Information processing of reading

**DOG**

**PERIPHERAL**

**DOG**

**CENTRAL**

4 legs, animal, bark

Semantics/meaning

Pronunciation/phonology

Visual stimulus

Visual analysis

Geschwind’s disconnection: isolation of visual regions from language regions

Visual Cognition

Pure alexia

• Dejerine 1892
  » alexia with agraphia
  » alexia without agraphia

Visual Cognition

Visual Word-Form Area (VWFA)

Petersen et al. (1992)

Devlin et al. (2006)
Visual Word-Form Area (VWFA)

McCandliss et al. (2003)

N170 waveform for letter strings

Bentin et al. (1999)

Bilateral activation: VWFA

Vinckier et al. (2007)

Experience dependence: VWFA

Baker et al. (2007)
Maturation of VWFA

Turkeltaub, Eden et al. (2008)

(6.4-11.6 yrs old)

Lesions to VWFA

- Pure alexia
  - Impairment in word recognition in premorbidly literate adults
  - Left occipitotemporal lesion
  - No general language impairment
  - Rely on sequential “letter-by-letter” strategy

Visual Cognition

Hallmark sequential reading

Pure alexic

• RT (ms)
Serial encoding

- Patients can do lexical decision and make semantic judgements at brief exposure duration
  - Too brief for sequential processing to account for this
- Even patients who can barely recognize letters seem to do better at this
- Also show ‘higher order influences on performance
  - Right hemisphere output?
  - Residual reading in normal system?

Very surprising

Evident in eye movements too

Higher order effects?
Think Interactive Activation Model

Behrmann et al. (1998, Cog. Neuropsych.)
Plaut (1999, Cog. Sci.)

Phonemes (t+1)

Position (t+1)

Done:

- 0 1 2 3 4 5 6 7

Hidden Units

(one time step)

Position (t)

Letters:

A     A     A     A     A     A
B     B     B     B     B     B
C     C     C     C     C     C
X     X     X     X     X     X
Y     Y     Y     Y     Y
Z     Z     Z     Z     Z     Z

Phonemes (t)

Plaut (1999, Cog. Sci.)

Mean Number of Fixations

Word Length

Percent Correct

Number of Fixations

Mean Number of Fixations

Word Length

- Low-frequency
- High-frequency

Word Presentations (x1000)
Domain generality

Pure alexia

Linear effect of visual complexity

Same-different matching

Same/different matching
Linear effect: Words and Symbols

Visual Cognition

Black and white line drawings

Reducing serial position effects

Therapeutic intervention

**TABLE 2**
Summary of Exposure Durations and Criterion Reached for Different Word Lengths in the Therapy Session

<table>
<thead>
<tr>
<th>Session</th>
<th>Exposure</th>
<th>Three</th>
<th>Five</th>
<th>Seven</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>900</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2</td>
<td>400</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>300</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>4</td>
<td>300</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>5</td>
<td>200</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>200</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>7</td>
<td>200</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>8</td>
<td>100</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

FIG 4 Reaction time for Si pre- and post-therapy to detect the presence of a target letter as a function of serial position in a nonword string.
But still a letter-by-letter - alas

Impaired reading in “surface” dyslexia

- Brain damage to left temporal lobe (stroke, head injury, or degenerative disease) in premorbidly literate adult
- Severe impairment to semantics, or to mapping from semantics to phonology
- Word reading accuracy influenced by frequency and consistency:

<table>
<thead>
<tr>
<th>Correct Performance</th>
<th>Patient</th>
<th>HFR</th>
<th>LFR</th>
<th>HFE</th>
<th>LFE</th>
<th>%Reg’s</th>
<th>NW</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP</td>
<td>95</td>
<td>98</td>
<td>93</td>
<td>73</td>
<td>90</td>
<td>95.5</td>
<td></td>
</tr>
<tr>
<td>KT</td>
<td>100</td>
<td>89</td>
<td>47</td>
<td>26</td>
<td>85</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

- Exception words produce **regularization** errors:
  - DEAF ⇒ “deef”
  - FLOOD ⇒ “flude”
  - SAID ⇒ “sayed”
  - GONE ⇒ “goan”
  - BROAD ⇒ “brode”
  - STEAK ⇒ “steek”
  - SHOE ⇒ “show”
  - SEW ⇒ “sue”
  - ONE ⇒ “own”
  - SOOT ⇒ “suit”

- **Nonword** reading accuracy is normal
- **Word and nonword naming latencies** are normal

Deep dyslexia

- Inability to read pronounceable nonwords
- **Error types in word reading**
  - Semantic: RIVER ⇒ “ocean”, CHEER ⇒ “laugh”
  - Visual: WAS ⇒ “saw”, SCANDAL ⇒ “sandals”
  - Visual-then-Semantic: SYMPATHY ⇒ “orchestra”, via symphony
  - Morphological/Derivational: LOVELY ⇒ “loving”, NEARER ⇒ “near”
  - Function-word Substitution: FOR ⇒ “and”, FROM ⇒ “with”

- **Part-of-speech effects**
  - Nouns > Adjectives > Verbs > Function-words

- **Concreteness/imageability effects**
  - Concrete > Abstract, Abstract ⇒ visual errors

- **Subvarieties based on location of damage within semantic pathway**
  - Input, Central, Output

Information processing of reading

**Visual stimulus**

**Visual analysis**

**Semantics/meaning**

**Pronunciation/phonology**

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**DOG**

4 legs, animal, bark

/dog/
Dual-route theory of word reading

- Systematic spelling-sound knowledge takes the form of grapheme-phoneme correspondence (GPC) rules (e.g., G \(\Rightarrow\) /g/, A \(\Rightarrow\) /A/)
- Applying GPC rules produces correct pronunciations for regular words (GAVE) and nonwords (MAVE), but incorrect pronunciations for exception words (HAVE)
- Exception words therefore require a separate lexical look-up procedure

A connectionist framework for word reading

- Separate Semantic and Phonological pathways
- Entire system participates in processing all types of items

Traditional “dual-route” model of word reading

Coltheart et al. (2001, Psych. Rev.)

- **Sublexical Route** encodes systematic spelling-sound knowledge by Grapheme-Phoneme Correspondence (GPC) rules
  - Necessary for pronouncing novel “pseudowords” (e.g., RINT)

- **Lexical Route** encodes whole-word spelling-sound correspondences
  - Necessary for overriding GPC rules to pronounce “exception” words (e.g., PINT)

- **Semantic Route** plays limited role

Connectionist framework for word reading

- Separate Semantic and Phonological pathways
- Entire system participates in processing all types of items

**Surface dyslexia**
- Normal pseudoword reading
- Regularize exception words

- **Phonological/Deep dyslexia**
  - Relatively intact word reading
  - Very poor pseudoword reading