Phonological Processing During Visual Word Recogntion and Reading:

Experimental and Computational Investigations

Overview

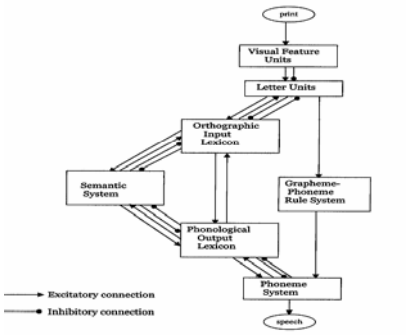
- Interactive Activation and Competition Models
- Phonological neighborhood
  - Density
  - Spread
  - Least supported phoneme
  - Neighborhood frequency
  - Reading for meaning

Why study word recognition?

Reading begins with perception of the printed word.

"One might argue that the word has been as central to developments in cognitive psychology and psycholinguistics as the cell has been to biology." Balota et al. (2004)

Dual Route Cascaded (DRC) Model
Coltheart et al. 2001



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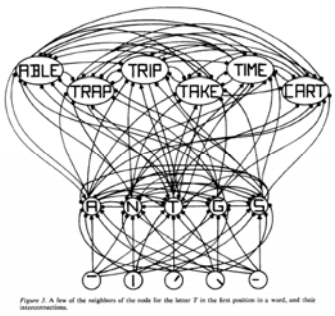
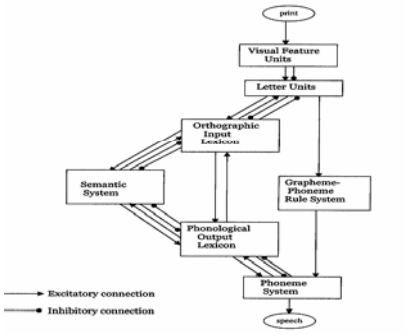


Figure 1. A few of the neighbors of the node for the letter *T* in the first position in a word, and their interconnections.

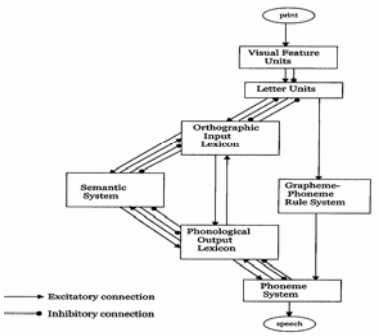
Dual Route Cascaded (DRC) Model
Coltheart et al. 2001



An Example

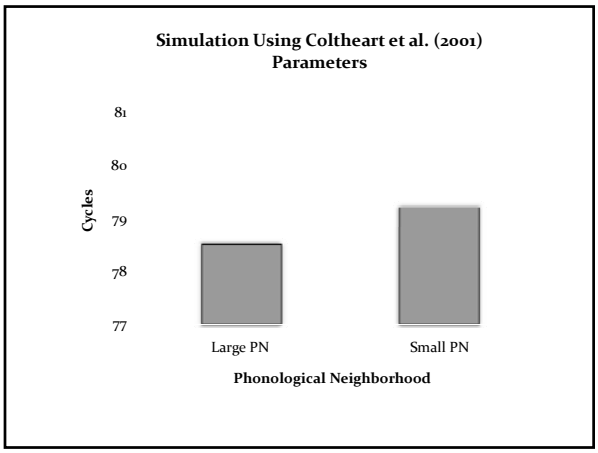
Mint
Lint
Squint
Flint
Hint
Glint
Print
Splint
Sprint
Stint
Pint
Tint

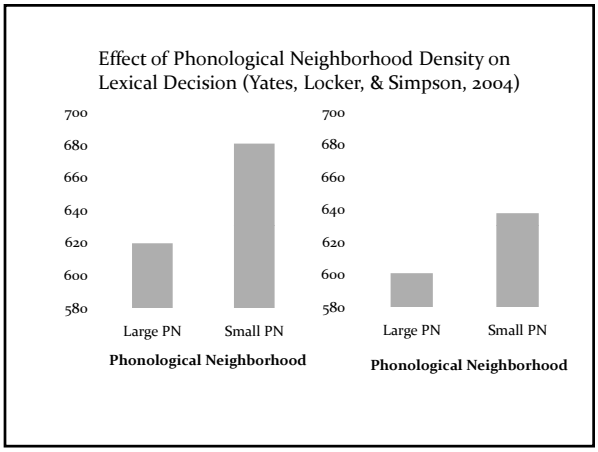
Dual Route Cascaded (DRC) Model
Coltheart et al. 2001



