

What is the Basis of Acquired Phonological Dyslexia?

- Phonological dyslexia is a reading impairment that primarily affects **generalization** (nonword reading).
- Its been taken as evidence for the “**rule**” (GPC) component of reading in the Dual-Route model of Coltheart et al. (1977). Poor generalization = impaired use of rules.
- Connectionist models (Seidenberg & McClelland, 1989; Plaut et al., 1996) have no **rule** component. How can they account for this impairment?

Answer: It's a Phonological Impairment

- Phonological dyslexics have phonological impairments (e.g. segmentation, syllable splitting, rhyme judgments).
- Phonological ability is related to nonword reading in:
 - Normal children's acquisition of reading (Adams, 1990).
 - Developmental phonological dyslexics (Manis et al., 1996).
 - Acquired phonological dyslexics.

Nonword reading is more difficult and is therefore more vulnerable to phonological damage than word reading.

Not So Fast!

Phonological dyslexics also exhibit “orthographic” processing deficits. For example, MJ (Howard & Best, 1996) showed:

- Effects of **Graphemic Complexity**.
 - More errors on **CHACK** than **BEM**.
 - Same number of phonemes. Different orthographic complexity.
 - Therefore, effect must be orthographic (parsing letters to graphemes).
- Effects of **Visual Similarity** on **Pseudohomophone Reading**.
 - More errors on **PHINED** than **GERL**. Both sound like words.
 - **GERL** is similar to **GIRL**, **PHINED** not similar to **FIND**.
 - Therefore effect must be due to *orthographic* deficit.

These effects are taken as evidence against the phonological deficit hypothesis (Coltheart, 1996; Howard & Best, 1996; Berndt et al., 1996).

“Orthographic” Effects in the **Dual Route Theory**

- Stagelike model: Nonwords are read by parsing graphemes, then applying GPC rules, then assembling phonemes.
- /bɛm/ and /tʃæk/ are equally easy in terms of phonology.
- So MJ’s impairment must be at the grapheme parsing level (e.g., identifying **CH** as one grapheme).

“Orthographic” Effects: **Connectionist Account**

- In models such as SM89, orthographic and phonological codes are *connected*.
- **CHACK** is more orthographically complex than **BEM**. Therefore orth→phon computation is also more complex.
- Because phonology is part of orth→phon computation, phonological impairments have bigger effect on **complex** nonwords like **CHACK** than simple ones like **BEM**.

Which Predicts...

Orthographic/visual complexity effects should be seen in:

- Normal subjects' **reaction times**.
- Patients' **errors**.

Further, such effects should also be seen in:

- The sum squared error (**SSE**) of an unimpaired model of reading.
- The **errors** of a reading model with a **phonological** not **orthographic** processing impairment.

