Atelier de Phonologie, SFL
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A probabilistic approach to Greek nominal stress

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The presentation is the result of collaborative work within the project

GRADIENCE: Modeling the limits of grammar: Integrating lexical frequency in a Gradient Harmonic model of lexical stress; Evidence from young and adult Greek speakers' grammars

https://gradience.lit.auth.gr

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H.F.R.I. Hellenic Foundation for Research & Innovation

Greece 2.0 NATIONAL RECOVERY AND RESILIENCE PLAN

Funded by the European Union NextGenerationEU

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Introduction

- Standard view: Greek has a lexical stress system → stress assignment is not predictable

(1)

a.	U:	a.ɣo.ˈra	‘market’
b.	PU:	ka.ˈre.kla	‘chair’
c.	APU:	ˈθa.la.sa	‘sea’

(see, among others, Malikouti-Drachman & Drachman 1989; Ralli & Touratzidis 1991; Drachman & Malikouti-Drachman 1999; Revithiadou 1999, 2007; Apoussidou 2003; Burzio & Tantalou 2007; van Oostendorp 2012)

Introduction

- The only restriction: trisyllabic window → stress may fall only on one of the last three syllables of a word

(2) a. ˈma.θi.ma. ‘lesson’

b. ma.ˈθi.ma.ta. ‘lessons’ *ˈma.θi.ma.ta.

Introduction

- However:
  - stress assignment in verbs is rather systematic (Spyropoulos & Revithiadou 2009; van Oostendorp 2012; Spyropoulos et al. 2015), e.g.:

(3)	a.	NON-PASS, NON-PAST (CONJ1):	PU	e.g. ðja.ˈva.zo. ‘I read’
	b.	PASS, IPFV, NON-PAST (CONJ1):	APU	ðja.ˈva.zo.me.
	c.	PASS, PFV, NON-PAST:	U	ðja.va.ˈsto.
	d.	PFV, PAST:	APU	ˈðja.va.sa.

Introduction

- However:
  - derivational affixes have dominant stress properties (Revithiadou 1999)

(4) *-ˈak(i) (NMZ 'DIMINUTIVE')*

a. aˈmaksi 'car'

b. amakˈsaki 'little car' *aˈmaksaki

Introduction

- What about stress assignment in non-derived nouns?
- GRADIENCE's main research hypothesis: The stress pattern of a noun is largely determined by its inflection class
- Evidence:
  - speakers' biases when assigning stress to pseudo-nouns (experimental tasks)
  - the distribution of stress patterns in the lexicon (lexical databases)
- Aim of today's presentation: To offer a theoretical analysis of the findings
- Theoretical framework: *Gradient Symbolic Representations* / *Gradient Harmonic Grammar* (Smolensky & Goldrick 2016)

Roadmap

1. Background
    - 1.1. Greek nominal system
    - 1.2. Previous studies
2. Research findings
    - 2.1. Lexical databases
    - 2.2. Experimental task
3. Analysis
    - 3.1. Gradient Symbolic Representations
    - 3.2. Phonological computation: Gradient Harmonic Grammar
4. Conclusions

1.1. Background: Greek nominal system

- Grammatical features:
  - gender (masculine/feminine/neuter)
  - number (singular/plural)
  - case (nominative/accusative/genitive/vocative)
- Various inflectional paradigms – inflection classes (Ralli 2000; Alexiadou & Müller 2008; Anastassiadis-Symeonidis 2012; cf. Markopoulos 2018)
- In most cases, inflection class is indicated by a Theme vowel/element (ThV/E) (see Thomadaki 1994; Revithiadou & Spyropoulos 2016; Markopoulos 2018)

1.1. Background: Greek nominal system

- Feminine nouns

(5) a. mi'ter-**a**-Ø
mother-**TH**-SG.NOM/ACC
'mother (FEM)'

b. 'zaxar-**i**-Ø
sugar-**TH**-SG.NOM/ACC
'sugar (FEM)'

- Neuter nouns

(6) a. 'prosop-**o**-Ø
face-**TH**-SG.NOM/ACC
'face (NEUT)'

b. tra'pez-**i**-Ø
table-**TH**-SG.NOM/ACC
'table (NEUT)'

1.1. Background: Greek nominal system

- Masculine nouns

(7) a. ˈanθrop-**o**-s
human-**TH**-SG.NOM
‘human (MASC)’

b. plaˈnit-**i**-s
planet-**TH**-SG.NOM
‘planet (MASC)’

1.1. Background: Greek nominal system

- Revithiadou & Spyropoulos (2016):
  - root exponents are accentless
  - exponents of grammatical morphemes (ThEs, DerSs, InflSs) are accent-bearing

⇒ stress position in SG.NOM forms is entirely determined by ThEs

1.1. Background: Greek nominal system

(8) a. a'lat-i-Ø
salt-TH-SG.NOM/ACC
'salt'

b. pi'per-i-Ø
pepper-TH-SG.NOM/ACC

cf. alat-o-'piper-o-Ø
salt-COMPOUND-pepper-TH-SG.NOM/ACC
'salt and pepper'

1.1. Background: Greek nominal system

- GRADIENCE: Focus on the distribution of stress patterns across 7 inflection classes

i.	-o(s)	($-o_{MASC}$)	e.g.	ˈanθropos	‘human’
ii.	-i(s)	($-i_{MASC}$)		plaˈnitis	‘planet’
iii.	-a	($-a_{FEM}$)		kaˈrekla	‘chair’
iv.	-i <-η>	($-i_{FEM}$)		ˈzaxari	‘sugar’
v.	-o	($-o_{NEUT}$)		ˈprosopo	‘face’
vi.	-i <-ι>	($-i_{NEUT}$)		traˈpezi	‘table’
vii.	-(m)a	($-a_{NEUT}$)		ˈmaθima	‘lesson’

1.1. Background: Greek nominal system

- Today's presentation: Focus on 4 inflection classes

i.	-i(s)	(-i_{MASC})	e.g.	plaˈnitis	‘planet’
ii.	-a	(-a_{FEM})		kaˈrekla	‘chair’
iii.	-o	(-o_{NEUT})		ˈprosopo	‘face’
iv.	-(m)a	(-a_{NEUT})		ˈmaθima	‘lesson’

1.2. Background: Previous studies

- Apostolouda (2018)
  - 2 tasks: production/perception
  - 2 age groups: children (7-8 y.o.) / adults (18-23 y.o.)
  - pseudo-nouns (pseudo-stems + actual suffixes), e.g.:

