants matched the phonological distribution of -jɒ and -ɒ in the lexicon

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- Participants matched the phonological distribution of -jɒ and -ɒ in the lexicon
- …Taking this into account, they also assigned -ɒ more to nonce words with plural -ɒk

Outline

Interpretation of results

Rácz and Rebrus (2012) and others: -jɒ is the productive default for most words

- recent loans and neologisms take -jɒ
- … unless they end in palatals and sibilants, in which case, they take -ɒ

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No obvious explanation for difference, but …

- clear that speakers have and can apply generalizations over the distribution of -jɒ and -ɒ in the lexicon
- these generalizations are both *phonological* and *morphological*

Generalizations and productivity

Existing formal models for productively learning phonological generalizations (e.g. Albright and Hayes, 2003; Hayes et al., 2009; Gouskova et al., 2015; Yang, 2016)

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Can they be used to capture morphological dependencies as well?

- easily with morphological features/natural classes (see my dissertation!)
  - lowering stem $\leftrightarrow$ [lower]
- somewhat less easily with alternatives like complex stem storage (Bermúdez-Otero, 2012, 2013)

Do we need inflection class features at all?

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(5) *Vocabulary insertion rules for Hungarian plural and possessive*

a. PL ↔ ɒk / [lower] ___
b. PL ↔ ok
c. POSS ↔ jɒ / [+j] ___
d. POSS ↔ ɒ / [−j] ___

(1) *Vocabulary insertion rules for Russian cases*

a. NOM ↔ a / II ___
b. DAT ↔ e / II ___
c. INS ↔ oj / II ___
d. NOM ↔ Ø / III ___
e. DAT ↔ i / III ___
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Ackerman et al. (2009); Baerman et al. (2017) and others: Russian and Hungarian differ in *degree* of cohesion, not kind

- We need separate generalizations to capture Hungarian morphological dependency between -ɒk and -ɒ
- Maybe Russian-style "inflection classes" are just very strong morphological generalizations

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Alternate Russian analysis

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Alternate Russian analysis

(1′) *Vocabulary insertion rules for Russian cases*

a. NOM ↔ a / [N:a] ___
b. DAT ↔ e / [D:e] ___
c. INS ↔ oj / [I:oj] ___
d. NOM ↔ Ø / [N:Ø] ___
e. DAT ↔ i / [D:i] ___
f. INS ↔ ju / [I:ju] ___

Do we need inflection class features at all?

Alternate Russian analysis

(1′) *Vocabulary insertion rules for Russian cases*

a.	NOM ↔ a	/ [N:a] ___	d.	NOM ↔ Ø	/ [N:Ø] ___
b.	DAT ↔ e	/ [D:e] ___	e.	DAT ↔ i	/ [D:i] ___
c.	INS ↔ oj	/ [I:oj] ___	f.	INS ↔ ju	/ [I:ju] ___

(2′) *Lexical entries for Russian nouns*

a. II: /gazet$_{[N:a,D:e,I:oj]}$/ ‘newspaper’, /tʃert$_{[N:a,D:e,I:oj]}$/ ‘characteristic’, /dolʲ$_{[N:a,D:e,I:oj]}$/ ‘portion’, …

b. III: /kostʲ$_{[N:Ø,D:i,I:ju]}$/ ‘bone’, /tetradʲ$_{[N:Ø,D:i,I:ju]}$/ ‘notebook’, /ploɕːadʲ$_{[N:Ø,D:i,I:ju]}$/ ‘square’, …

References I

Ackerman, F., Blevins, J. P., and Malouf, R. (2009). Parts and wholes: Implicative patterns in inflectional paradigms. In Blevins, J. P. and Blevins, J., editors, *Analogy in Grammar: Form and Acquisition*, chapter 3, pages 54–82. Oxford University Press, Oxford.

Ackerman, F. and Malouf, R. (2013). Morphological organization: The low conditional entropy conjecture. *Language*, 89(3):429–464.

Albright, A. and Hayes, B. (2003). Rules vs. analogy in English past tenses: a computational/experimental study. *Cognition*, 90(2):119–161.

Baerman, M., Brown, D., and Corbett, G. G. (2017). *Morphological Complexity*, volume 153 of *Cambridge Studies in Linguistics*. Cambridge University Press, Cambridge.

Bermúdez-Otero, R. (2012). The architecture of grammar and the division of labor in exponence. In Trommer, J., editor, *The Morphology and Phonology of Exponence*, volume 41 of *Oxford Studies in Theoretical Linguistics*, chapter 2, pages 8–83. Oxford University Press, Oxford.

Bermúdez-Otero, R. (2013). The Spanish lexicon stores stems with theme vowels, not roots with inflectional class features. *Probus: International Journal of Romance Linguistics*, 25(1):3–103.

Chomsky, N. and Halle, M. (1968). *The Sound Pattern of English*. Studies in Language. Harper & Row, New York, Evanston, and London.

Corbett, G. G. and Baerman, M. (2006). Prolegomena to a typology of morphological features. *Morphology*, 16:231–246.

Embick, D. and Marantz, A. (2008). Architecture and blocking. *Linguistic Inquiry*, 39(1):1–53.

Gouskova, M., Newlin-Łukowicz, L., and Kasyanenko, S. (2015). Selectional restrictions as phonotactics over sublexicons. *Lingua*, 167:41–81.