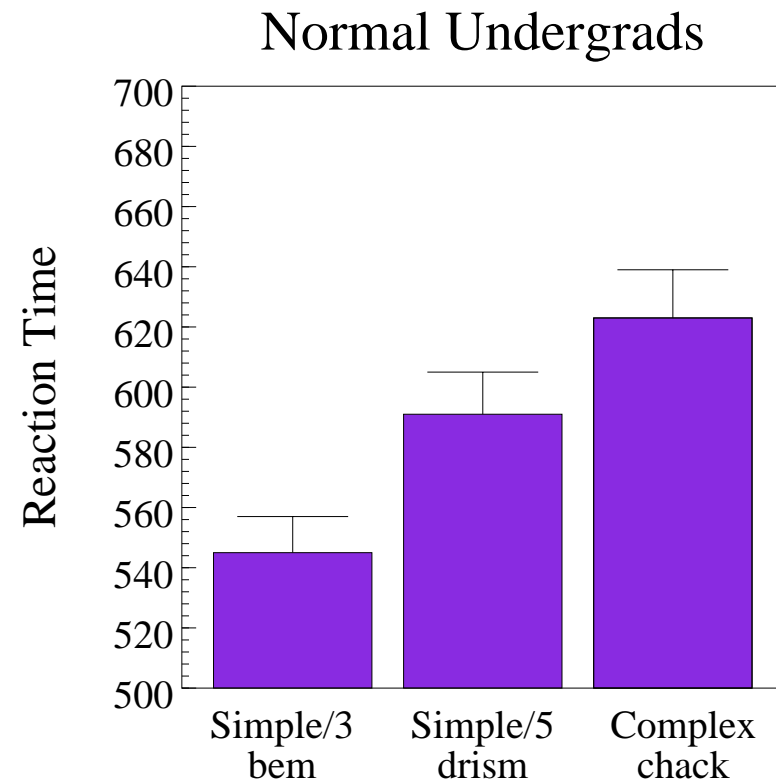
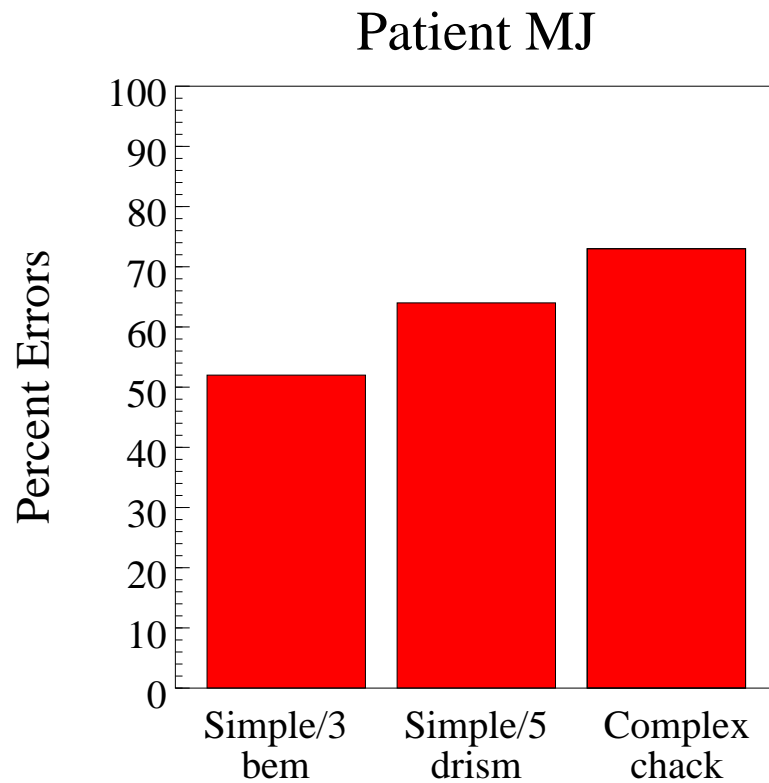
Experiment 1: Graphemic Complexity Effects in Normals

We tested younger normal subjects on Howard & Best stimuli.

- 24 USC undergraduates, all good readers.
- Naming task. RTs and errors recorded.
- 3 conditions:
 - Simple/3: 3 letters, 3 phonemes (e.g. **BEM**)
 - Simple/5: 5 letters, 5 phonemes (e.g. **DRISM**)
 - Complex: 5 letters, 3 phonemes (e.g. **CHACK**)

Experiment 1: Results

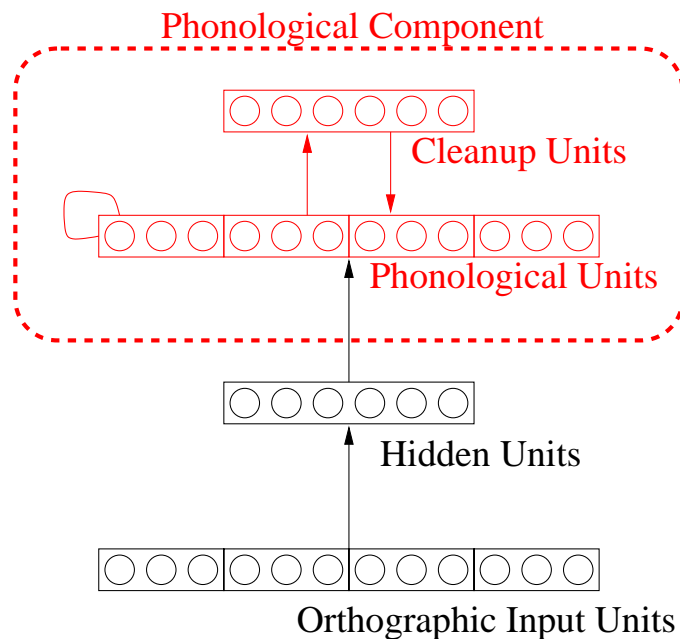
Effect of complexity seen in MJ's **errors** also seen in normal subjects' **RTs**.



