General-over-specific markedness bias as a balancing force in GLA-style learning

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The plan!

1. Overview
2. Typology of Balto-Finnic vowel patterns
3. OT analysis of Balto-Finnic vowel patterns
4. Learning, related challenges, and a proposed solution
5. Conclusion

Overview

Grammar-learner relationships

Grammar vs learner, scaled up

Grammar: Constraints needed to account for the patterns of one language

Learner: Settings (parameters, biases) needed to learn a target grammar

… in a vacuum

… situated in a typology

https://www.pexels.com/photo/tennis-ball-on-tennis-court-8224638/ https://www.pickpik.com/tennis-exercise-playground-ball-sport-hobby-134795

Typology

Balto-Finnic vowel patterns

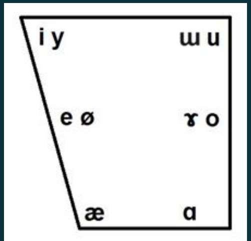
Inventory gaps

Positional restrictions (PR)

Progressive back-front vowel harmony (VH)

Key references: Kiparsky & Pajusalu (2003), Bakró-Nagy et al (2022), Vesik (2023).

Balto-Finnic vowel typology



	Language	Inventory	Restrictions outside of σ1	Vowel harmony		
				Back	Front	Neutral
PR	N Estonian	i, e, æ, y, ø, ɤ, ɑ, u, o	* æ, y, ø, ɯ, ɤ	-	-	-
	Livonian	i, e, æ, y, ø, ɯ, ɤ, ɑ, u, o	* æ, y, ø, ɯ, ɤ, o	-	-	-
VH	Finnish; Karelian; Ingrian	i, e, æ, y, ø, ɑ, u, o	-	ɑ, u, o	æ, y, ø	i, e
	Votic; Kihnu Est	i, e, æ, y, ø, ɤ, ɑ, u, o	-	ɤ, ɑ, u, o	e, æ, y, ø	i, (e)
PR + VH	N Seto (S Est)	i, e, æ, y, ø, ɯ, ɤ, ɑ, u, o	* ɯ	ɯ, ɤ, ɑ, u, o	e, æ, y, ø	i
	S Seto (S Est)	i, e, æ, y, ø, ɯ, ɤ, ɑ, u, o	* ø, ɯ	ɯ, ɤ, ɑ, u, o	e, æ, y, ø	i, (e), o
	Veps	i, e, æ, y, ø, ɑ, u, o	(* æ, y, ø)	ɑ, u, o	æ, y, ø	i, e

Ariste (1968); Campbell et al. (2013); Fejes et al. (2024); Grünthal (2015, 2022); Karlsson (2018); Kiparsky & Pajusalu (2003); Laakso (2022); Léonard (1993); Markus & Rozhanskiy (2022a,b); Metslang (2022); Nikolaev (2018, 2019); Pajusalu (2022); Sang (2009); Sarhimaa (2022); Suomi et al. (2008).

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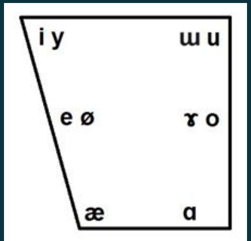
Balto-Finnic vowel typology



PR

Language	Inventory	Restrictions outside of σ1	Vowel harmony		
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Finnish; Karelian; Ingrian	i, e, æ, y, ø, ɑ, u, o	-	ɑ, u, o	æ, y, ø	i, e
Votic; Kihnu Est	i, e, æ, y, ø, ɤ, ɑ, u, o	-	ɤ, ɑ, u, o	e, æ, y, ø	i, (e)
N Seto (S Est)	i, e, æ, y, ø, ɯ, ɤ, ɑ, u, o	* ɯ	ɯ, ɤ, ɑ, u, o	e, æ, y, ø	i
S Seto (S Est)	i, e, æ, y, ø, ɯ, ɤ, ɑ, u, o	* ø, ɯ	ɯ, ɤ, ɑ, u, o	e, æ, y, ø	i, (e), o
Veps	i, e, æ, y, ø, ɑ, u, o	(* æ, y, ø)	ɑ, u, o	æ, y, ø	i, e

Ariste (1968); Campbell et al. (2013); Fejes et al. (2024); Grünthal (2015, 2022); Karlsson (2018); Kiparsky & Pajusalu (2003); Laakso (2022); Léonard (1993); Markus & Rozhanskiy (2022a,b); Metslang (2022); Nikolaev (2018, 2019); Pajusalu (2022); Sang (2009); Sarhimaa (2022); Suomi et al. (2008).

