Taking morphology a level higher:

A lemma-extended interactive activation model

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23 June 2017

Background

Morphological ‘levels’

- Morphology mediates between ‘form’ and ‘meaning’
- Morpho-orthography vs. morphosyntax/morpho-semantics

Psycholinguistic evidence

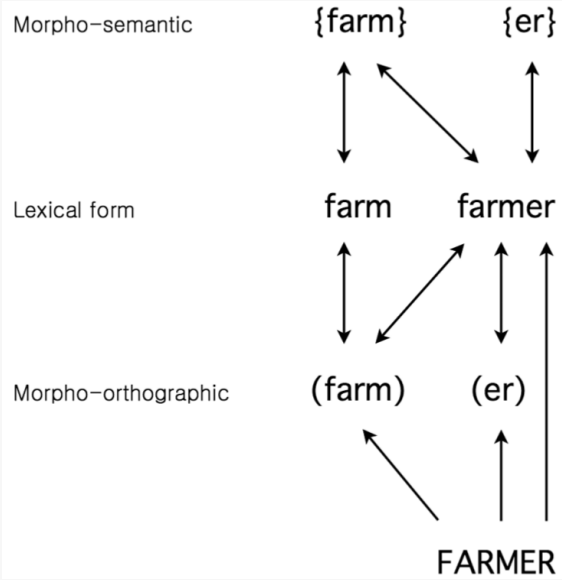
- Surface-form segmentation of complex words
- What about processing at “higher levels”?

Background

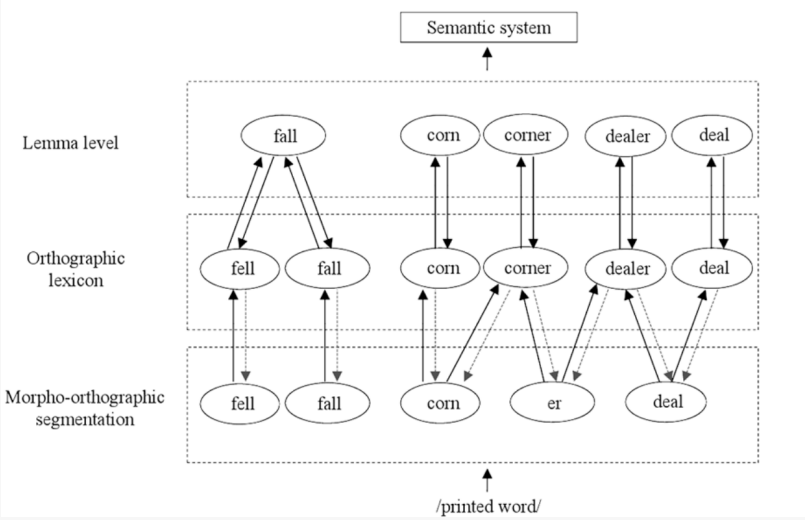
‘Localist’ models of morphology

- Often make use of a “higher level”, which interacts with morpho-orthography
- ‘Morpho-semantic’, ’lemma’, ’lexical’ . . .

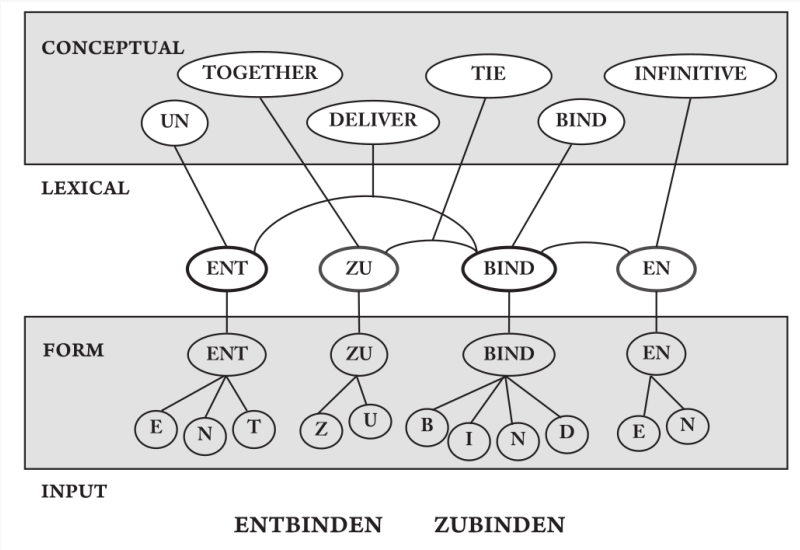
Diependaele et al. (2009)



Crepaldi et al. (2010)



Smolka et al. (2014)