Phonological Neighborhood

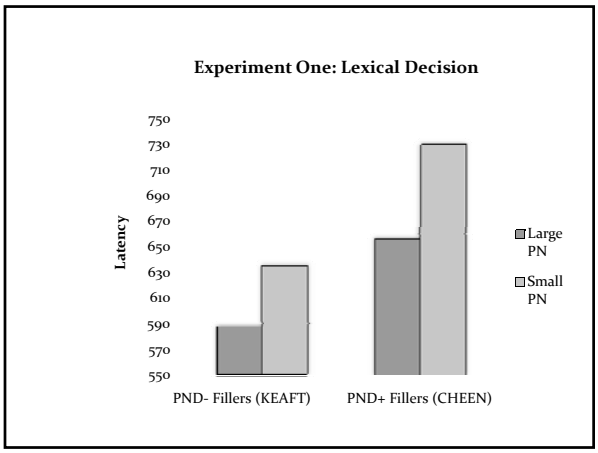
- Phonological neighbors (Differ by a phoneme)
  - MALT → Salt, Fault, etc.
- Orthographic neighbors (Differ by a letter)
  - MALT → Salt, Mast, etc.
- Why study PN in visual word recognition?
  - Offers a new way of assessing phonological activation
  - Does not suffer from the problems of other phonological variables (e.g., homophony).
  - Has been used extensively in spoken word recognition
  - Has been confounded with orthographic neighborhood in virtually every orthographic neighborhood study for the past 30 years
- Does the DRC predict an effect?

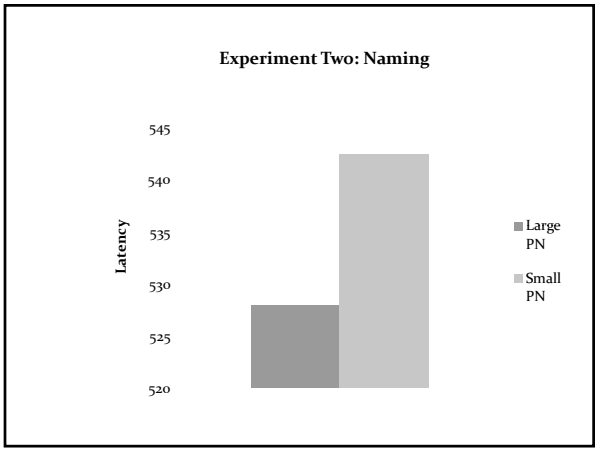


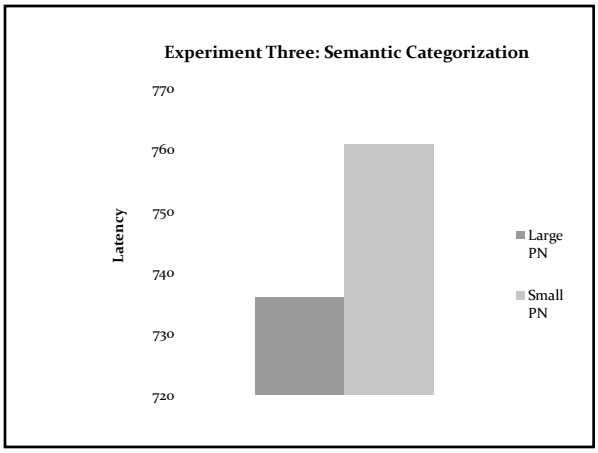


Effect of PN Density on Visual Word Recognition (Yates, 2005)

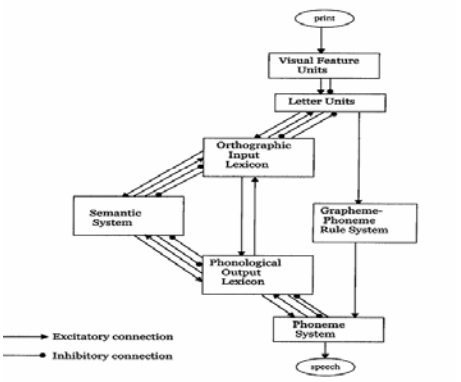
- Other tasks used in visual word recognition
  - Lexical decision
  - Speeded naming
  - Semantic categorization (is this word an animal?)