OT Analysis

Balto-Finnic vowel patterns

Stringency + No-disagreement

Constraints - overview

- Context-free markedness constraints for inventory gaps and positional restrictions
- Harmony constraints
- Faithfulness constraints
    - ID-σ_1(Back)

      >>
    - ID(Back)

Stringency relations

Back markedness scale:

- ɯ > ɤ > o > ɑ, u

Sets & scale-referring constraints:

- $*B_1$ = *{ɯ}
- $*B_2$ = *{ɯ,ɤ}
- $*B_3$ = *{ɯ,ɤ,o}
- $*B_5$ = *{ɯ,ɤ,o,ɑ,u}

Front markedness scale:

- ø > æ, y > e > i

Sets & scale-referring constraints:

- $*F_1$ = *{ø}
- $*F_3$ = *{ø,æ,y}
- $*F_4$ = *{ø,æ,y,e}
- $*F_5$ = *{ø,æ,y,e,i}

de Lacy (2002)

No-disagreement

Use local and non-local bans on specific co-occurrences to drive VH. (Pulleyblank, 2002)

- E.g. *BF ; *B…F

No-disagreement

Use local and non-local bans on specific co-occurrences to drive VH. (Pulleyblank, 2002)

- E.g. *<u>B</u>F ; *<u>B</u>…F

Stringency relations + no-disagreement!

E.g.

	$*F_3\underline{B}_5$	$*\underline{B}_5...F_4$
a. æ..y..ɯ	*	
b. ɯ..o..æ..e		**

B_5 = {ɯ,ɤ,o,ɑ,u}

F_3 = {ø,æ,y}

F_4 = {ø,æ,y,e}

No-disagreement

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- E.g. *<u>B</u>F ; *<u>B</u>…F

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	$*F_3\underline{B}_5$	$*\underline{B}_5...F_4$
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b. ɯ..o..æ..e		**

B_5 = {ɯ,ɤ,o,ɑ,u}

F_3 = {ø,æ,y}

F_4 = {ø,æ,y,e}

→ Total of 64 harmony constraints, for a total of 64 + 8 + 2 = 74 constraints overall

North Estonian rankings - inventory gaps

- No /ɯ/ in inventory
- $*B_1$ >> ID-σ_1(Bk) >> ID(Bk)

/ɯ/		*B1	ID-σ1(Bk)	ID(Bk)
a.	ɯ	*!		
b. ☞	i		*	*

Surfaces in e.g. *silm* [silm] “eye”

→ B_1 = {ɯ}

B_2 = {ɯ,ɤ}

B_3 = {ɯ,ɤ,o}

B_5 = {ɯ,ɤ,o,ɑ,u}

F_1 = {ø}

F_3 = {ø,æ,y}

F_4 = {ø,æ,y,e}

F_5 = {ø,æ,y,e,i}

North Estonian rankings - positional restrictions

- No /æ, y, ø, ɯ, ɤ/ in non-initial syllables
- ID-σ_1(Bk) >> $*F_3$; $*B_2$ >> ID(Bk)

/æ..y/	ID-σ_1(Bk)	$*F_3$	ID(Bk)
a. æ..y		**!	
b. ☞ æ..u		*	*
c. ɑ..u	*!		**

Surfaces in e.g. *käru* [kæru] "cart"

