Cognitive Neuroscience of Language: 12: The dyslexias

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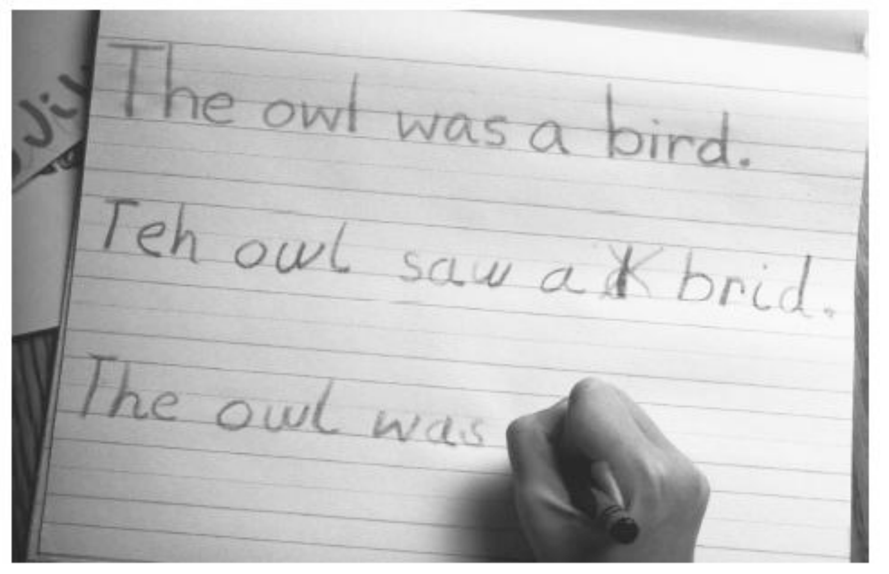
Goals



Understand the range of behaviours that characterize the (non-deep) dyslexias, and explore how such behaviours have been modelled

Reading

Bishop, D.V.M. & Snowling, M.J. (2004). Developmental dyslexia and specific language impairment: Same or different. *Psychological Bulletin,* 130, 858–886.

Dyslexias

5-10% of the population (Pennington, 2002)

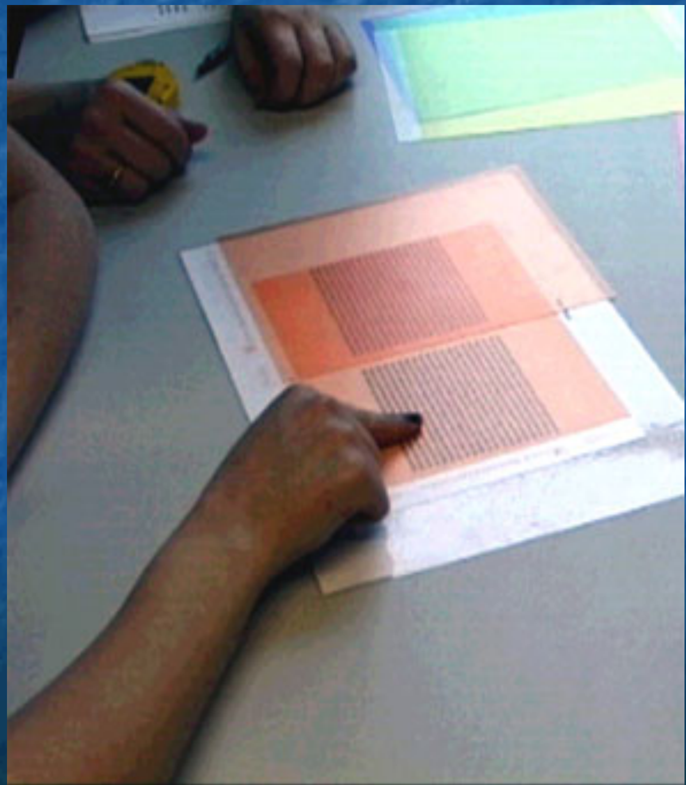
Proximal and distal causes (Jackson & Coltheart, 2001)

Double dissociation: if function *X* is impaired and function *Y* spared in one person, and *Y* impaired and *X* spared in another – see Shallice (1988) for a fuller discussion

Widespread agreement on phonological impairment (Adams, 1990; Bishop & Snowling, 2004)

