Cues to stress assignment in reading aloud

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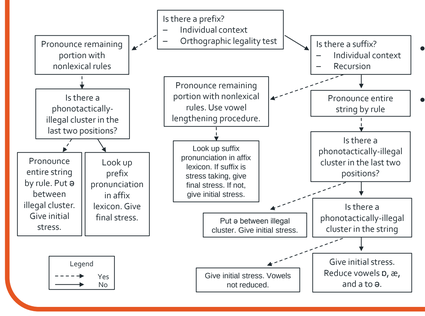
1. Overview

- Reading aloud research has focused almost exclusively on monosyllables, yet the majority of words in English, like in most languages, are multisyllabic.
- Reading aloud multisyllabic words requires the assignment of stress ('record as a noun & re'cord as verb). However, little is known about the sublexical information that readers use to assign stress.
- Three key sources of sublexical information have been proposed to influence stress assignment in reading aloud (e.g., Baker & Smith, 1976; Kelly et al., 1998; Rastle & Coltheart, 2000).
  - Prefixation: the presence of prefixes repels stress (**re'**mind, **dis'**trust)
  - Vowel Length: long vowels attract stress (('**coa**stal, la'g**oo**n)
  - Orthographic weight: syllables with more letters attract stress (rou'**lette**, ga**'zelle**)
- However, most studies confounded these cues and their individual influence is not yet understood.
- In Exps. 1-3, we used carefully constructed nonwords to factorially vary the presence of these cues and we examined their effects on 2nd-syllable stress at the level of single word reading.
- Human data were compared with three computational accounts of disyllabic reading, including a rule-based algorithm and two connectionist models.
- In Exp. 4, we tested the impact of these sublexical cues against the influences of higher-level contextual factors that arise in sentence reading, i.e. syntax & rhythm (Kelly & Bock, 1988).

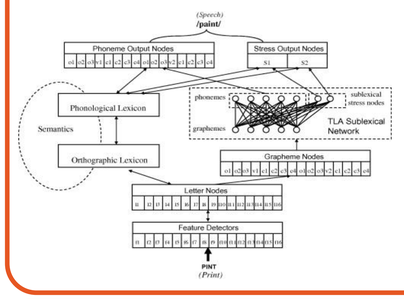
2. Models of stress assignment

Rule-based RCoo algorithm
(Rastle & Coltheart, 2000)



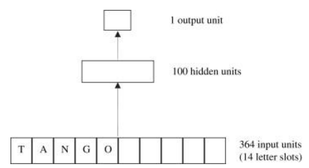
- Implemented **set of sublexical rules** for pronunciation and stress
- Stress assignment principally based on morphological cues
  - **Explicit rule that prefixes-repel stress**
  - No rules about vowel length & orthographic weight

CDP++ model
(Perry, Ziegler & Zorzi, 2010)



- Dual-pathway model that provides pronunciation, stress marker & RT
- **Sublexical pathway** incorporates a connectionist learning network & **learns** how to map spelling to sound & **spelling to stress from the statistical regularities of the language**
- Orthographic input is organized along a structured grapho-syllabic template

SMAo9 network
(Ševa, Monaghan & Arciuli, 2009)



- Simple feedforward network of stress assignment
- Uses **connectionist-learning principles** like the sublexical pathway of the CDP++
- **Learns** to map **spelling to stress from the statistical regularities** of the language
- Orthographic input is left-aligned

3. Single Nonword Reading

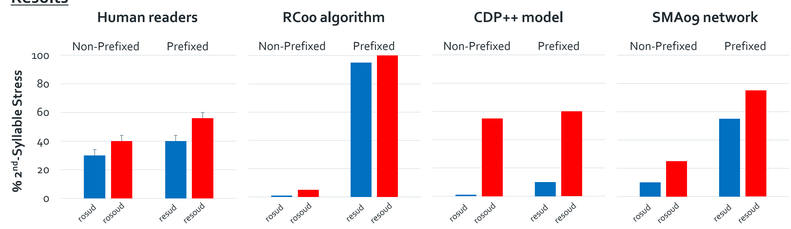
Experiment 1: Prefixation & Vowel Length

Design & Stimuli

- 80 pairwise-matched nonwords
- DV: 2nd-syllable stress assignment
- N = 20

	Prefixation	
Vowel Length	**Non-Prefixed**	**Prefixed**
Short 2nd Vowel	rosud	resud
Long 2nd Vowel	rosoud	resoud

Results



- Human readers: Main effects of Prefixation & Vowel Length on 2nd-syllable stress
- SMAo9 network resembles human performance the closest

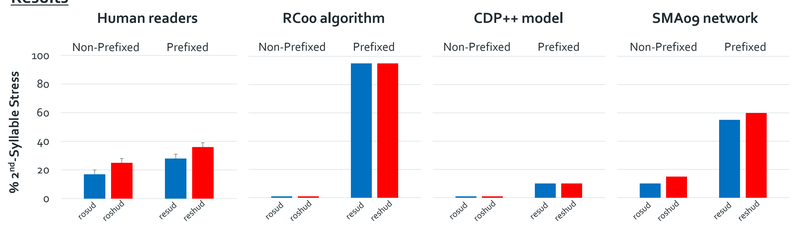
Experiment 2: Prefixation & Orthographic Weight