B_1 = {ɯ}

→ B_2 = {ɯ,ɤ}

B_3 = {ɯ,ɤ,o}

B_5 = {ɯ,ɤ,o,ɑ,u}

F_1 = {ø}

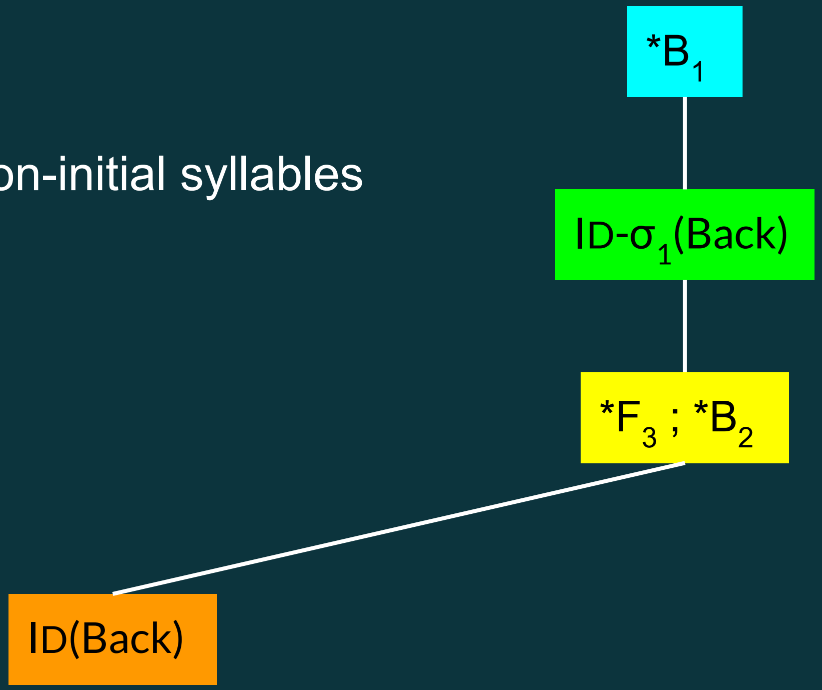
→ F_3 = {ø,æ,y}

F_4 = {ø,æ,y,e}

F_5 = {ø,æ,y,e,i}

North Estonian rankings - overall

- No /ɯ/ in inventory
- No /æ, y, ø, ɯ, ɤ/ in non-initial syllables

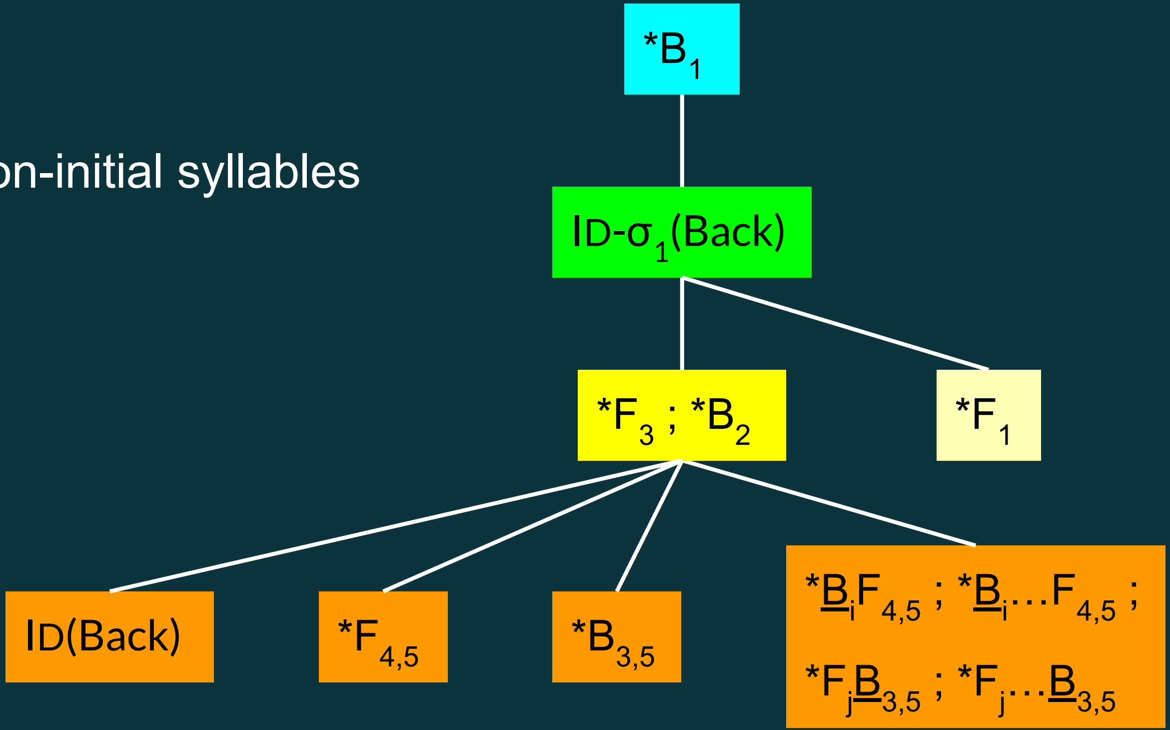


North Estonian rankings - overall

- No /ɯ/ in inventory
- No /æ, y, ø, ɯ, ɤ/ in non-initial syllables

$*\underline{B}_iF_{1,3}$; $*\underline{B}_i\ldots F_{1,3}$;

$*F_j\underline{B}_{1,2}$; $*F_j\ldots\underline{B}_{1,2}$



Learning

Simulations

Obstacles

A novel proposal

Learning is hard

Biases widely used + Biases for this typology

Even with all the usual suspects for biases, a GLA[1]-type learner can't learn this simple North Estonian grammar from positive evidence.