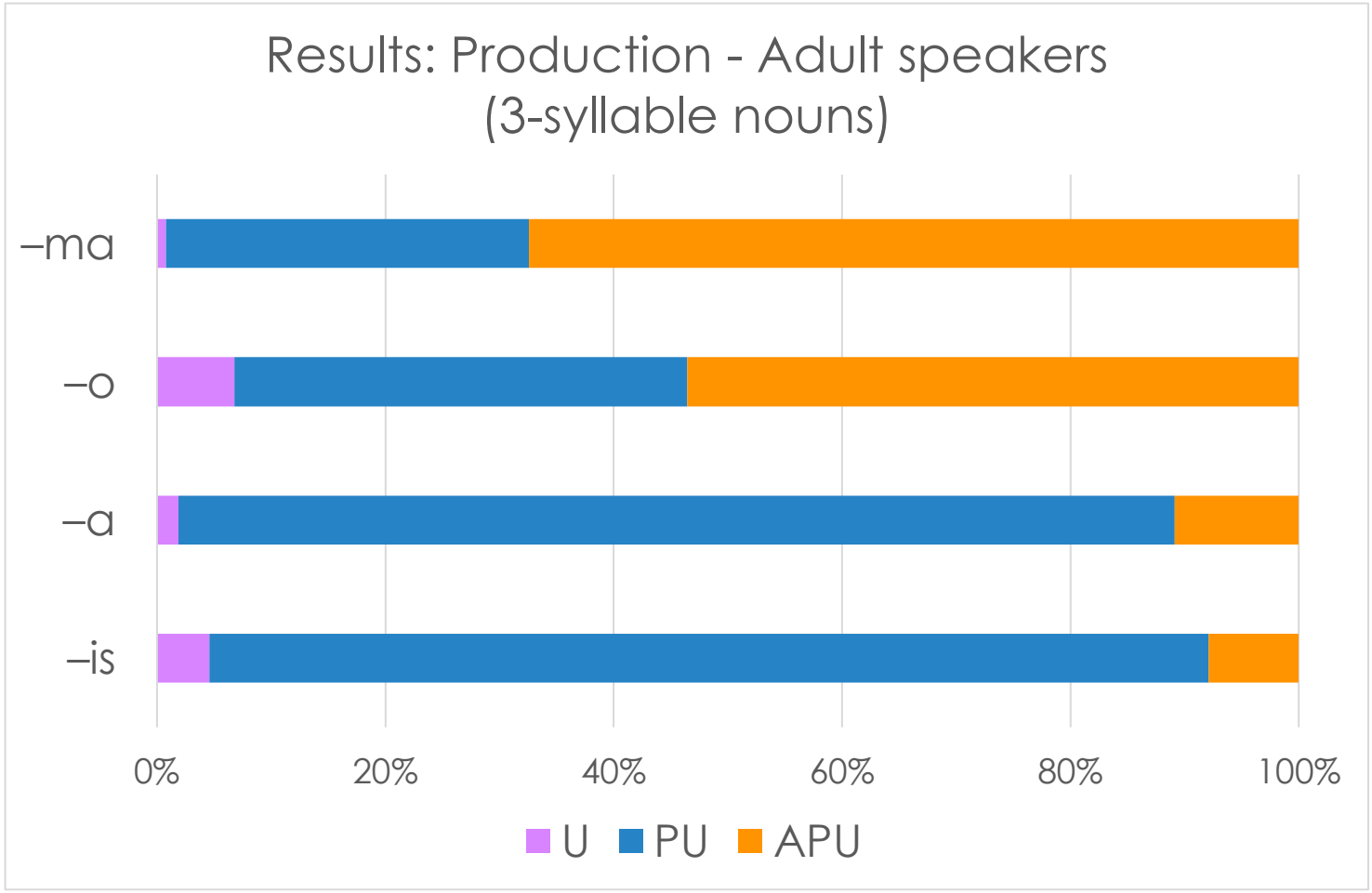
(9) Production task

ΛΕΡΙΧΟ (/lerixo/)

Possible realizations

i. 'lerixo
ii. le'rixo
iii. leri'xo

1.2. Background: Previous studies



APU > PU > U

APU > PU > U

PU > APU > U

PU > APU, U

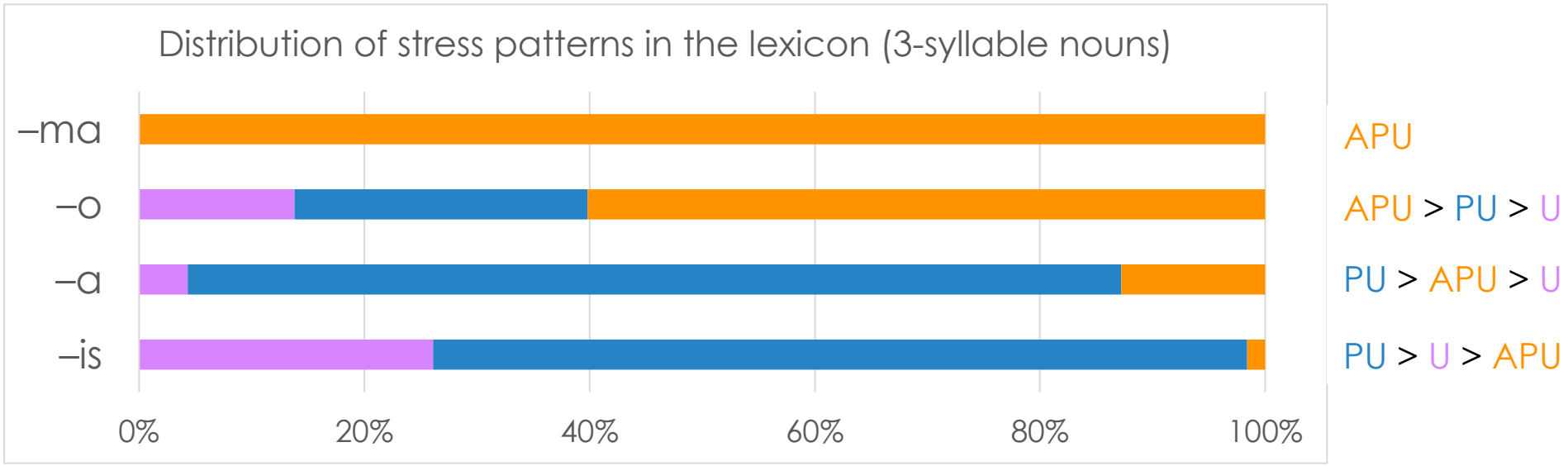
1.2. Background: Previous studies

- Adult speakers: Main findings
  - preference for APU or PU stress is determined by the particular suffix at hand (*-ma, -o* → APU; *-a, -is* → PU)
  - U stress seems to be the most marked option

- Further evidence: Revithiadou & Lengeris (2016) – perception task
  - preference for APU stress is stronger in pseudo-nouns with *-o* compared to pseudo-nouns with *-a*
  - U has been found again to be the most marked option