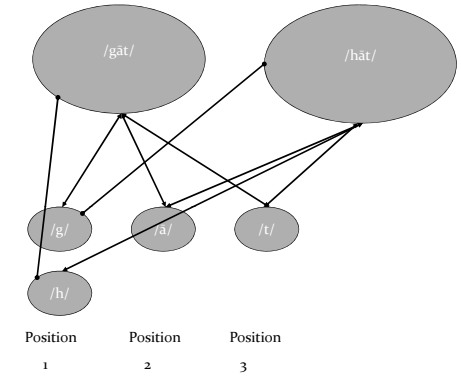

Experiment One: Lexical Decision
750
730
710
690
670
650
630
610
590
570
550
Latency
Large PN
Small PN
PND- Fillers (KEAFT)
PND+ Fillers (CHEEN)

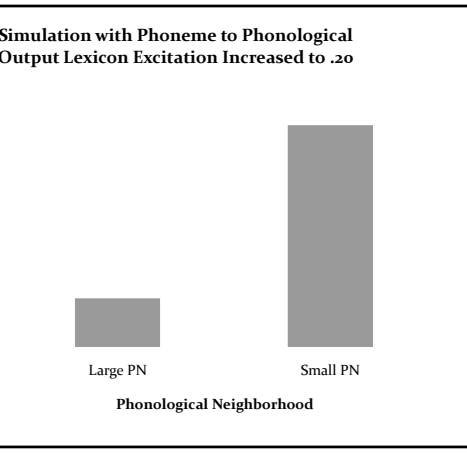

Experiment Two: Naming
545
540
535
530
525
520
Latency
Large PN
Small PN


Experiment Three: Semantic Categorization
770
760
750
740
730
720
Latency
Large PN
Small PN

Dual Route Cascaded (DRC) Model





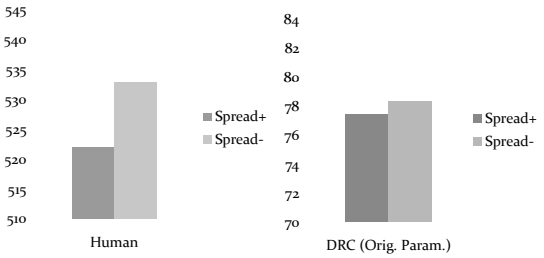


The impact of neighborhood spread

- Is there a facilitative effect of neighborhood spread on visual word recognition?

Spread 2 (P=2)	Spread 3 (P=3)
MOB	MOP
-rob	-hop
-m*b	-map
-mock	-mock

Yates, Friend, & Ploetz, (2008)



Dual Route Cascaded (DRC) Model
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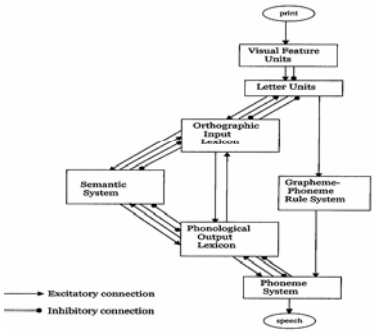


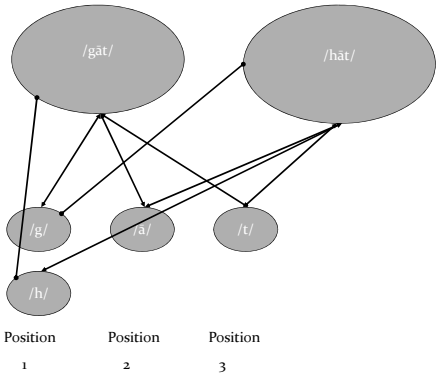
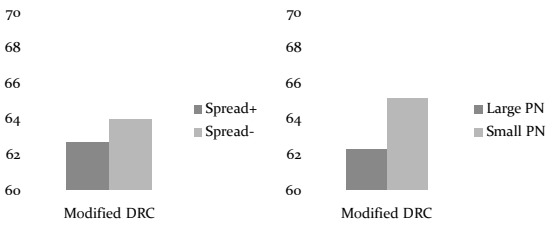