- How does it fail?
- What can we do?

[1] OT-based Gradual Learning Algorithm (Boersma & Hayes, 2001)

Learning - basic setup

Commonly-used settings:

- Low initial faithfulness (Smolensky, 1996)
  M constraints start at 100 / F at 0

- Specific over general faithfulness (Hayes, 2004)
  ID-σ_1(Back) ≥ ID(Back) + 20

https://www.flaticon.com/free-icon/ear_748202 https://creazilla.com/media/clipart/3152059/beer

Learning - basic setup

Learning data:

- Simulated North Estonian
- Positive evidence only
  (i.e. identity-mapped inputs)

"õlu"
[ɣlu]

/ɣlu/	$*B_1$	$*B_2$	$*F_3$	…	ID-σ_1(Bk)	ID(Bk)
a. ɣlu		*		…		
b. ɣly		*	*	…		*
c. elu				…	*	*
d. ely			*	…	*	**

Learning - basic setup

Bias needed to address other learning challenges in this typology:

- Update rule with tempered promotion rate
- $promotion\, rate = \frac{1}{1+W} \times demotion\, rate$ (Magri & Kager, 2015)
- *W* = # of winner-preferring constraints

Learner A

As proposed:

- Constraint set
- Commonly-used settings/biases
- Tempered promotion rate

Learner A - Results (excerpts)

Ideal results: $*B_1$
\>>
ID-σ_1(Bk)
\>>
$*F_3$; $*B_2$
\>>
ID(Bk) ; $*F_{4,5}$; $*B_{3,5}$; $*\underline{B}_iF_{4,5}$; $*\underline{B}_i...F_{4,5}$; $*F_j\underline{B}_{3,5}$; $*F_j...\underline{B}_{3,5}$

Actual results:

constraint	final ranking value
*B1	100.000
*F5B2	100.000
*F5...B2	100.000
*B5F3	100.000
*B5...F3	100.000
Id-σ1(Bk)	83.021
*F1	65.286
*B2	63.267
Id(Bk)	63.021
*F3	23.457
*B3	3.859
*F4	-40.324
*F5	-40.324
*B5	-40.656
*B5...F5	-47.456
*B5F5	-49.727
*F5B5	-84.667
*F5...B5	-102.667

Learner A - Results (excerpts)

Ideal results: $*B_1$

$>>$

$\text{ID-}\sigma_1(\text{Bk})$

$>>$

$*F_3$; $*B_2$

$>>$

ID(Bk) ; $*F_{4,5}$; $*B_{3,5}$; $*B_iF_{4,5}$; $*B_i...F_{4,5}$; $*F_jB_{3,5}$; $*F_j...B_{3,5}$

Actual results:

- $*F_3$ below Id(Bk)
- Coincidental VH
- Success rate on test evaluations: 0.7865

constraint	final ranking value
*B1	100.000
*F5B2	100.000
*F5...B2	100.000
*B5F3	100.000
*B5...F3	100.000
Id-σ1(Bk)	83.021
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*B5...F5	-47.456
*B5F5	-49.727
*F5B5	-84.667
*F5...B5	-102.667

Learner A - Results

Under the grammar acquired by Learner A…

/u..ɑ/	$*\underline{\mathbf{B}}_5 \ldots \mathbf{F}_3$	Id-σ_1(Bk)	Id(Bk)	$*\mathbf{F}_3$
a. ☞ u..ɑ				
b. u..æ	*!		*	*

A grammatical UR surfaces faithfully.

/y..æ/	$*\underline{\mathbf{B}}_5 \ldots \mathbf{F}_3$	Id-σ_1(Bk)	Id(Bk)	$*\mathbf{F}_3$
a. ☹ ☞ y..æ				**
b. y..ɑ			*!	*

An ungrammatical UR also surfaces faithfully.

