Learning Stress with Feet and Grids

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Assumption: are Feet a burden?

- Gordon (2011): "… adoption of a grid-based rather than a foot-based approach to stress avoids the **burden** of having to model the learning of the hidden structure implicit in a foot-based theory."
- What could "burden" mean?
  - **Foot-based approach may fail to learn some languages or take longer to learn languages**

Learning Simulations

- Data: 28/33 Quantity Insensitive languages (Gordon 2002, Hayes & Wilson 2008) that the foot-based approach can represent
- Question 1: Does the foot-based approach correctly converge on every language?
- Question 2: Is the foot-based or grid-based approach faster?
- Learner: MaxEnt learning with hidden structure (Pater & Prickett 2022)
  - Initial weight = 1, Gradient Descent (as opposed to L-BFGS-B in P&P 2022)
- Input/Output: 1-7 syllables in length, marked with $\sigma/\grave{\sigma}/\acute{\sigma}$
  For example,

$\acute{\sigma}\sigma$	Candidates	Constraints
Grid	$\acute{\sigma}\sigma, \sigma\acute{\sigma}, \grave{\sigma}\acute{\sigma}, \acute{\sigma}\grave{\sigma}$	Gordon (2002) (n=12)
Foot	$(\acute{\sigma}\sigma), (\sigma\acute{\sigma}), (\grave{\sigma})(\acute{\sigma}), (\acute{\sigma})(\grave{\sigma})$	M&P (1993), Kager (2005) (n=9)

  - Learning data and all aspects of learning for both constraint sets were identical
  - Only difference is that the foot-based learner had to assign prosodic structure to the learning data (see P&P 2022)
- Learning success: For each syllable-length, 0.90 prob on correct surface form
- Learning speed: The number of epochs it takes for the learner to succeed in learning
- Learning failure: no success until maximum number of epoch (1000)

Differences between Grid and Foot

- Foot introduces hidden structure, Grid doesn't

$\sigma\acute{\sigma}\sigma$		
Grid	Level 2	x
	Level 1	x
	Level 0	x x x
		σ σ σ
Foot	$\sigma(\acute{\sigma}\sigma)$	
	$(\sigma\acute{\sigma})\sigma$	

- Grid counts grid marks to the edge, Foot counts syllables to the edge

$\sigma\grave{\sigma}\sigma\acute{\sigma}\sigma\grave{\sigma}$			
Grid			Align (X_2, R)
	Level 2	x	*
	Level 1	x x x	
	Level 0	x x x x x x	
		σ σ σ σ σ σ	
Foot			AlignHeadRight
	$(\sigma\grave{\sigma})(\sigma\acute{\sigma})(\sigma\grave{\sigma})$		**

Grid vs. Foot

	Learned	Faster
Grid	28	11
Foot	28	**14**
Total	28	28 (3 equal)

- Foot correctly converges on all 28 languages it can represent
- Foot faster than or equal to Grid on 17/28 languages (61%)

Grid-main-revised

- One of the major differences between Grid and Foot is how main stress placement is penalized. So we adopted the syllable counting AlignHead constraint from the foot-based approach.

$\sigma\grave{\sigma}\sigma\acute{\sigma}\sigma\grave{\sigma}$		Grid-main-revised
Grid	Level 2 x Level 1 x x x Level 0 x x x x x x σ σ σ σ σ σ	Align (X_2, R) Syll **
Feet	$(\sigma\grave{\sigma})(\sigma\acute{\sigma})(\sigma\grave{\sigma})$	AlignHeadRight **

Grid-main-revised vs. Foot vs. Grid

- This change had a great consequence on learning
- Grid-main-revised faster than or equal to Grid on 25/28 languages (89%)

	Learned	Faster
Grid	28	3
Grid-main-revised	28	**19**
Total	28	28 (6 equal)

- Grid-main-revised faster than or equal to Foot on 19/28 languages (68%)

	Faster
Foot	9
Grid-main-revised	**15**
Total	28 (4 equal)

- Foot was faster than Grid or Grid-main-revised on 8 languages

References

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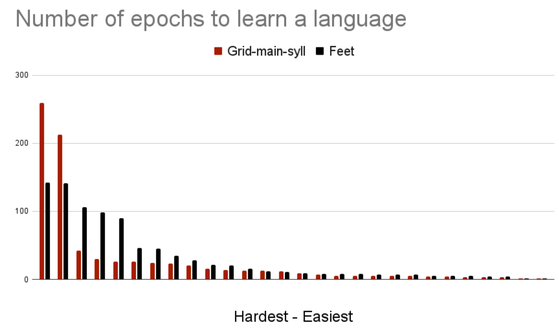
Learning speed (Number of epochs)

	Grid	Grid-main-revised	Foot
Mean	56.8	28.3	31.8
SD	87.6	59.9	42.5
Min	1	1	1
Max	401	259	142



- On average, Grid was slower than Foot,
- and Foot slower than Grid-main-revised
  - The hardest language for Grid-main-revised took longer than the hardest language for Foot

Conclusion

- Foot can correctly converge on all the languages it can represent
- Foot was **not slower** than Grid
- Grid learned faster with the **main stress** constraints that counts the number of **syllables**, rather than grid marks.
- Even with the revised constraints, Grid-main-revised was consistently slower on certain languages than Foot
- **The fact that Feet introduce hidden structure does not necessarily make learning harder for all languages in general.**
- **Details of the constraint set can have considerable effect on the speed of learning.**

Future work

- Will the current result hold if weights are initialized randomly?
- Quantity-sensitive languages in StressTyp2 (Goedemans et al. 2015)

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The MaxEnt learner we used is publically available at https://github.com/blprickett/Hidden-Structure-MaxEnt