1.2. Background: Previous studies

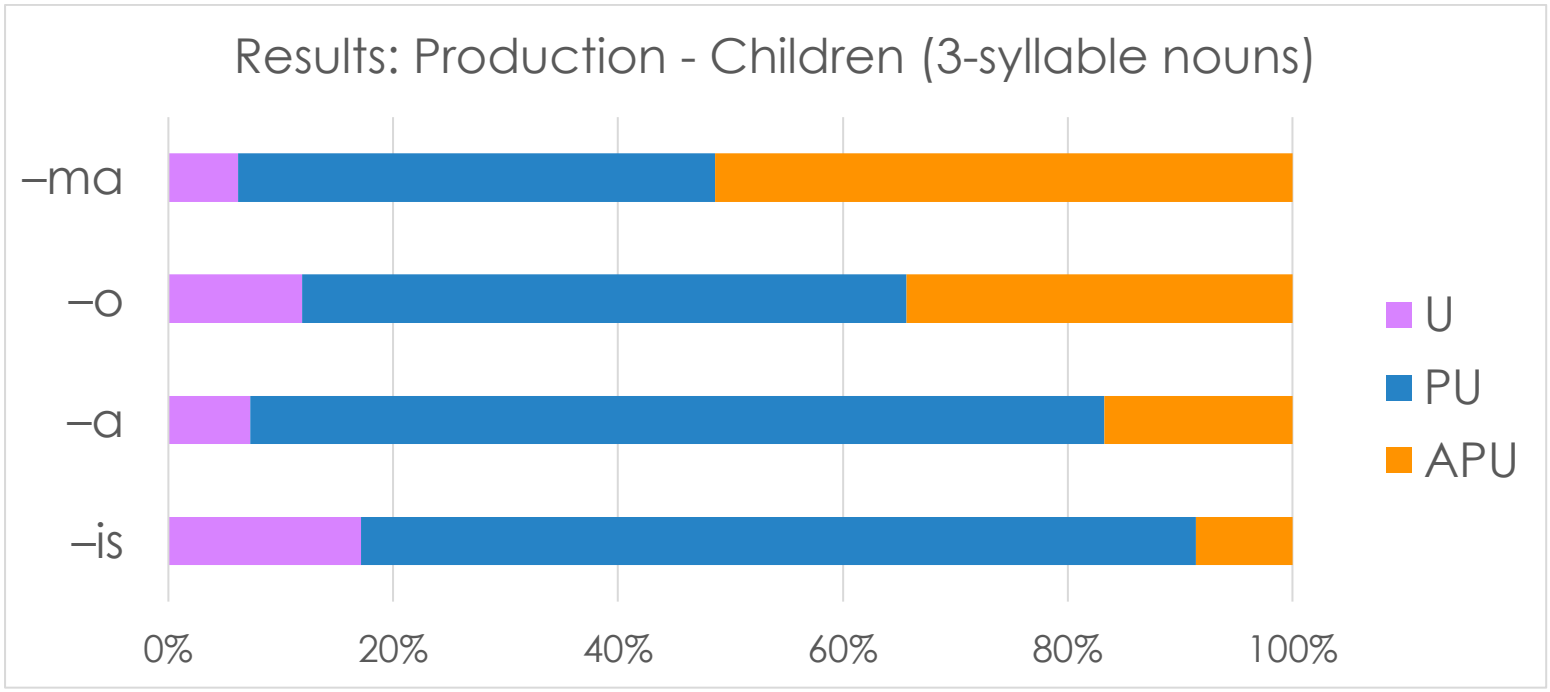
- Interestingly, the experimental findings seem to mirror the distribution of stress patterns in the lexicon (Apostolouda 2018):*



*according to *Annotated-Lexicon*, a lexical database based on Anastassiadis-Symeonidis' (2002) *Reverse Dictionary of Modern Greek* (5,133 nouns)

1.2. Background: Previous studies

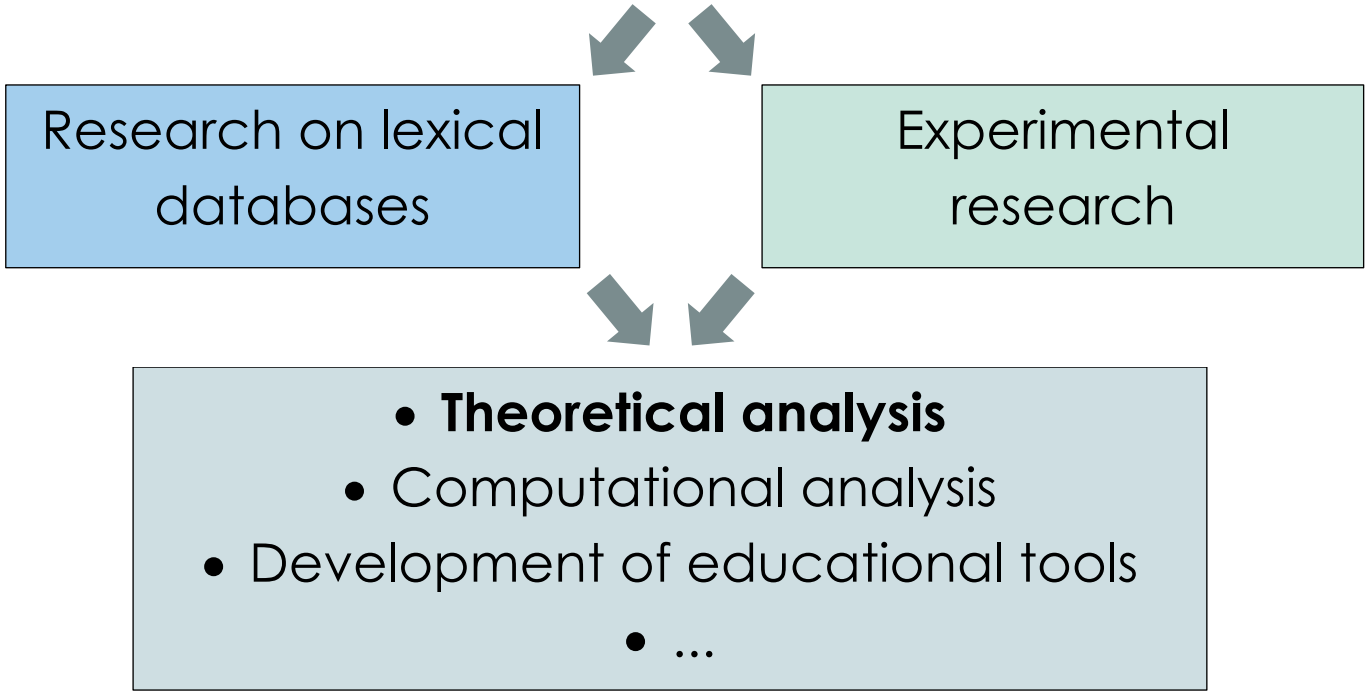
- On the other hand, children show a general preference for PU stress (Apostolouda 2018):



2. The present study

- GRADIENCE

Are speakers' stress grammars shaped by the lexicon?