A novel proposal

Idea: Give general M constraints a chance to get credit for the phonotactics of the target grammar.

- Ensures maximal restrictiveness.

Inspiration: Albright & Hayes (2006) determine initial ranking based on generality.

- Prevents super-specific “junk” constraints (induced by the MGL) from taking too much credit.
- Allows more general constraints to be active where possible.

Implementation: Initial articulated hierarchy of markedness constraint values.

- Function of each constraint’s rate of application in a sample set of inputs.
- Can be freely reversed by learning data.

M_{gen} >> M_{spec} bias

During pre-learning "observation" stage:

- Learning rate = 0
- Learner is fed randomly-sampled inputs
- Learner keeps a running total of the number of times each markedness constraint is violated by the heard inputs

$M_{gen} >> M_{spec}$ bias

After observation stage and before learning:

- Calculate average generality for each M

$$g_M = \frac{\#\ \text{violations of M}}{\text{total}\ \#\ \text{inputs}}$$

- Calculate initial ranking value for each M

Initial $\theta_M = 100(b + mg_M)$

where g_M = generality for constraint M
b = y-intercept coefficient
m = slope coefficient

Learner B

Same as Learner A but with this change:

- Markedness constraints distributed by generality
  $\theta_{\mathrm{M}} = 100(b + mg_{\mathrm{M}})$ $\quad$ $b = 1.0, m = 1.0$

Learner B - Initial hierarchy

Same as Learner A but with this change:

- Markedness constraints distributed by generality
  $\theta_M = 100(b + mg_M)$ $b = 1.0, m = 1.0$

constraint	initial ranking value
*B5	254.280
*F5	228.860
*F4	182.420
*F5..._B5	170.700
*B3	159.520
*F5_B5	153.640
*_B5...F5	146.660
*_B5F5	137.780
*F3	133.900
*F1	111.800
*B2	111.320
*B1	100.000
*F5_B2	100.000
*F5..._B2	100.000
*_B5F3	100.000
*_B5...F3	100.000

Learner B - Results (excerpts)

Ideal results: $*B_1$

>>

$\textsc{Id}\text{-}\sigma_1(Bk)$

>>

$*F_3$; $*B_2$

>>

$\textsc{Id}(Bk)$; $*F_{4,5}$; $*B_{3,5}$; $*\underline{B}_iF_{4,5}$; $*\underline{B}_i...F_{4,5}$; $*F_j\underline{B}_{3,5}$; $*F_j...\underline{B}_{3,5}$

Actual results:

constraint	final ranking value
*B1	110.667
*F5B2	100.000
*F5...B2	100.000
*B5F3	100.000
*B5...F3	100.000
Id-σ1(Bk)	96.941
*B2	88.243
*F1	86.771
*F3	80.563
Id(Bk)	76.941
*F5	68.419
*F4	49.199
*B3	48.106
*B5	45.902
*B5...F5	-32.551
*B5F5	-39.249
*F5...B5	-114.758
*F5B5	-127.038

Learner B - Results (excerpts)

Ideal results: $^*B_1$

>>

$\text{I}D\text{-}\sigma_1(Bk)$

>>

$^*F_3$; $^*B_2$

>>

$\text{I}D(Bk)$; $^*F_{4,5}$; $^*B_{3,5}$; $^*\underline{B}_iF_{4,5}$; $^*\underline{B}_i…F_{4,5}$; $^*F_j\underline{B}_{3,5}$; $^*F_j…\underline{B}_{3,5}$

Actual results:

- Align with ideal!
- Success rate on test evaluations: 0.9837

constraint	final ranking value
*B1	110.667
*F5B2	100.000
*F5...B2	100.000
*B5F3	100.000
*B5...F3	100.000
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*F5...B5	-114.758
*F5B5	-127.038

Learner B - Results

Under the grammar acquired by Learner B…

/u..ɑ/	*$\underline{B}_5$…F_3	ID-σ_1(Bk)	*F_3	ID(Bk)
a. ☞ u..ɑ				
b. u..æ	*!		*	*

/y..æ/	*$\underline{B}_5$…F_3	ID-σ_1(Bk)	*F_3	ID(Bk)
a. y..æ			**!	
b. ☞ y..ɑ			*	*

A grammatical UR surfaces faithfully.

*F_3>>ID-σ_1(Bk) ensures that an ungrammatical UR is repaired.