Halle, M. and Marantz, A. (1993). Distributed morphology and the pieces of inflection. In Hale, K. and Keyser, S. J., editors, *The View from Building 20: Essays in Linguistics in Honor of Sylvain Bromberger*, volume 24 of *Current Studies in Linguistics*, chapter 3, pages 111–176. MIT Press, Cambridge.

Hayes, B., Zuraw, K., Siptár, P., and Londe, Z. (2009). Natural and unnatural constraints in Hungarian vowel harmony. *Language*, 85(4):822–863.

References II

Jackendoff, R. (1975). Morphological and semantic regularities in the lexicon. *Language*, 51(3):639–671.

Lieber, R. (1980). *On the Organization of the Lexicon*. PhD thesis, Massachusetts Institute of Technology, Cambridge.

Müller, G. (2004). On decomposing inflection class features: Syncretism in Russian noun inflection. In Müller, G., Gunkel, L., and Zifonun, G., editors, *Explorations in Nominal Inflection*, volume 10 of *Interface Explorations*, pages 189–227. Mouton de Gruyter, Berlin.

Papp, F. (1969). *A magyar nyelv szóvégmutató szótára*. Akadémiai Kiadó, Budapest.

Rácz, P. and Rebrus, P. (2012). Variation in the possessive allomorphy of Hungarian. In Kiefer, F., Ladányi, M., and Siptár, P., editors, *Current Issues in Morphological Theory: (Ir)regularity, analogy and frequency: Selected papers from the 14th International Morphology Meeting, Budapest, 13–16 May 2010*, volume 322 of *Current Issues in Linguistic Theory*, pages 51–64, Amsterdam, Philadelphia. John Benjamins.

Siptár, P. and Törkenczy, M. (2000). *The Phonology of Hungarian*. The Phonology of the World's Languages. Oxford University Press, Oxford, New York.

Stump, G. (2001). *Inflectional Morphology: A Theory of Paradigm Structure*, volume 93 of *Cambridge Studies in Linguistics*. Cambridge University Press, Cambridge.

Yang, C. (2016). *The Price of Linguistic Productivity: How Children Learn to Break the Rules of Language*. MIT Press, Cambridge, London.

Full procedure

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> In 1997, the **lufɒn** entered into the competition for flowery **lufɒnok** for the first time.
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> *Please select the word's plural form:* [lufɒnøk / lufɒnɒk / lufɒnɛk / lufɒnok]

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> *That's correct! Now select the word in the appropriately inflected form according to you.*
>
> My [lufɒnɒm / lufɒnɛm / lufɒnøm / lufɒnom] couldn't sing well, however my husband's [lufɒnɛ / lufɒnjɛ / lufɒnɒ / lufɒnjɒ] sang brilliantly.

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Full procedure

Sample trial (lowering stem)

> In 1997, the **lufɒn** entered into the competition for flowery **lufɒnɒk** for the first time.
>
> *Please select the word's plural form:* [lufɒnøk / **lufɒnɒk** / lufɒnɛk / lufɒnok]
>
> *That's correct! Now select the word in the appropriately inflected form according to you.*
>
> My [**lufɒnɒm** / lufɒnɛm / lufɒnøm / lufɒnom] couldn't sing well, however my husband's [lufɒnɛ / lufɒnjɛ / **lufɒnɒ** / **lufɒnjɒ**] sang brilliantly.

Phonological model of lexicon

	β *coef*	*SE*	*Wald z*	*p*
Intercept	**3.02**	**.32**	**9.55**	**<.0001**
C Manner (default: plosive)				
fricative	**−1.44**	**.39**	**−3.73**	**.0002**
sibilant	**−10.69**	**.80**	**−13.36**	**<.0001**
nasal	**−1.95**	**.27**	**−7.16**	**<.0001**
approximant	**−4.08**	**.30**	**−13.47**	**<.0001**
C Place (default: alveolar)				
labial	**−2.02**	**.26**	**−7.94**	**<.0001**
palatal	**−8.88**	**1.10**	**−8.06**	**<.0001**
velar	**−3.26**	**.29**	**−10.96**	**<.0001**
Harmony (default: back)				
front	**−2.03**	**.18**	**−10.96**	**<.0001**
variable	**2.26**	**.97**	**2.33**	**.0197**
V Height (default: mid)				
high	**1.73**	**.22**	**7.89**	**<.0001**
low	.28	.19	1.50	.1342
V Length (default: short)				
long	**1.40**	**.17**	**7.98**	**<.0001**
Coda (default: singleton)				
geminate	**2.47**	**.40**	**6.25**	**<.0001**
cluster	.04	.21	0.18	.8602
Syllables (default: monosyllabic)				
polysyllabic	**1.15**	**.17**	**6.67**	**<.0001**

Phonological model of experimental results

Random effect	*variance*	*SD*		
Participant	.55	.74		
Fixed effects	*β coef*	*SE*	*Wald z*	*p*
Intercept	**.67**	**.10**	**7.03**	**<.0001**
Phon_odds	**.34**	**.01**	**22.76**	**<.0001**

Phonological and morphological model of experimental results

Random effect	*variance*	*SD*		
Participant	.54	.74		
Fixed effects	*β coef*	*SE*	*Wald z*	*p*
Intercept	**.74**	**.10**	**7.48**	**<.0001**
Phon_odds	**.34**	**.02**	**22.77**	**<.0001**
Plural (default: -ok)				
-ɒk	**−.33**	**.13**	**−2.62**	**.0086**