2.1. The present study: Lexical databases

- 3 databases:
  - *GreekLex 2* (Kyparissiadis et al. 2017): 20,363 nouns
  - *A-Clean* (Apostolouda 2018; based on Protopapas et al.'s (2012) *Clean Corpus*): 7,590 nouns
  - *A-Lexicon* (Apostolouda 2018; based on Anastassiadis-Symeonidis' (2002) *Reverse Dictionary of Modern Greek*): 5,279 nouns

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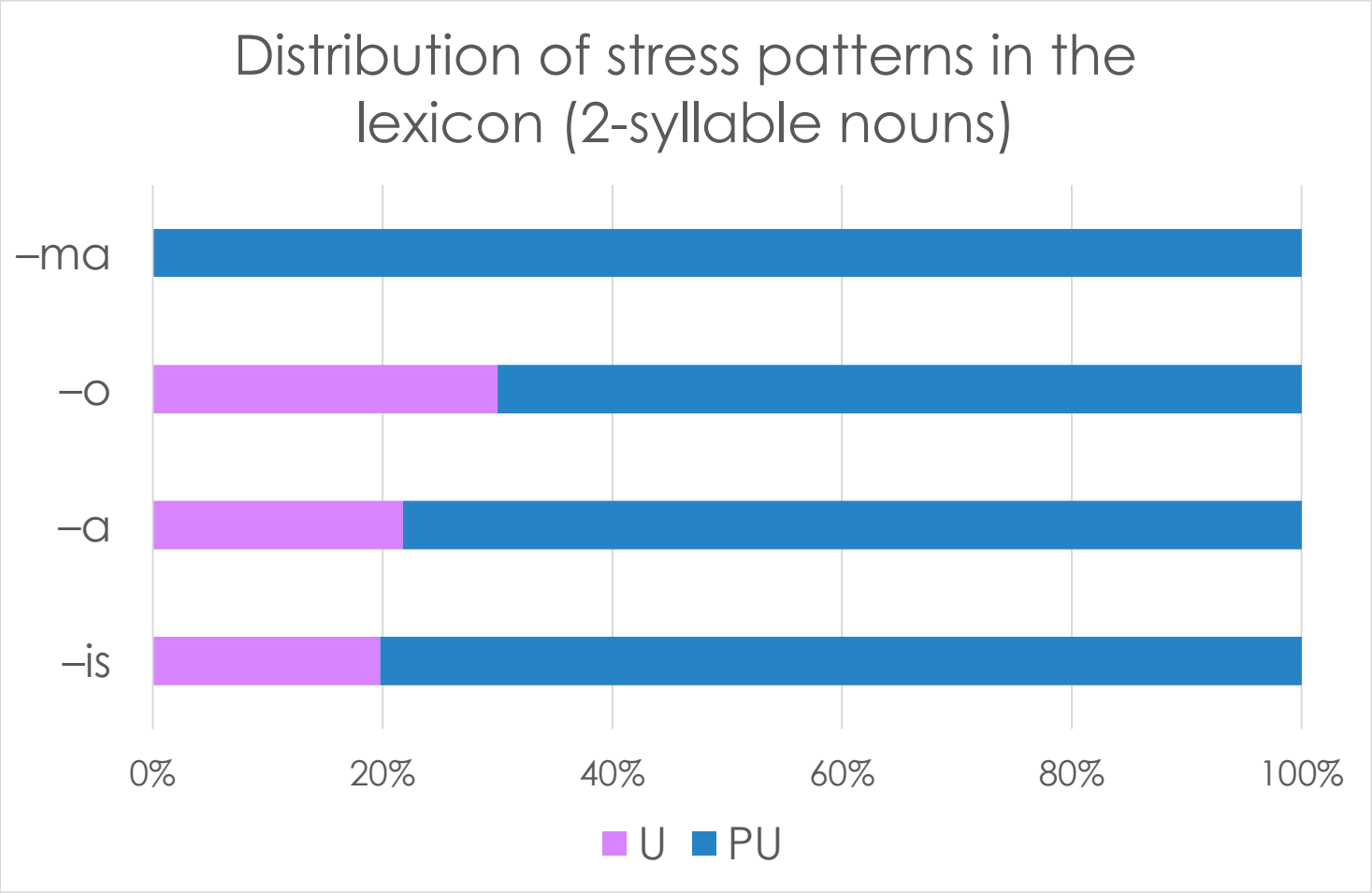

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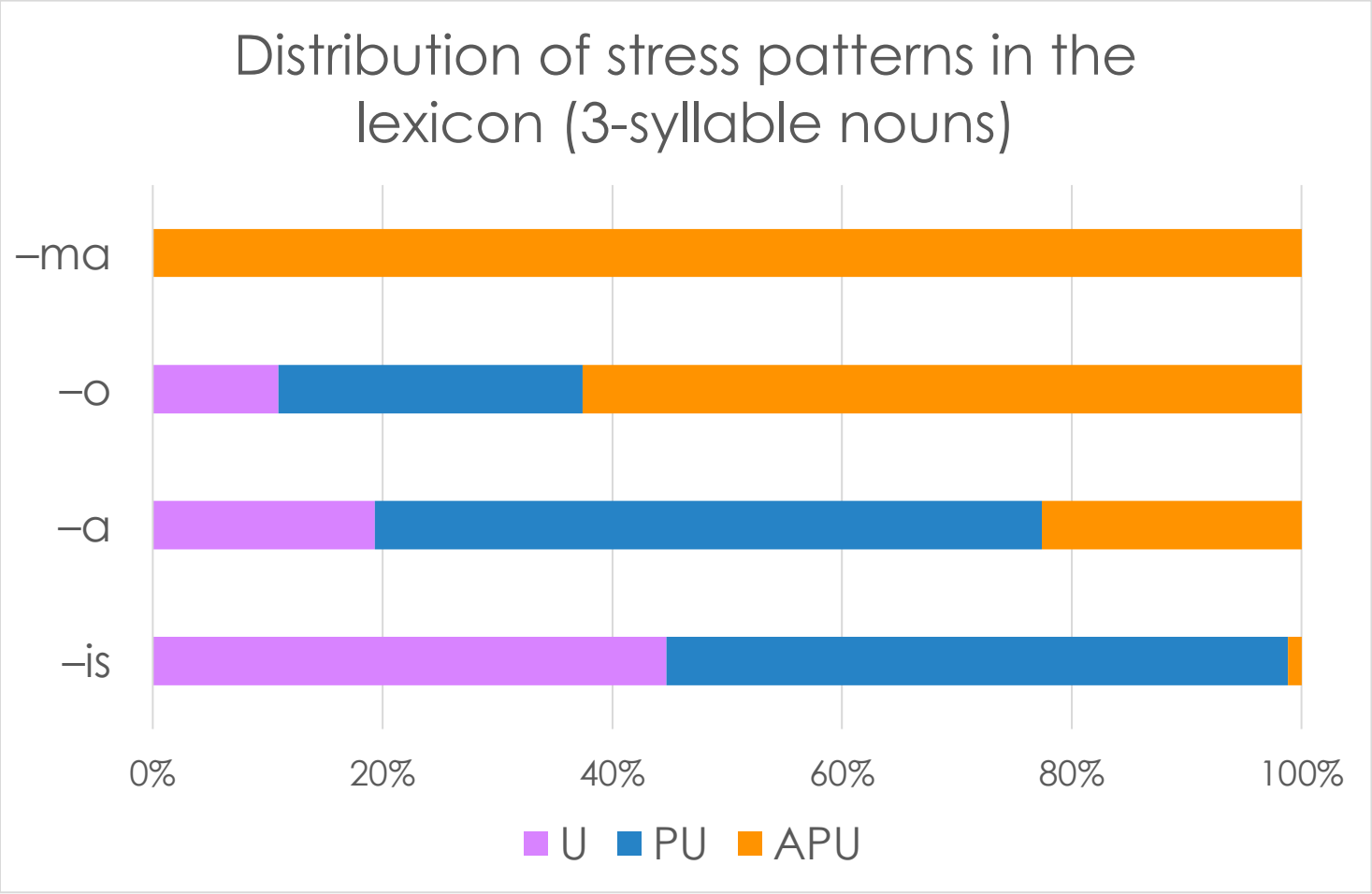