Conclusion

Grammar-learner relationships

Summary

Takeaways

Summary

Main ideas from today:

- Constraints with competing violation profiles cause challenges with respect to the Credit Problem (Dresher, 1999).
- ***General-over-specific markedness*** bias as counterpart to ***specific-over-general faithfulness*** helps to offset potential adverse effects
- Specifically, it allows a GLA-type learner to avoid falling into the subset problem resulting from learning a less-restrictive grammar (Jesney & Tessier, 2011)

Summary

This talk zooms in on just a mere slice of my dissertation.

Summary

This talk zooms in on just a mere slice of my ~~dissertation~~.

dessert-ation?

Summary

This talk zooms in on just a mere slice of my dissertation. The whole cake involves:

- The entire Balto-Finnic vowel pattern typology
- The parameters and biases that are needed to make sure that any language's patterns can be learned in that broader context
- The general-markedness bias being crucial to the most successful learners

https://freerangestock.com/photos/66657/slice-of-cake-on-plate-with-sprinkles.html

Takeaways

Takeaways

Grammar vs learner, scaled up

Grammar: Constraints needed to account for the patterns of one language

Learner: Settings (parameters, biases) needed to learn a target grammar

… in a vacuum

… situated in a typology

https://www.pexels.com/photo/tennis-ball-on-tennis-court-8224638/ https://www.pickpik.com/tennis-exercise-playground-ball-sport-hobby-134795

Takeaways

Specific-faithfulness bias is often used to maintain restrictiveness

- General-markedness bias can help too

Takeaways

Specific-faithfulness bias is often used to maintain restrictiveness

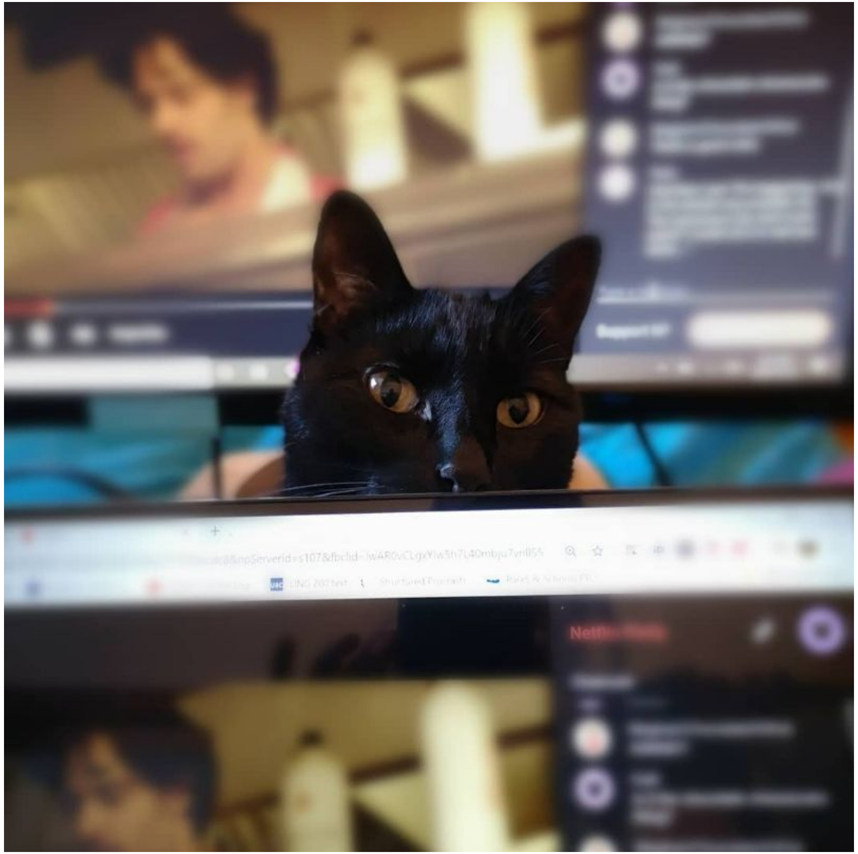
- General-markedness bias can help too

Related problems could arise in other contexts in which constraints are similar enough to compete for credit/blame

- By definition
- By accident / sheer numbers (what does reality look like)?

Thank you!