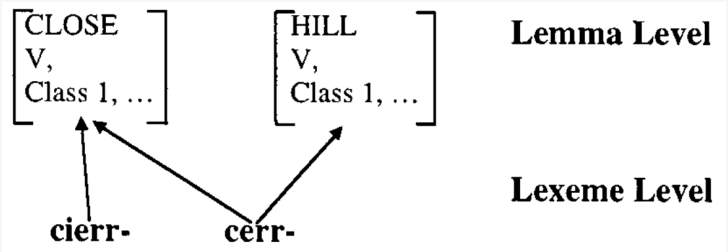


Background

‘Lemma’ level

- as the locus of morphosyntactic/morphosemantic information

Allen & Badecker (1999, 2002)



Background

Models of morphological processing

- Many expressed as ‘verbal’ theories or ‘boxese’
- Less precisely defined
- Difficult to generate quantitative predictions

Models of visual word recognition (Norris, 2013)

Model	Style	Task	Phenomena	Large lexicon
Models of visual word recognition				
IA [11,22]	IA	PI	Word-superiority effect	
Multiple read-out [3]	IA	PI, LD	Word-superiority effect	
SCM [2]	IA	LD, MP	Letter order	
BR [4–6]	Math/comp	LD, MP	Word frequency, letter order, RT distribution	√
LTRS [8]	Math/comp	MP, PI	Letter order	
Overlap [66]	Math/comp	PI	Letter order	
Diffusion model [30]	Math/comp	LD	RT distribution, word frequency	
SERIOL [7]	Math/comp	LD, MP	Letter order	
Models of reading aloud				
CDP++ [13]	Localist/symbolic	RA	Reading aloud	√
DRC [12]	IA	RA, LD	Reading aloud	
Triangle [24,25]	Distributed connectionist	RA	Reading aloud	
Sequence encoder [15]	Distributed connectionist	RA	Reading aloud	√
Junction model [50]	Distributed connectionist	RA	Reading aloud	√
Models of eye-movement control in reading				
E-Z reader [17,18]	Symbolic	R	Eye movements	
SWIFT [19]	Symbolic	R	Eye movements	
Model of morphology				
Amorphous discriminative learning [16]	Symbolic network	Self-paced reading, LD	Morphology	√

Current studies

Main objectives

- Bridge the gap between:
  - ‘verbal’ models of morphological processing
  - computational models of visual word recognition
  - representational concepts from theoretical morphology
- Take the first steps in building a fully specified localist model of morphological processing

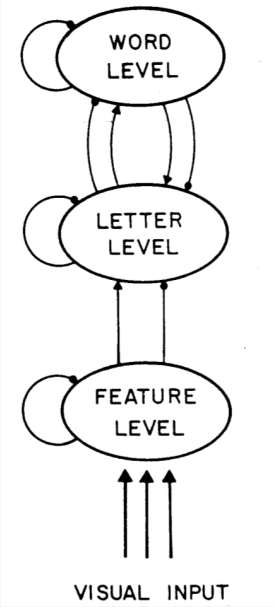
Current studies

General method

- Extension of the Interactive Activation model
- Nested modelling (Grainger & Jacobs, 1996)

Interactive Activation model

McClelland & Rumelhart (1981)

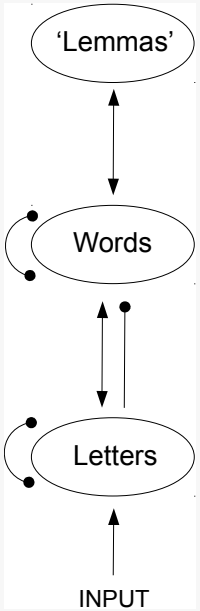


Theoretical assumptions

- 'Part-to-whole' processing
- Cascaded and interactive
- Lateral inhibition

LEIA

Lemma-Extended Interactive Activation



Architecture

- Letters
- Orthographic words
- Morphosyntactic 'lemmas'

LEIA

Lemma-Extended Interactive Activation

'Lemma' level

- as the locus of morphosyntactic/morphosemantic information
- Separate nodes for allomorphic stems/forms
- Underspecified lemma nodes
- 'Marked' stems/forms activate both marked and unmarked nodes at the lemma level