2.2. The present study: Experimental task

- Participants:
  - 105 monolingual typically developing children (7–12 y.o.)
  - 105 monolingual adults (18-62 y.o.)
- Stress elicitation reading task
  - 126 two-syllable and three-syllable pseudo-nouns consisting of pseudo-stems and actual suffixes (*-ma*$_{NEUT}$, *-o*$_{NEUT}$, *-i*$_{NEUT}$, *-a*$_{FEM}$, *-i*$_{FEM}$, *-os*$_{MASC}$, *-is*$_{MASC}$)

2.2. The present study: Experimental task

- Example

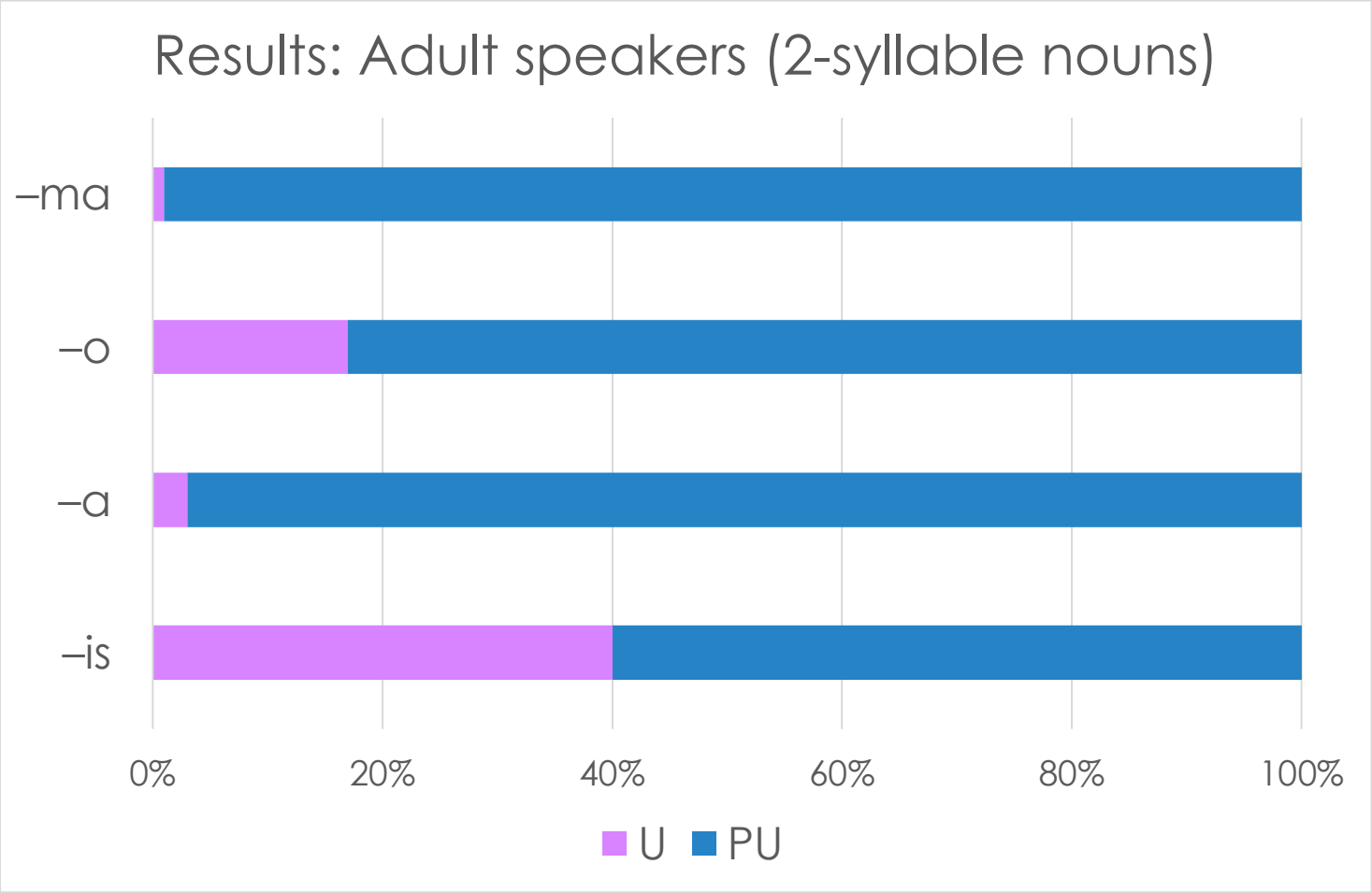
Possible realizations

i. 'fusemo

ii. fu'semo

iii. fuse'mo

2.2. The present study: Experimental task



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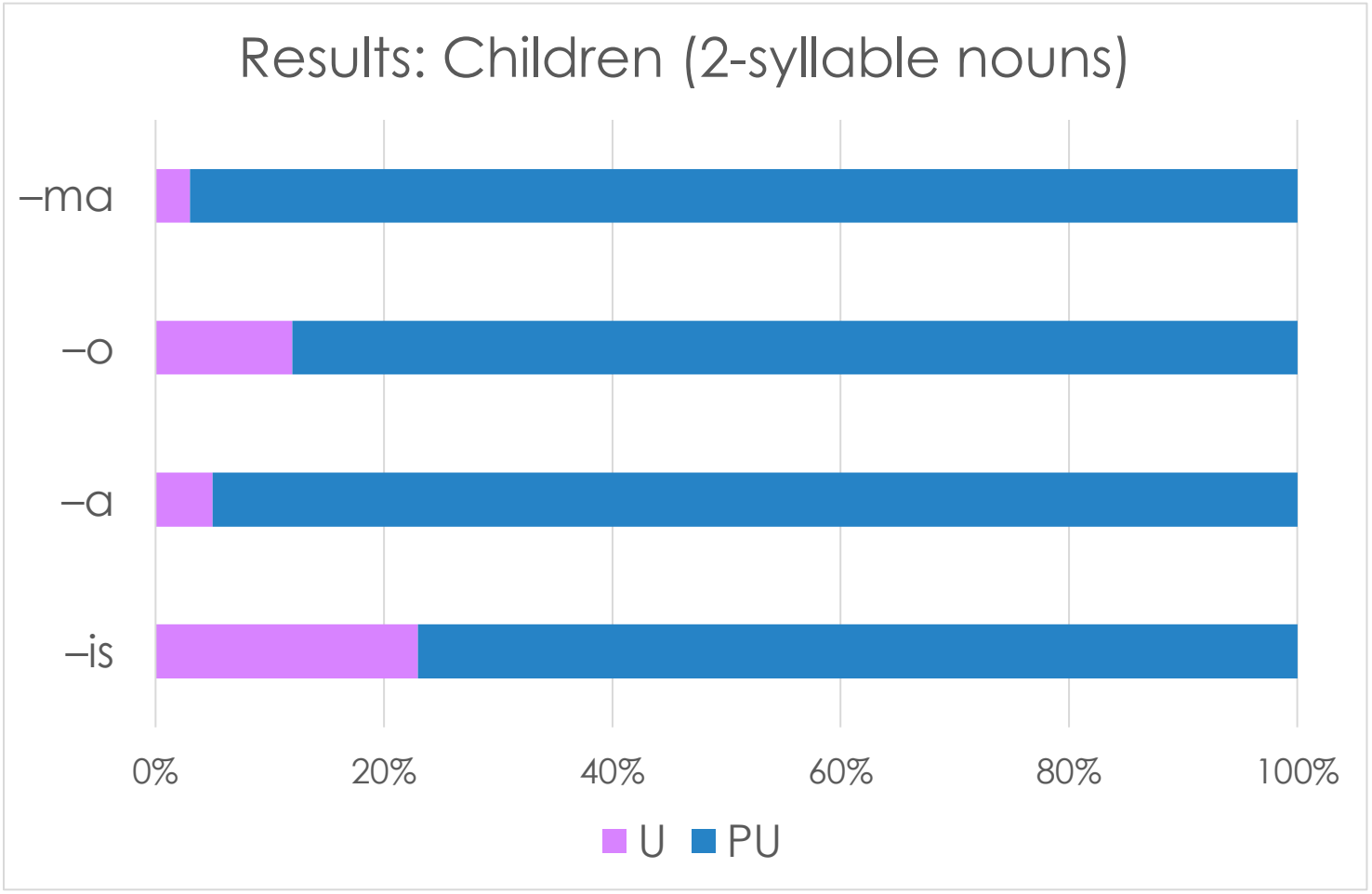