Design & Stimuli

- 80 pairwise-matched nonwords
- DV: 2nd-syllable stress assignment
- N = 20

	Prefixation	
Orthographic Weight	**Non-Prefixed**	**Prefixed**
Light 2nd Syllable	rosud	resud
Heavy 2nd Syllable	roshud	reshud

Results



- Human readers: Main effects of Prefixation & Orthographic Weight on 2nd-syllable stress
- SMAo9 network resembles human performance the closest

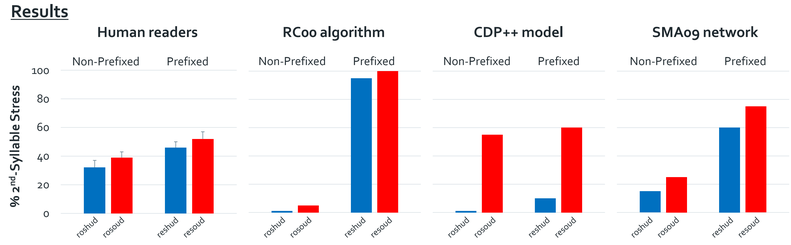
Experiment 3: Prefixation & Vowel Length (with Orthographic Weight Controlled)

Design & Stimuli

- 80 pairwise-matched nonwords
- DV: 2nd-syllable stress assignment
- N = 20

	Prefixation	
Vowel Length	**Non-Prefixed**	**Prefixed**
Short 2nd Vowel	roshud	reshud
Long 2nd Vowel	rosoud	resoud

Results



- Human readers: Main effects of Prefixation & Vowel Length on 2nd-syllable stress
- SMAo9 network resembles human performance the closest

4. Sentence Reading

Experiment 4: Sublexical vs. Contextual Cues

Background

Stress assignment in sentence reading is influenced by syntax and rhythm (Kelly & Bock, 1988).

- *Syntactic Context*

In English , ~90% of disyllabic nouns take 1st-syllable stress, while ~67% of disyllabic verbs take 2nd-syllable stress.
Nonwords in a **noun** context tend to receive **1st-syllable stress** (The 'rosud chased the ball)
Nonwords in a **verb** context tend to receive **2nd-syllable stress** (The dog ro'sud the ball)

- *Rhythmic Context*

Language is rhythmically organized and this involves the alternation between strong and weak beats.
Nonwords in a **trochaic** (Strong-Weak) context tend to receive **1st-syllable stress** (Save the 'rosud quickly)
Nonwords in an **iambic** (Weak-Strong) context tend to receive **2nd-syllable stress** (The big ro'sud escaped)

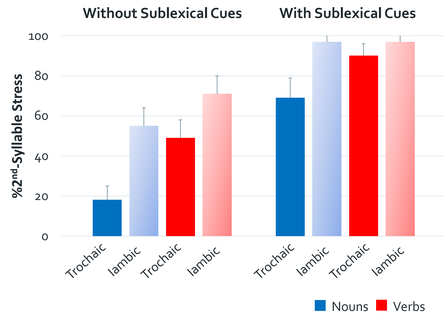
To what extent do lower-level sublexical cues interact with higher-level contextual cues in sentence reading?

Design & Stimuli

- 40 nonwords with sublexical cues (prefixed + a long vowel + high orthographic weight in 2nd syllable)
- 40 nonwords without sublexical cues
- Nonwords placed in sentence positions that varied in terms of their syntactic and rhythmic contexts
- DV: 2nd-syllable stress assignment
- N = 20

	Without Sublexical Cues		With Sublexical Cues	
	Syntactic Context		Syntactic Context	
Rhythmic Context	**Noun**	**Verb**	**Noun**	**Verb**
Trochaic	Save the *rosud* quickly	Milk will *rosud* butter	Save the *resoud* quickly	Milk will *resoud* butter
Iambic	The big *rosud* escaped	The god *rosud* dismay	The big *resoud* escaped	The god *resoud* dismay

Results



- More 2nd-syllable stress for nonwords
  - with sublexical cues
  - in a verb context
  - in an iambic context
- Syntactic X Rhythmic Context interaction

5. Conclusions

- First clear evidence of independent effects of Prefixation, Vowel Length, and Orthographic Weight on stress assignment in reading aloud.
- None of the three models perfectly matched the performance of human readers.
- The RCoo algorithm massively overestimated the effect of prefixation, and the sublexical rules of the model are not sufficient to capture the other non-morphological cues to stress.
- The profile of SMAo9 network was the closest to the human data, followed by the CDP++ model. This suggests that stress assignment in reading may be best conceived within the connectionist learning approach. However, further work remains to be done to overcome the limitations of these models, including training on realistic corpora.
- Sublexical cues continue to influence stress assignment in sentence reading, even in the presence of the higher-level contextual cues of syntax and rhythm.

References:
Baker, R., & Smith, P. (1976). *Lang Speech, 19*, 9-27; Kelly, M., & Bock, J. (1988). *J Exp Psych Human, 14*(3), 389-403; Kelly, M., Morris, J., & Verrekia, L. (1998). *Mem Cognition, 26*(4), 822-832; Perry, C., Ziegler, J., & Zorzi, M. (2010). *Cognitive Psychol, 61*(2), 106-151; Rastle, K., & Coltheart, M. (2000). *J Mem Lang, 42*(3), 342-364; Ševa, N., Monaghan, P., & Arciuli, J. (2009). *J Neurolinguistics, 22*(3), 237-249.