LEIA

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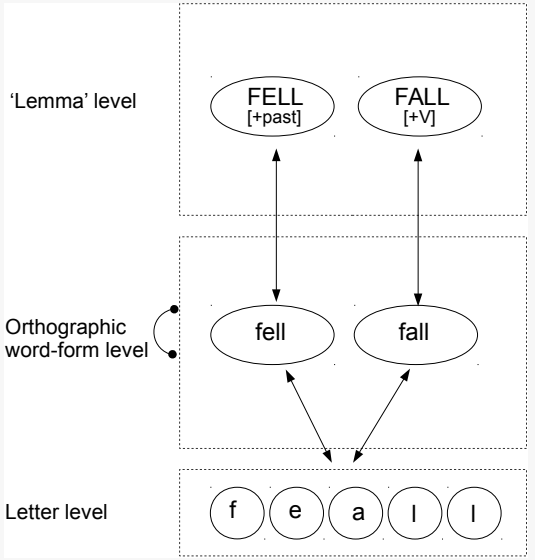

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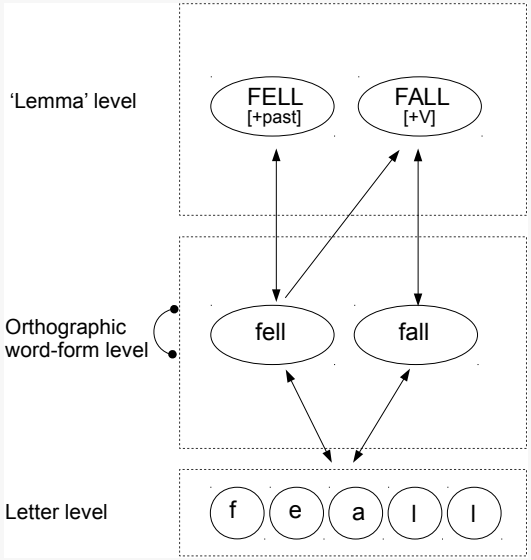

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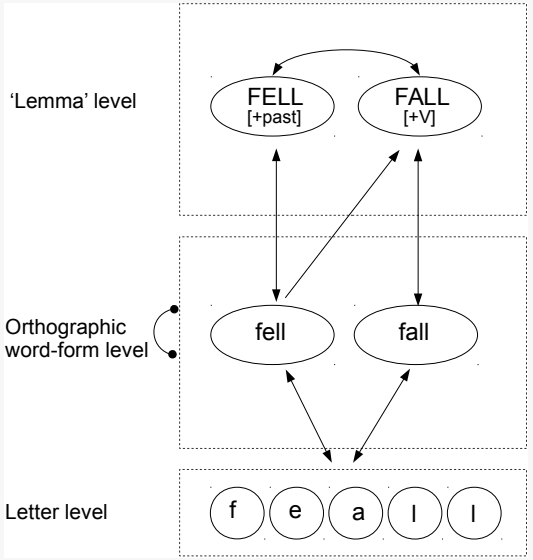


Current studies

Simulations

- Sim. 1: Irregular priming
- Sim. 2: Regular vs. irregular priming
- Sim. 3: Affix priming
- Sim. 4: Stem homographs

Method

Simulations of priming results

- Presentation of prime (60 cycles) + target
- Lexical decision made at word-form level
- Threshold = 0.7

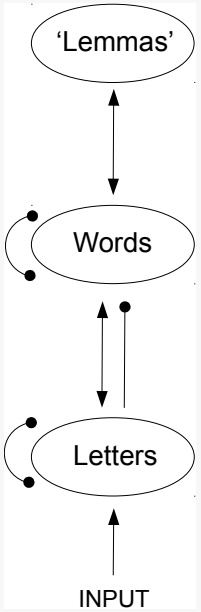
Method

‘Proof of principle’ simulations

- Minimum of words required for simulation
- 4-letter words, 2-letter suffixes
- Neighbours/irregulars have 1-letter difference
- No frequency/neighbourhood effects, etc.

LEIA

Lemma-Extended Interactive Activation



Parameters

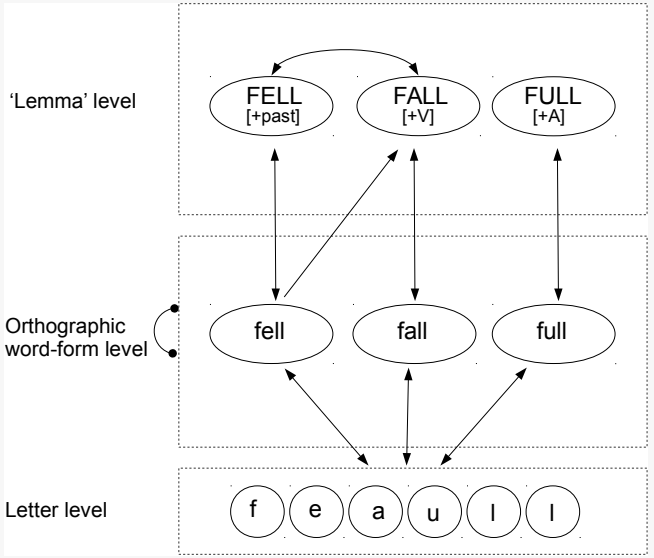
- Mostly identical to IA model
- Lemma level: optimization
- All simulations conducted with the same parameter values