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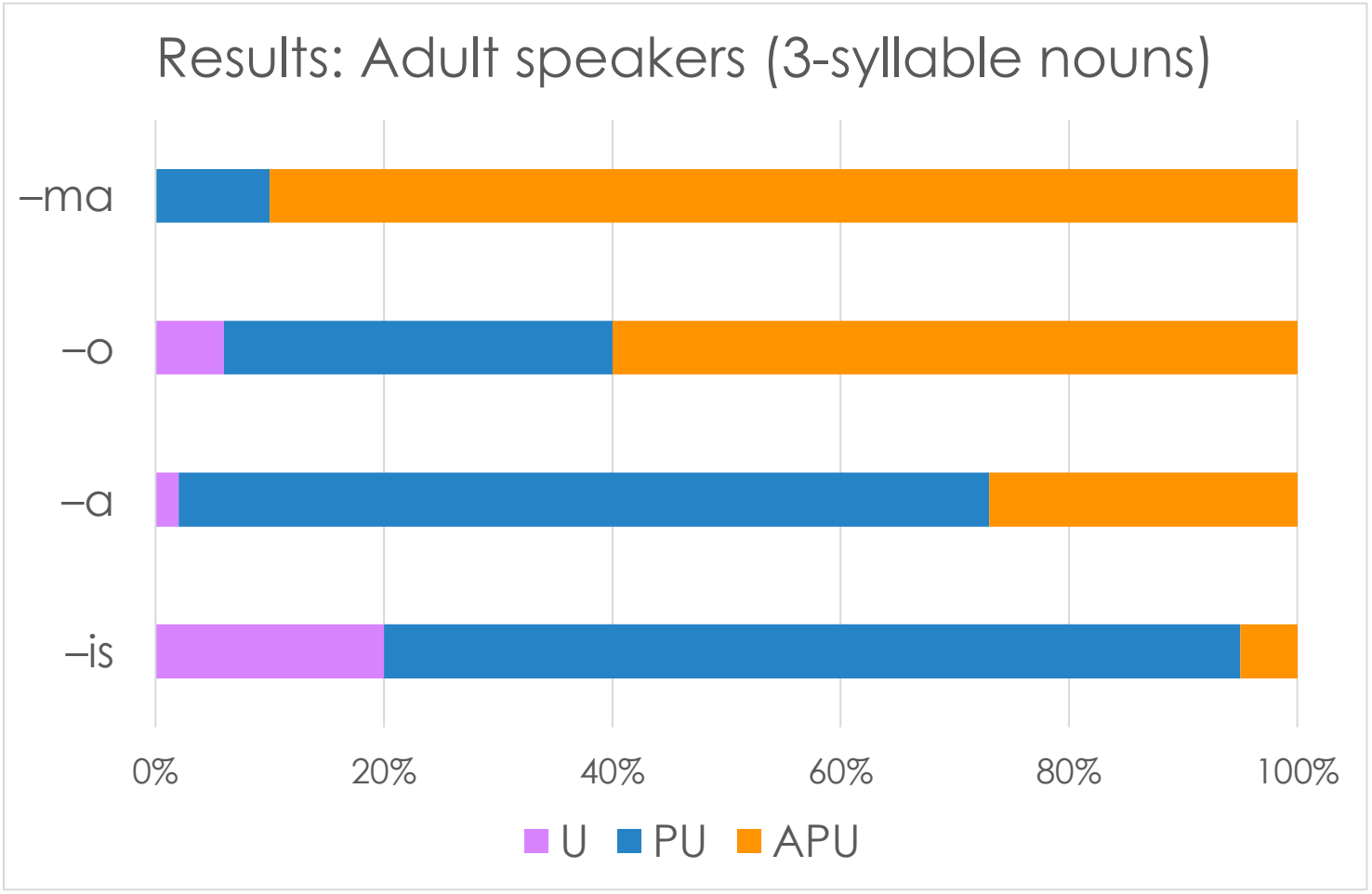