Table 2
Parameters for the Dual-Route Cascaded Model Simulations

Parameter	Standard parameter set	Increased phoneme to phonological excitation	No GPC	GPC to phoneme reduced
General				
Activation rate	.2	.2	.2	.2
Frequency scale	.05	.05	.05	.05
Reading-aloud criterion	.43	.43	.43	.43
Feature Level				
Feature to letter excitation	.005	.005	.005	.005
Feature to letter inhibition	−.15	−.15	−.15	−.15
Letter Level				
Letter to orthographic excitation	.07	.07	.07	.07
Letter to orthographic inhibition	−.435	−.435	−.435	−.435
Letter to letter inhibition	0	0	0	0
Orthographic Lexicon				
Orthographic to phonological excitation	.2	.2	.2	.2
Orthographic to letter excitation	.3	.3	.3	.3
Orthographic to letter inhibition	0	0	0	0
Orthographic to orthographic inhibition	−.06	−.06	−.06	−.06
Phonological Lexicon				
Phonological to phoneme excitation	.14	.14	.14	.14
Phonological to phoneme inhibition	0	0	0	0
Phonological to orthographic excitation	.2	.2	.2	.2
Phonological to phonological inhibition	−.07	−.07	−.07	−.07
Phoneme Level				
Phoneme to phonological excitation	.04	**.15**	**.15**	**.15**
Phoneme to phonological inhibition	−.16	−.16	−.16	−.16
Phoneme to phoneme inhibition	−.15	−.15	−.15	−.15
GPC Route				
GPC to phoneme excitation	.055	.055	**0**	**.035**
Cycles before route begins	10	10	**0**	10
Cycles before next letter accessed	17	17	**0**	17

Note. Changes from the standard parameter set of Coltheart et al. (2001) are in bold. GPC = grapheme–phoneme correspondence.

Simulations with modified DRC (Yates, et al. 2008)

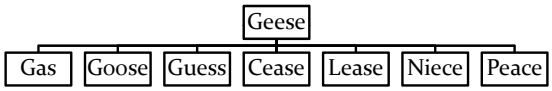


How is the model *really* simulating the effect?

- Two things to consider
  - When does the DRC issue a pronunciation?
    - All phonemes must reach threshold
    - Pronunciation can only be as fast as the slowest phoneme
  - How do neighbors overlap in the DRC

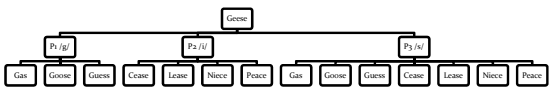
How is the model *really* simulating the effect?

- The old way of thinking about neighbors



How is the model *really* simulating the effect?

- The Least Supported Phoneme (LSP)



Evidence for the Least Supported Phoneme

- Words differing on PN size and spread also differ on LSP
- DRC controlling for the LSP
  - No PN effect
  - No spread effect
- Human naming data controlling for the LSP
  - No PN effect
  - No spread effect
- The LSP cannot explain the spread effect on visual lexical decision (Yates, 2009).

What about neighbor frequency?

- Models with an interactive activation and competition (IAC) architecture make a clear prediction that higher frequency neighbors should inhibit lower frequency neighbors.

$$a_i(t) = \sum_j w_{ij} o_j(t) - \sum_k \gamma_k o_k(t) + \mathrm{CFS}_i \qquad (6)$$

$$\mathrm{CFS}_i = \left(\left(\frac{\log_{10}(\text{frequency}_i)}{\log_{10}(\text{max frequency in lexicon})} \right) - 1 \right) \times \text{frequency scaling}. \qquad (7)$$

jIAM

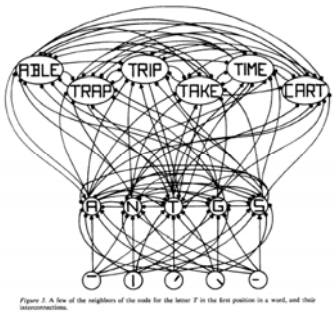
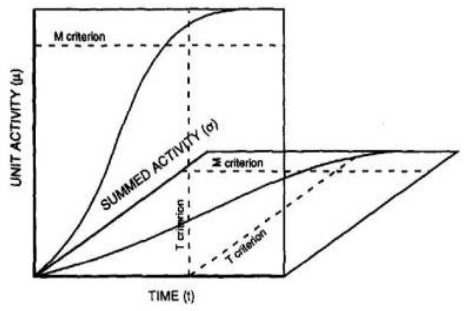


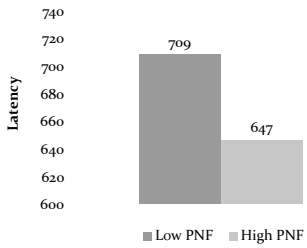
Figure 1. A few of the neighbors of the node for the letter *T* in the first position in a word, and their interconnections.