Sim. 1: Irregular priming

Crepaldi et al. (2010)

- Masked priming
- *fell* $\rightarrow$ *fall*: Facilitation
- *full* $\rightarrow$ *fall*: Slight inhibition

Sim. 1: Irregular priming



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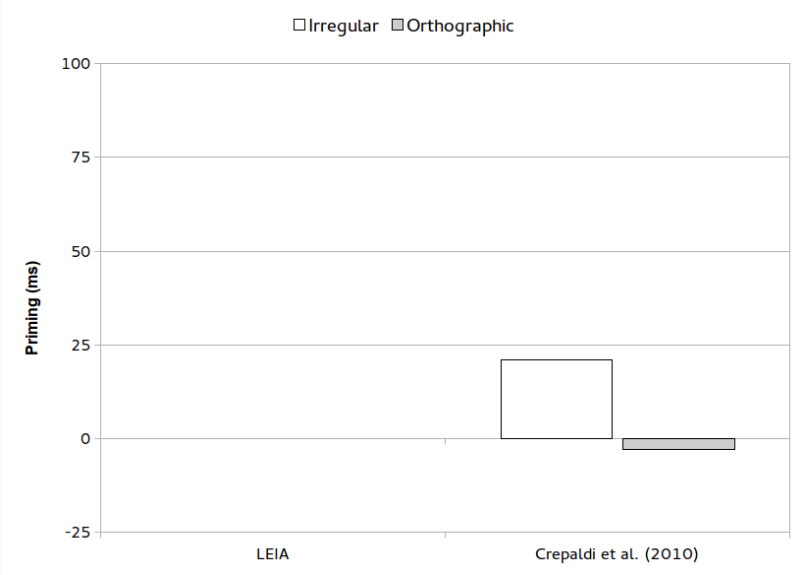

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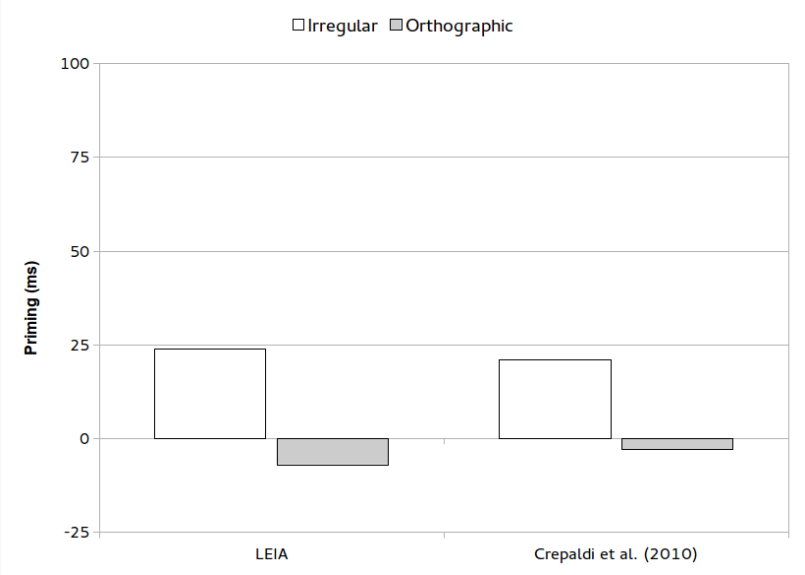
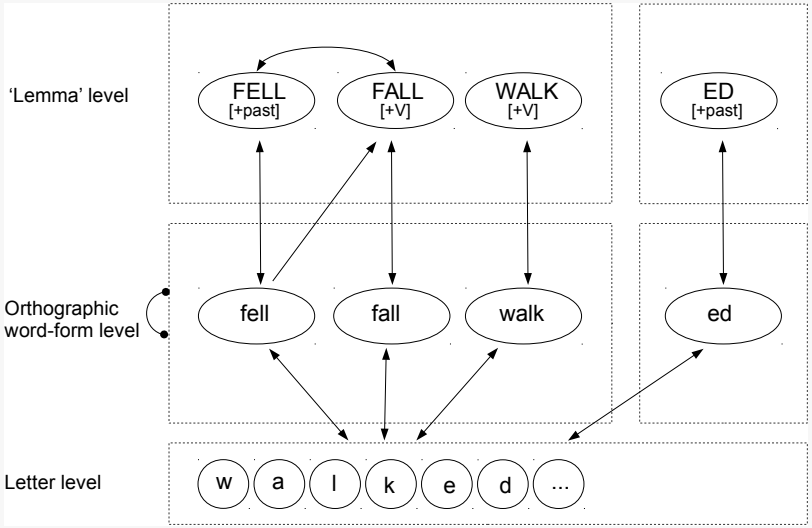