Model 1:

Graphemic Complexity Effects in Model

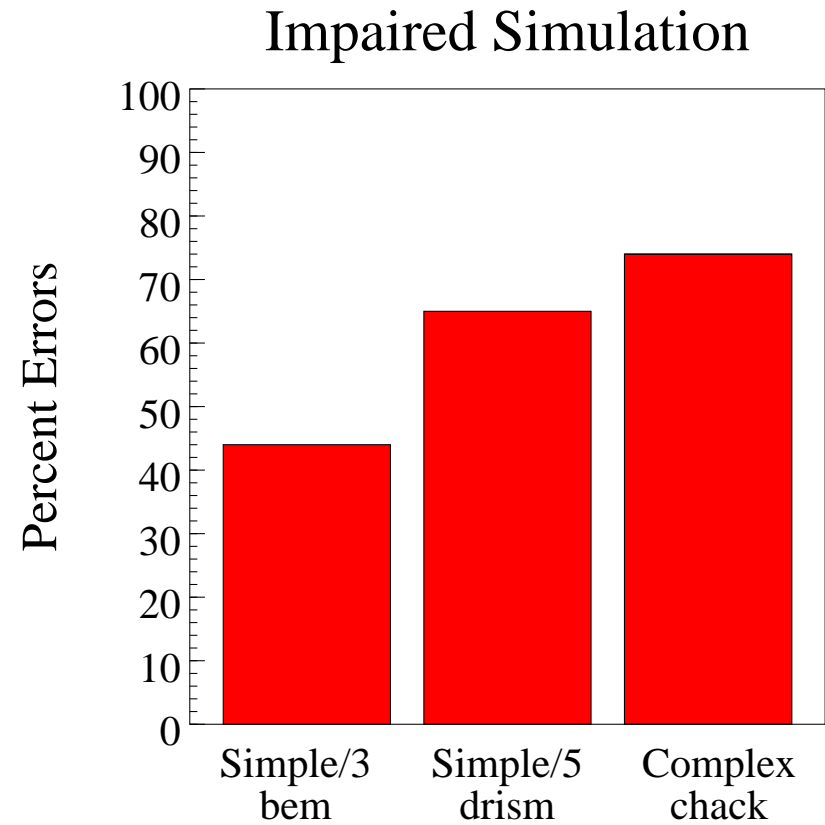
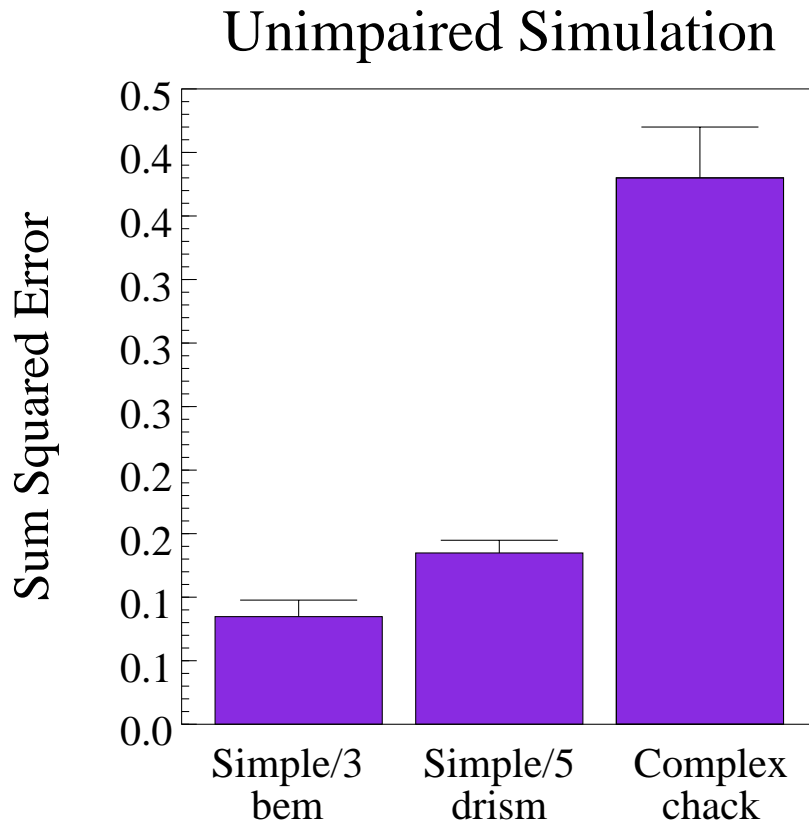
Test connectionist model on Howard & Best stimuli.