MROM model

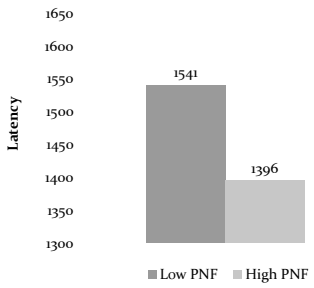
- Three ways to respond
  - *M* (local lexical activity)
  - *Σ* (global lexical activity)
  - *T* (Timeout for NO responses in LDT)



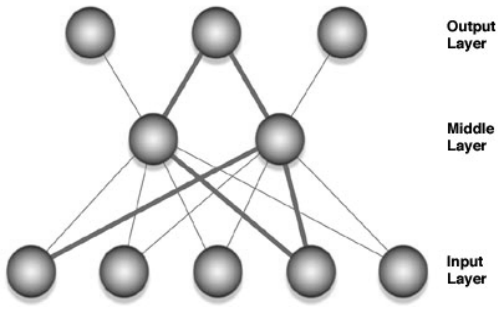
Experiment 1: Lexical Decision



Experiment 2: Progressive Demasking



Localist					Dist				
	U1	U2	U3	U4		U1	U2	U3	U4
John	1	0	0	0	John	1	1	0	0
Paul	0	1	0	0	Paul	0	1	1	0
George	0	0	1	0	George	0	0	1	1
Ringo	0	0	0	1	Ringo	1	0	0	1



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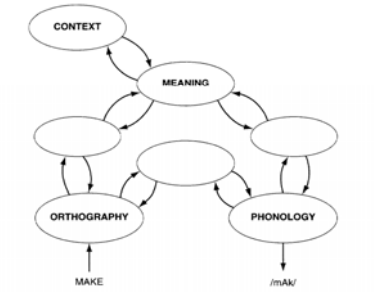
An Interactive Model with Phonological Processing

The model depicted here is an extension of the interactive activation model of McClelland and Rumelhart (1981). Separate sets of phonological and orthographic units interact with each other and with meaning units during lexical processing. The unlabeled ovals represent sets of "hidden units" that allow for all the units of one type to be connected to all the units of another type. So, for example, all the orthographic units and all the phonemic units are connected through the hidden units between these two levels.



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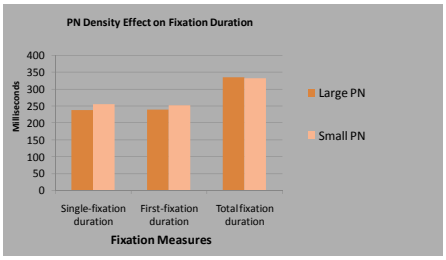
PN and reading for meaning

- Phonological neighbors also affect "real reading" (Yates, Friend, & Ploetz, 2008 b)

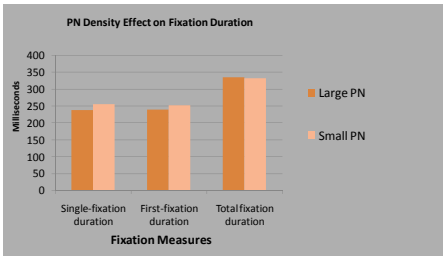


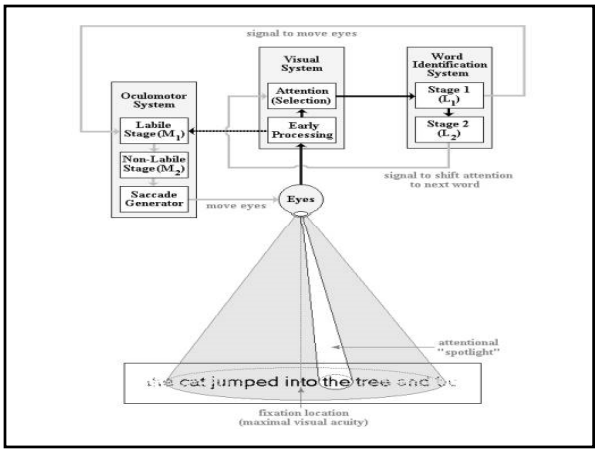
readvid.mpg

- High PN Sentence
- Low PN Sentence

PN and reading for meaning

- Phonological neighbors also affect "real reading" (Yates, Friend, & Ploetz, 2008 b)





Parafoveal Processing

The man found the elusive [snake/bvrtl] sunning itself on the rock.
*
The man found the elusive [snake/bvrtl] sunning itself on the rock.
*
The man found the elusive [snake/bvrtl] sunning itself on the rock.
*
The man found the elusive [snake/bvrtl] sunning itself on the rock.
*
The man found the elusive snake sunning itself on the rock.
*
The man found the elusive snake sunning itself on the rock.
*
The man found the elusive snake sunning itself on the rock.
*
The man found the elusive snake sunning itself on the rock.
*

Switch Video

Wrapup

- Phonological neighbors facilitate visual word recognition and reading.
- In the naming task, the neighbors overlapping with the least supported phoneme is of key importance.
- The phonological code is central to our ability to read.