Sim. 2: Regulars vs. irregulars

Morris & Stockall (2012); Rastle et al. (2015)

- Masked priming (w/ ERP)
- *walked* → *walk*: Substantial priming (same as identity)
- *fell* → *fall*: Smaller priming (less than identity)

Sim. 2: Regulars vs. irregulars



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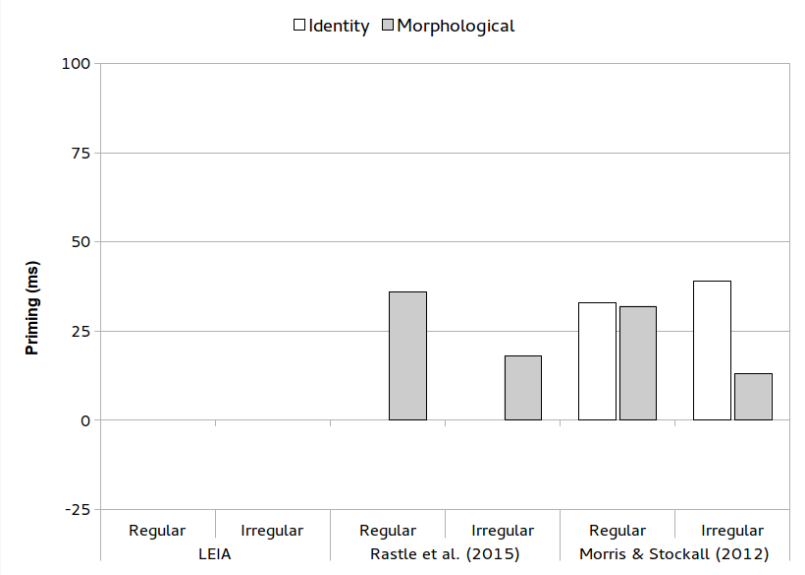

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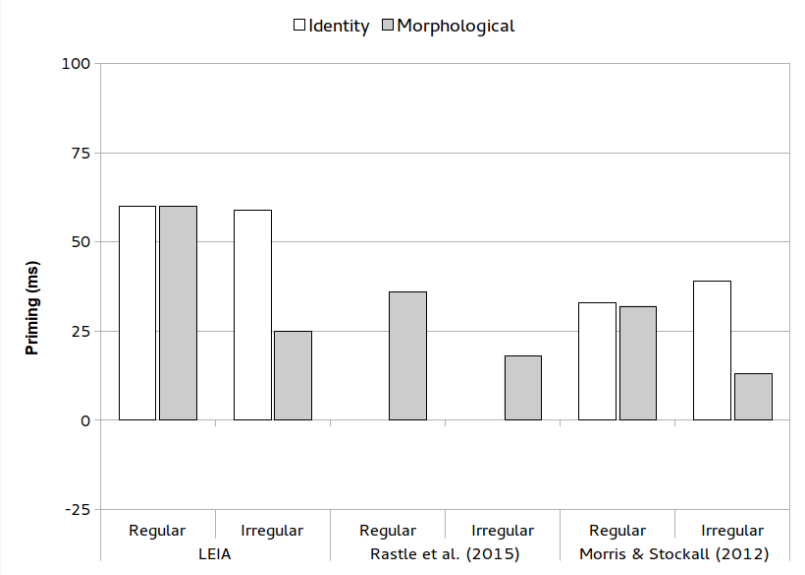
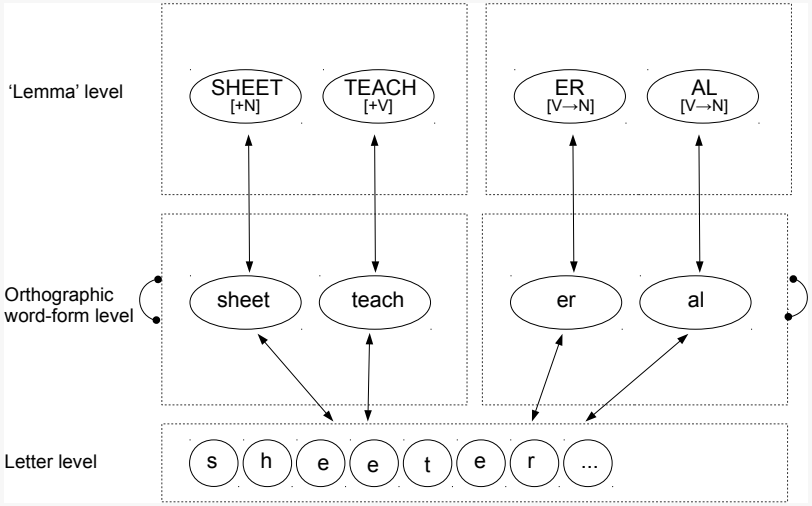