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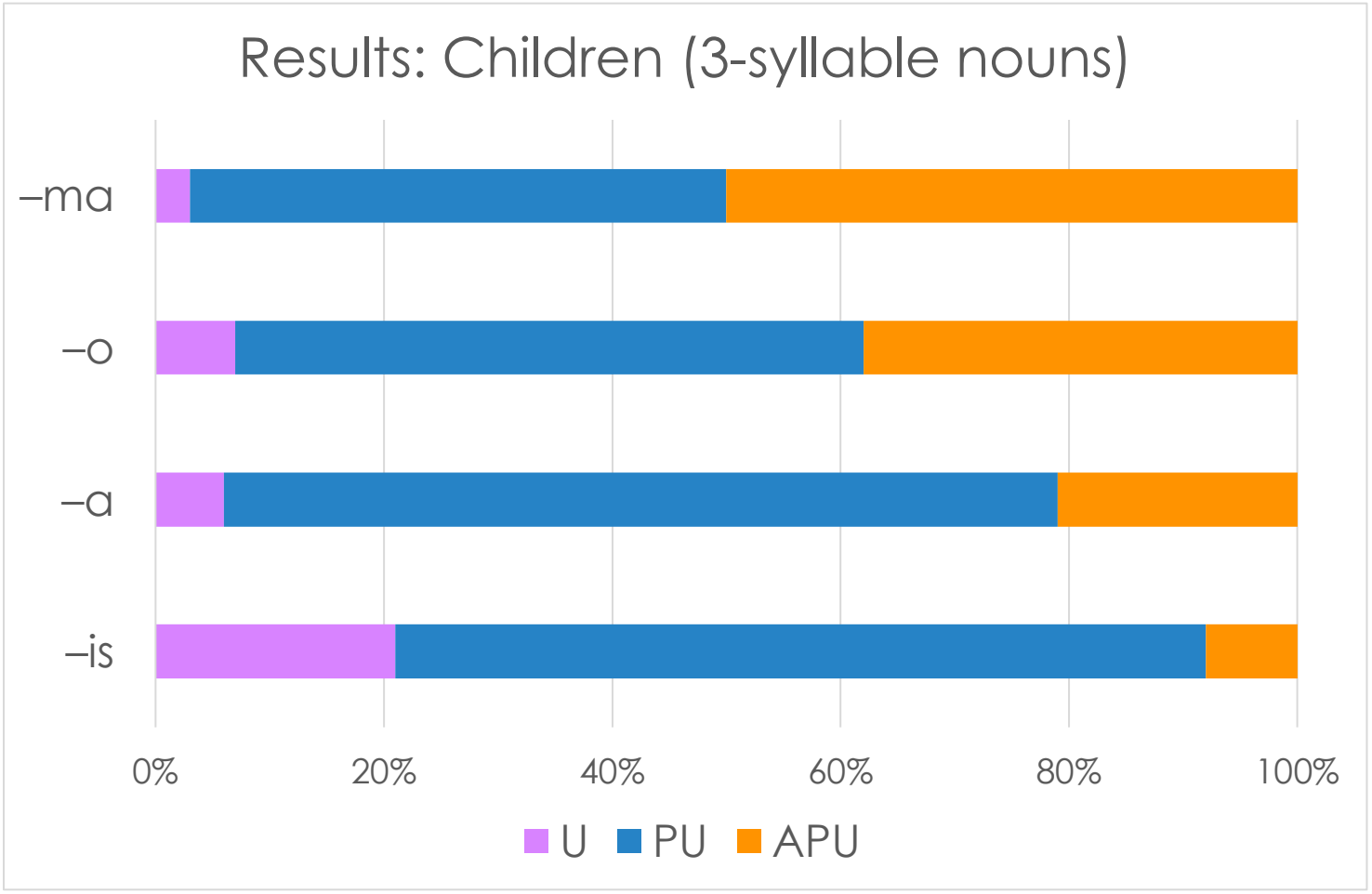


2.2. The present study: Experimental task

⇒ The adult speakers' responses are aligned with the distribution of stress patterns in the lexicon

⇒ Children tend to prefer the most unmarked stress position, i.e., PU, and are less influenced by the lexicon

⇒ The results replicate Apostolouda's (2018) findings

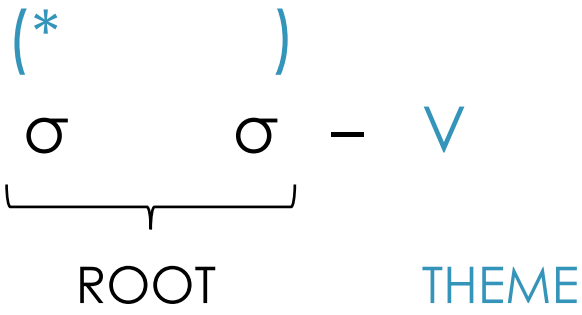
2.2. The present study: Experimental task

- Main conclusions:
  - PU → default stress position (as reflected in children's responses)
  - APU → the overrepresentation of APU stress in certain inflection classes affects adult speakers' grammars
  - U → least preferred stress position overall (except for nouns ending in *-is*)
  - Desideratum → a formal analysis that models the probability for each stress position to emerge

3. Analysis

- In a nutshell:
  - Greek Theme elements (ThEs) carry an inherent APU stress property, i.e., they are pre-pre-stressing: ←←*V_{TH}

(10)



3. Analysis

- This property is stronger in some ThEs and weaker in others
- High strength → it can dominate over default PU stress
- Medium strength → APU stress comes second
- Low strength → APU stress is the least preferred option

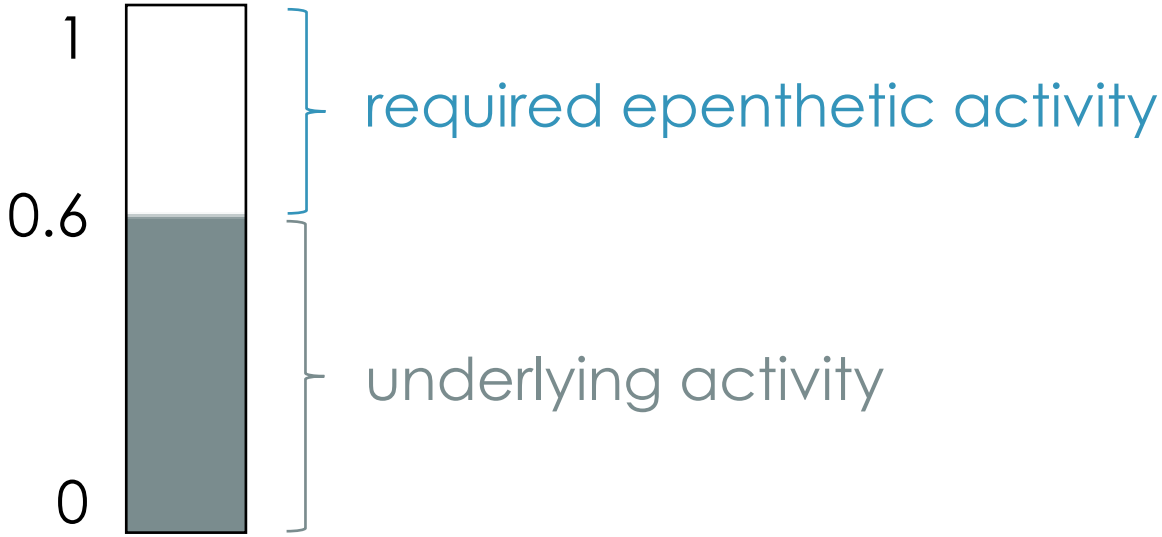
3.1. Gradient Symbolic Representations

- The APU stress property is not equally strong in all ThEs
- Formalization of strength differences → *Gradient Symbolic Representations* (Smolensky & Goldrick 2016; see also Rosen 2016; Faust & Smolensky 2017; Zimmermann 2018, 2021; Revithiadou et al. 2019; Smolensky et al. 2020; Hsu 2022, among others)
  - phonological elements bear an inherent Activity Level value (*a*)
  - $0 \leq a \leq 1$
  - Required *a* value for realization: 1

3.1. Gradient Symbolic Representations

- Weak elements, i.e., elements with $a<1$, require epenthetic activity
- E.g. /*$^{0.6}$/

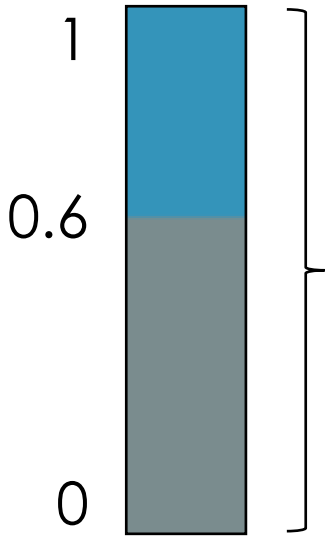
(11)



3.1. Gradient Symbolic Representations

- /*0.6/ → [*0.6+0.4]