- To all of you 🙂
- UBC Phonology Discussion Group and Child Phonology Lab members
- AMP 2022 & 2023 audiences



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Typological examples

Inventory gaps
E.g. Finnish: *{ɯ, ɤ}

- varpunen [ɑ..u..e] (*sparrow*) *[ɑ..u..ɤ]

Positional restrictions
E.g. N Estonian: *{æ, y, ø, ɤ}

- küla [y..ɑ] (*village*) *[y..æ]

Back-front vowel harmony
E.g. North Seto: transparent {i}

- lusikka [u..i..ɑ] (*spoon*) *[u..i..æ]

Typological tangents 1

From Slide 7: Balto-Finnic vowel typology re variably transparent vowels

South Seto

- /e/ as first-syllable vowel does not trigger front harmony
- Non-initial /e/ is found only in front-harmonic words

Kihnu Estonian

- /e/ sometimes triggers front harmony & sometimes doesn't
- Can vary even within a single lexical item e.g. mõttes~mõttõs [ɤ..e]~[ɤ..ɤ] (*in thought*)

Lindstrom (2013)

	Language(s)	Inventory	Restrictions in σ_{2+}	Vowel harmony			
				Back	Front	Transp't	Opaque
(d)	Votic; Kihnu Est	i, e, æ, y, ø, ɤ, ɑ, u, o	-	ɤ, ɑ, u, o	e, æ, y, ø	i, (e)	-
(f)	S Seto (S Est)	i, e, æ, y, ø, ɯ, ɤ, ɑ, u, o	* ø, ɯ	ɯ, ɤ, ɑ, u, o	e, æ, y, ø	i, (e)	o

Typological tangents 2

From Slide 7: Balto-Finnic vowel typology re opaque vowels

South Seto

- /o/ as first-syllable vowel triggers back harmony
- Non-initial /o/ interrupts front harmony and begins a back-harmonic domain

  E.g. hämonõ [æ..o..ɤ] (*bleary*) *[æ..o..e] Pajusalu (2022: 369)

	Language(s)	Inventory	Restrictions in σ_{2+}	Vowel harmony			
				Back	Front	Transp’t	Opaque
(f)	S Seto (S Est)	i, e, æ, y, ø, ɯ, ɤ, ɑ, u, o	* ø, ɯ	ɯ, ɤ, ɑ, u, o	e, æ, y, ø	i, (e)	o

Typological tangents 3

From Slide 7: Balto-Finnic vowel typology re decaying vowel harmony

Veps

- VH no longer productive past first few syllables (precise domain is unclear)
- Vowels in later syllables restricted to /i, e, ɑ, u, o/
- E.g. tütär [y..æ] (*girl*) Grünthal (2015: 45)
  külmetumaa [y..e..u..ɑ] (*we get cold*) Grünthal (2015: 47)

	Language(s)	Inventory	Restrictions in σ_{2+}	Vowel harmony			
				Back	Front	Transp't	Opaque
(g)	Veps	i, e, æ, y, ø, ɑ, u, o	(* æ, y, ø)	ɑ, u, o	æ, y, ø	i, e	-

“Missing” stringency sets

From Slide 11: Stringency relations

- Go back to slide

Opacity as a function of focus

From Slide 14: No-disagreement

- Focus on B ensures that front harmony goes as far as possible (no “sour grapes”)

		/æ..u..o..y/	Id-σ1(Bk)	*B5F4	*B5...F4	*F1	*F3B5	*F3...B5	Id(Bk)
Front harmony all the waaaaaay!	a)	æ..y..ø..y				*			**
Front harmony until /o/, then back	b)	æ..y..o..u 👈					*	**	**
Sour grapes (why bother changing the /u/ if we’re going to switch to back anyway?)	c)	æ..u..o..u					*	***!	*

MaxEnt learner (UCLA-PL)

From Slide 20: Learning is hard

- Could also consider a MaxEnt learner (e.g. UCLA Phonotactic Learner; Hayes & Wilson, 2008)
- No URs and therefore no faith constraints at all; just a probability distribution over possible surface forms
- Induces feature-based co-occurrence constraints, given:
    - Inputs consisting of surface forms only
    - Feature values of each segment
- Can't seem to figure out opacity because it doesn't have a way to induce "focus"

3 learners on 3 sample languages

Final grammars' success rates on test evaluations:

	N Estonian (PR)	Finnish (VH)	N Seto (PR + VH)
Learner ∅	0.2455	0.2683	0.2984
Learner A	0.7865	1.0000	0.9988
Learner B	0.9837	1.0000	0.9999