Sim. 3: Affix priming

Crepaldi et al. (2015)

- Masked priming
- *sporter* → *teacher* (vs. *sportuc*): Facilitation
- *sportal* → *teacher* (vs. *sportuc*): Small inhibition

Sim. 3: Affix priming



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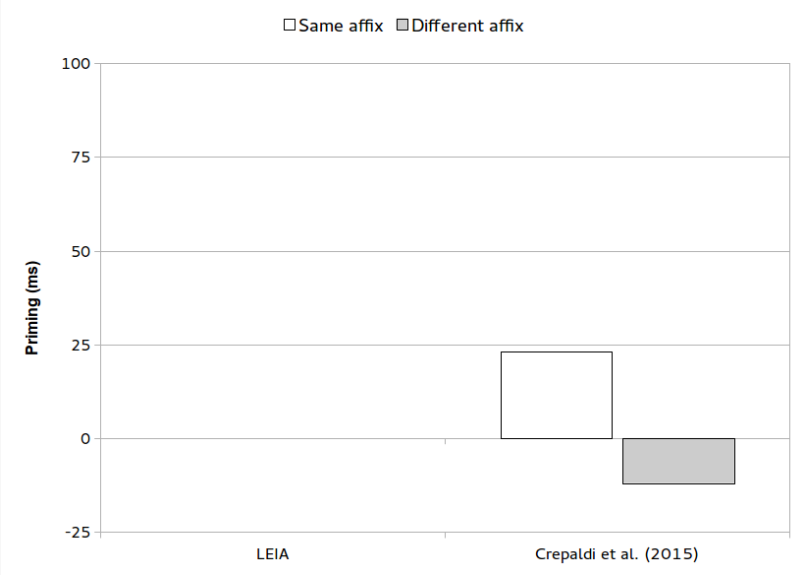

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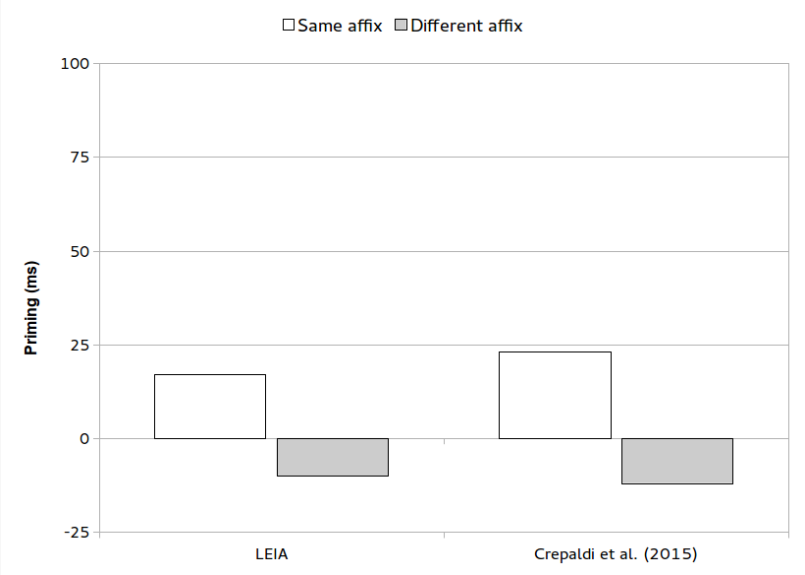

Sim. 4: Stem homographs

Allen & Badecker (1999)

- Unmasked visual priming
- *cerrar* 'to close' → *cerros* 'hills': Strong inhibition
- *cierras* '(you) close' → *cerros* 'hills': Strong inhibition

Badecker & Allen (2002)

- Masked priming
- *cerrar* 'to close' → *cerros* 'hills': Facilitation
- *cierras* '(you) close' → *cerros* 'hills': Small inhibition