(12)



underlying + epenthetic activity

3.2. Phonological computation: Gradient Harmonic Grammar

- Activity epenthesis → violation of DEP (Smolensky & Goldrick 2016)
- Non-realization of underlying activity → violation of MAX (Faust & Smolensky 2017)

(13)	/*0.6/	DEP *weight*: 4	MAX *weight*: 4
	[*1]	– (1–0.6) × 4 = –1.6	
	[*0]		– (0.6 × 4) = –2.4

3.2. Phonological computation: Gradient Harmonic Grammar

- The penalty for the violation of any other constraint is determined only by the *weight* (w) value

(14)	/σσ-←←*0.6V_{TH}/	DEP w: 4	MAX w: 4	TROCHEE w: 4	ALIGN-R w: 6	IAMB w: 4
	APU	–1.6			–6	–4
	PU	–4	–2.4			–4
	U	–4	–2.4	–4		

3.2. Phonological computation: Gradient Harmonic Grammar

- *Harmony* (H): the sum of penalty scores for each candidate
- The candidate with the highest H value has the highest probability of surfacing

(15)	/σσ-←←*0.6V_{TH}/	DEP w: 4	MAX w: 4	TROCHEE w: 6	ALIGN-R w: 6	IAMB w: 4	*H*
	APU	–1.6			–6	–4	–11.6
	PU	**–4**	**–2.4**			**–4**	**–10.4**
	U	–4	–2.4	–6			–12.4

3.2. Phonological computation: Gradient Harmonic Grammar

- Harmony differences formalize differences in probability (P)

(16) a. $H_{APU} - H_{PU} = \ln(P_{APU} / P_{PU})$

b. $H_{APU} - H_{U} = \ln(P_{APU} / P_{U})$

c. $H_{PU} - H_{U} = \ln(P_{PU} / P_{U})$

$\Rightarrow$ $a = (\ln(P_{APU} / P_{PU}) + w_{ALIGN\text{-}R}) / (w_{DEP} + w_{MAX})$

$\Rightarrow$ $w_{TROCHEE} = \ln(P_{PU} / P_{U}) + w_{IAMB}$

3.2. Phonological computation: Gradient Harmonic Grammar

- DEP, MAX, ALIGN-R and IAMB can be assigned arbitrary values, provided that $0 \leq a \leq 1$

(17)	/σσ-←←*^{a}V$_{TH}$/	DEP w: 4	MAX w: 4	TROCHEE **w**	ALIGN-R w: 6	IAMB w: 4	*H*
	APU	**–(1–*a*) × 4**			–6	–4	
	PU		**–*a* × 4**			–4	
	U		–1.2	**– $w_{TROCHEE}$**			

3.2. Phonological computation: Gradient Harmonic Grammar

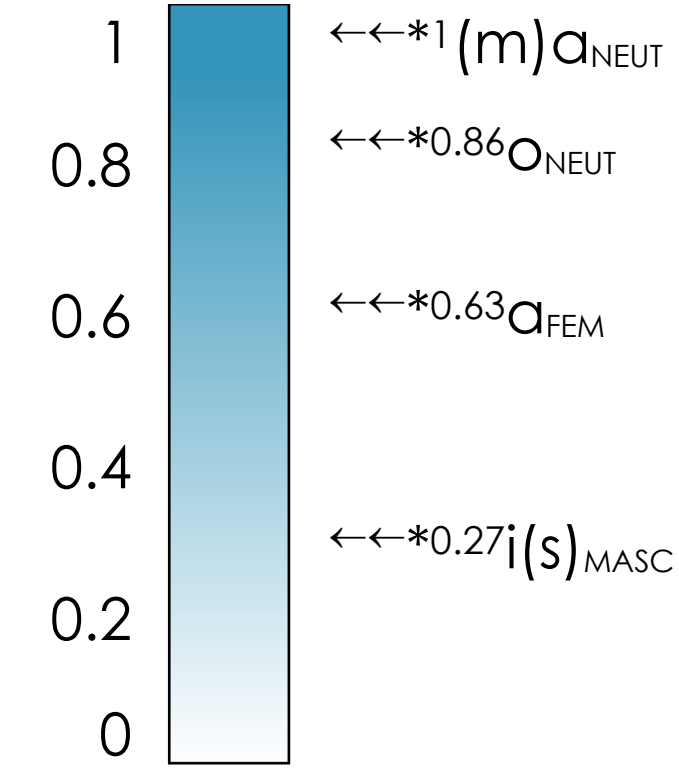
- α and $w_{TROCHEE}$ values are determined by P_{APU}, P_{PU} and P_{U}

- The probability of each stress pattern is calculated based on its frequency in the lexical databases

3.2. Phonological computation: Gradient Harmonic Grammar

- *a* values of lexical accents (according to *GreekLex 2*):

(18)



3.2. Phonological computation: Gradient Harmonic Grammar

- ←←*0.86O_{NEUT} (APU > PU > U)

(19)	/lerif-←←*0.86o/	DEP w: 4	MAX w: 4	TROCHEE w: 4.89	ALIGN-R w: 6	IAMB w: 4	*H*
1	['lerifo]	–0.57			–6	–4	–10.57
2	[le'rifo]	–4	–3.43			–4	–11.43
3	[leri'fo]	–4	–3.43	–4.89			–12.31

3.2. Phonological computation: Gradient Harmonic Grammar

- ←←*0.63a_{FEM} (PU > APU > U)

(20)	/lerif-←←*0.63a/	DEP w: 4	MAX w: 4	TROCHEE w: 5.12	ALIGN-R w: 6	IAMB w: 4	*H*
2	['lerifa]	–1.48			–6	–4	–11.48
1	[le'rifa]	–4	–2.52			–4	–10.52
3	[leri'fa]	–4	–2.52	–5.12			–11.64

3.2. Phonological computation: Gradient Harmonic Grammar

- ←←*0.27i_{MASC} (PU > U > APU)

(21)	/lerif-←←*0.27i-s/	DEP w: 4	MAX w: 4	TROCHEE w: 4.19	ALIGN-R w: 6	IAMB w: 4	*H*
3	['lerifis]	–2.97			–6	–4	–12.97
1	[le'rifis]	–4	–1.07			–4	–9.07
2	[leri'fis]	–4	–1.07	–4.19			–9.27

4. Conclusions

Greek phonology

- Stress assignment in Greek nouns is not that unpredictable after all!
- Early grammars (children) → default PU stress
- Adult speakers' grammars → influenced by the lexicon
  - high probability of APU stress in nouns with certain ThEs
  - high probability of default PU stress elsewhere
  - low probability of U stress in most cases

4. Conclusions

Phonological theory

- Gradient Harmonic Grammar → a suitable theoretical framework for modeling non-categorical outputs with varying probabilities
- Use of lexical databases → fine-tuning of *a* and weight values

Acknowledgements

The research project with the title “Gradience" is being implemented within the framework H.F.R.I call “Basic research Financing (Horizontal support of all Sciences)” under the National Recovery and Resilience Plan “Greece 2.0” funded by the European Union – NextGenerationEU (H.F.R.I. Project No: 15053, AUTH RC No: 76809)

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Thank you for your attention!

(ongoing project → feedback is welcome ☺)

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