- Use connectionist network with phonological attractor component (Harm & Seidenberg, 1997).
- Complexity effect should appear in **SSE** (analogous to RTs).
- Introduce **phonological** damage to model.
- → Complexity effect should appear in **errors**.

Model 1: Results

Effect of complexity seen in **SSE** of unimpaired model and **errors** of phonologically impaired model.



Summary: Graphemic Complexity

- Orthographically complex items are more difficult to map onto phonology.
- This effect is seen in normal subjects and the normal model.
- **Phonological** damage exacerbates differences between stimuli.
- Thus, the same effect is seen in MJ and the **phonologically** impaired model, in **errors**.

“Orthographic” complexity effects do not involve an orthographic processing impairment.

Effect of Visual Similarity on Pseudohomophone Reading

A second effect observed in patient MJ (Howard & Best, 1996):

- Visually similar pseudohomophones (**GERL**, similar to **GIRL**) were read more accurately than visually dissimilar ones (**KWAK**, not similar to **QUACK**).
- Effect not seen in non pseudohomophones (**DERL** read as well as **PRAK**).

	Similar	Dissimilar	Visual Similarity Effect: Accuracy
Pseudohomophone	GERL	KWAK	32%
Non Pseudohomophone	DERL	PRAK	-3%

Visual Similarity Effect on Pseudohomophone Reading: Interpretations

- One Claim: MJ's impairment cannot be exclusively **phonological**, because there is **orthographic** modulation of the pseudohomophone advantage (Coltheart, 1996).
- Our Claim: Effects follow from **orthographic complexity** differences in stimuli.

What is the Source of the Observed Effects?

Dissimilar pseudohomophones had many low frequency letter combinations (KWAK, PHREA) compared to similar pseudohomophones. No such differences seen in control nonwords.

We analyzed the Howard and Best (1996) stimuli, measuring frequency of occurrence of word onsets.

	Similar	Dissimilar	Visual Similarity Effect: $\sum \log f$
Pseudohomophone	GERL	KWAK	326
Non Pseudohomophone	DERL	PRAK	2

Howard and Best's visual similarity manipulation was confounded with onset complexity. Therefore, same effects should be seen in RTs and in normal simulation.

Experiment 2: Visual Similarity Effect in Normals

Same USC undergrads used in Experiment 1 read items from Howard and Best study. RTs and errors recorded.

	Similar	Dissimilar	Visual Similarity Effect: RTs
Pseudohomophone	GERL	KWAK	17ms
Non Pseudohomophone	DERL	PRAK	-6ms

Normal subjects show same effect in RTs that MJ shows in errors.

Model 2: Visual Similarity Effect

- We used a subset of their items. Many of the Howard & Best pseudohomophones would not fit in our model's orthographic template. Also, some of their items are not pseudohomophones in American English (e.g. **GLARCE** is not homophonous with **GLASS**).
- Replicated **RT** effect in normals.
- Tested normal and phonologically impaired models on same items.

Model 2: Results

			Visual Similarity Effect	
			Normal Model	Impaired Model
	Similar	Dissimilar	SSE	Accuracy
Psh	GERL	KWAK	0.17	21%
Non Psh	DERL	PRAK	0.03	3%

- **Normal** model shows similarity effect in **SSE**.
- **Impaired** model shows similarity effect in **errors**.

Summary: Visual Similarity

- Howard and Best's pseudohomophones differed in terms of orthographic complexity; their non-pseudohomophones did not.
- This is why "visual similarity" only had an effect on pseudohomophones.
- This effect appeared in:
 - Normal subjects' naming latencies,
 - Patient MJ's errors,
 - The normal model's SSE,
 - The phonologically impaired model's errors.
- Thus, phonological impairment exacerbated the effect seen in normals.

Conclusion

- The “graphemic complexity” and “visual similarity” effects are the same: they reflect orthographic variation that affects the computation of phonology.
- We simulated MJ’s deficits by introducing **phonological** damage, not **orthographic**.
- Consistent with the hypothesis that phonological dyslexia derives from a **phonological** impairment.

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