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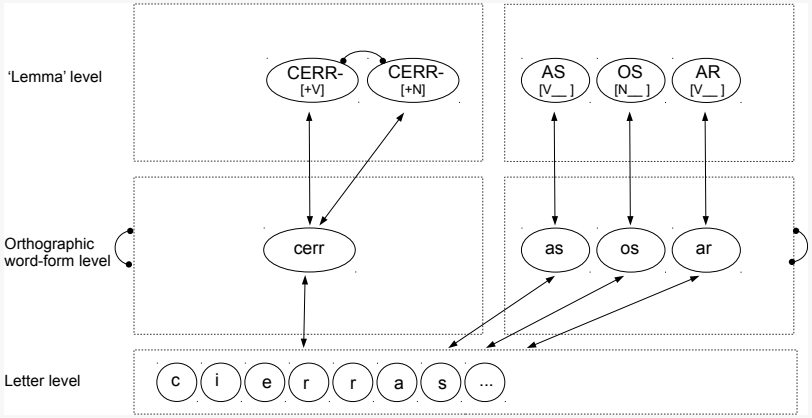

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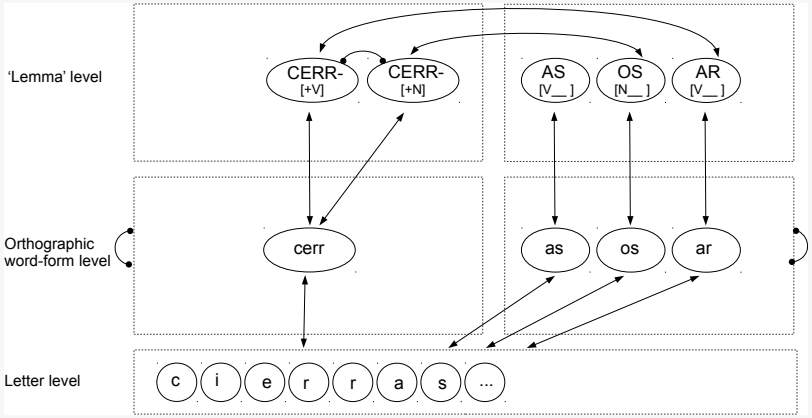

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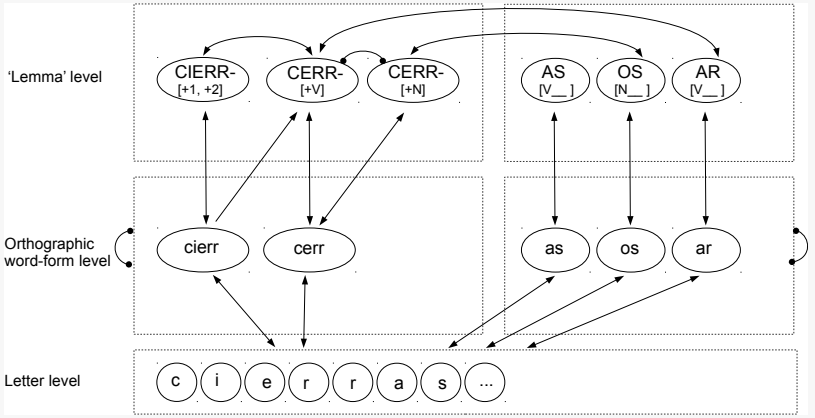

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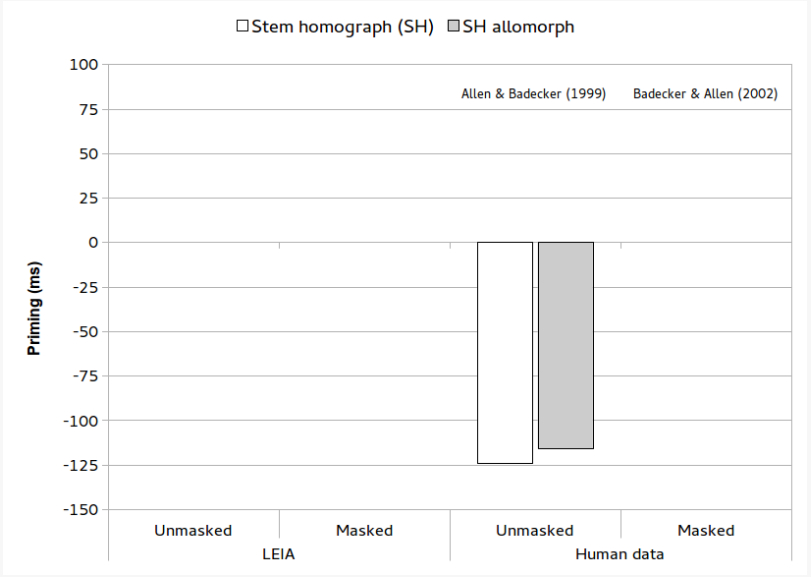

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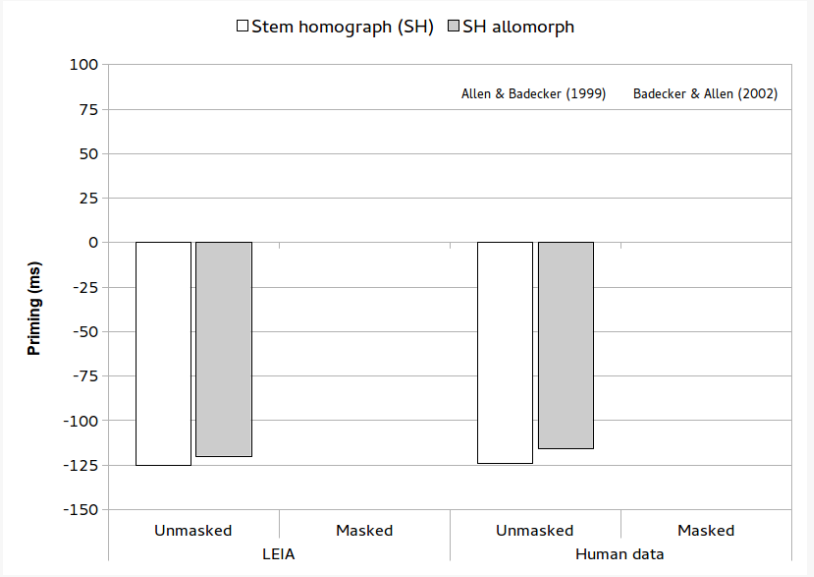

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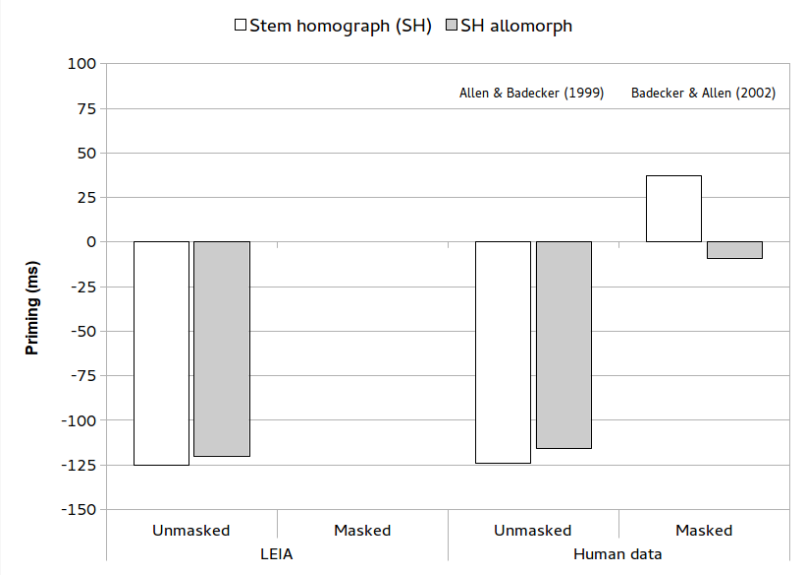

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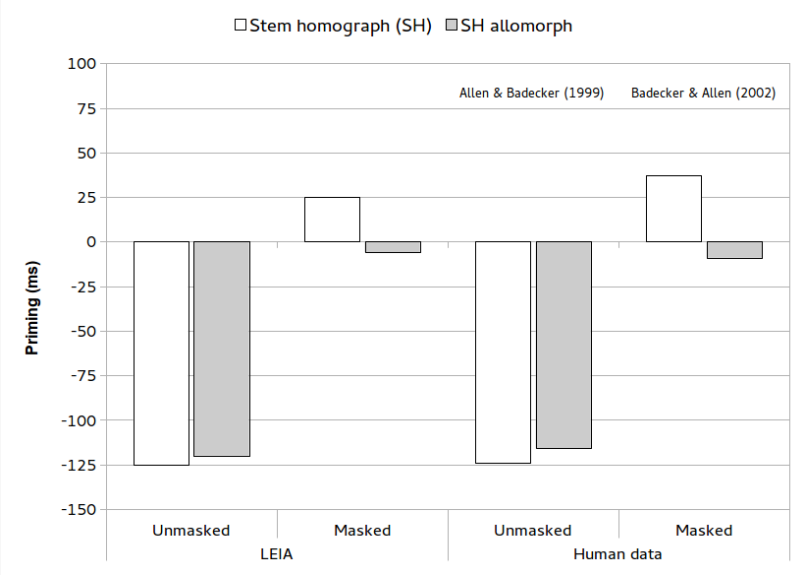

Discussion

We have simulated . . .

- . . . a range of distinct priming effects
- . . . and some aspects of the timecourse of morphological processing
- . . . within a single computational architecture

Conclusion

- Support for a lemma level that interacts in a top-down manner with morpho-orthographic processing

Thank you!