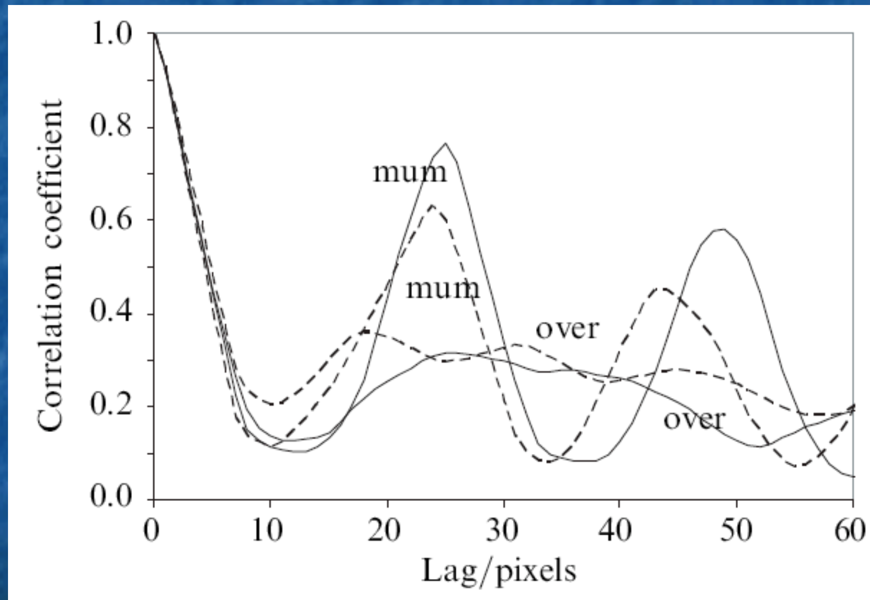
Visual stress

Some stimuli, including text, can cause cortical excitation, ameliorated by coloured overlays (Wilkins, 1995)



Visual stress

Autocorrelation predicts reading difficulty (Wilkins, 2008)



Suggested distal causes

Left hemispheric impairment (Shaywitz, *et al.*, 2003)

Cerebellar deficit (Nicholson *et al.*, 1990, 1999)

Magnocellular impairment (Livingstone *et al.*, 1991; Stein *et al.*, 1993; Lovegrove *et al.*, 1980; see, also, Ramus *et al.*, 2003)

N.B. High comorbidity (*c.f.* ADHD and dyslexia)

Simple delay (in the case of surface dyslexia) (Manis *et al.*, 1996)

Dyslexia and the hemispheres

- Hemispheric coordination/transfer (Geschwind & Galaburda, 1987; Orton, 1925); the LH should dominate the RH in reading
- Thus reading difficulties reflect an absence of asymmetry (Geschwind & Galaburda, 1986); *cf.* the planum temporale (Beaton, 1997)
- More left-handedness in dyslexics (Bishop, 1990)
- There are mixed reports of morphological differences in the corpus callosum
- Certain behaviours suggest callosal transfer problems in dyslexics

Callosal agenesis

Children with callosal agenesis present with phonological and other problems, resembling dyslexics (Mather, 2001; Temple & Ilsley, 1993)

Lateralised presentation of words

Redundant bilateral presentations in the RVF and LVF produce no bilateral gain for dyslexics (Henderson, Barca & Ellis, 2007)

The presence of the gain in normal readers suggests an initial *intra*hemispheric processing for parts of a word divided by the fixation, followed by *inter*hemispheric coordination/transfer

Surface and phonological dyslexia

Surface dyslexia: impaired reading of irregular words, which are typically regularized – pint rhyming with hint (Patterson *et al.*, 1985)

Phonological dyslexia: impaired reading of nonwords like nug (Beauvois & Dérouesné, 1979)

Surface dyslexia

Bub *et al.* (1985), patient MP

Nonword reading: Normal (100% correct)

Irregular word reading: Poor (Only 40% correct)

Regularisation errors:

flood → "flude"; *yacht* → "yatched"

Miscomprehensions of homophones:

stake → "meat – you can cook it on a BBQ"

Frequency by regularity interaction with impaired reading most for low frequency irregular words

Phonological dyslexia

Funnell (1983) Patient WB

Familiar words read better than unfamiliar:

Nouns: 93/100

Nonwords: 2/20

Errors to nonwords tended to be visually similar lexicalisations:

cobe → "comb"

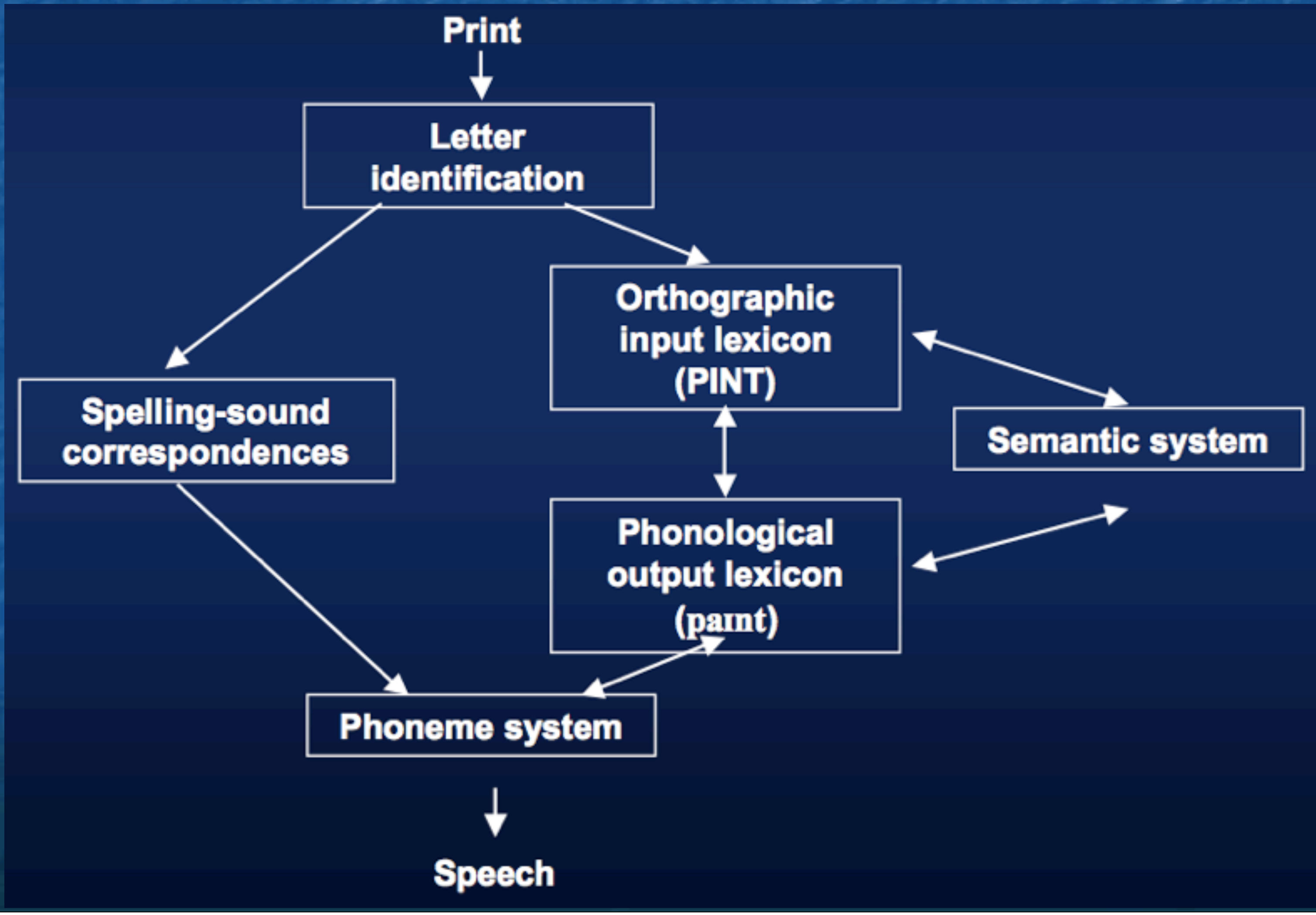
ploon → "spoon"

fude → "fudge"

Can name letters (h = "aitch") but not sounds of letters (h = "huh")

Dual-route model of reading

Coltheart *et al.* (1993)



Dual-Route Cascaded (DRC) model of reading

Coltheart *et al.* (1993, 2001)

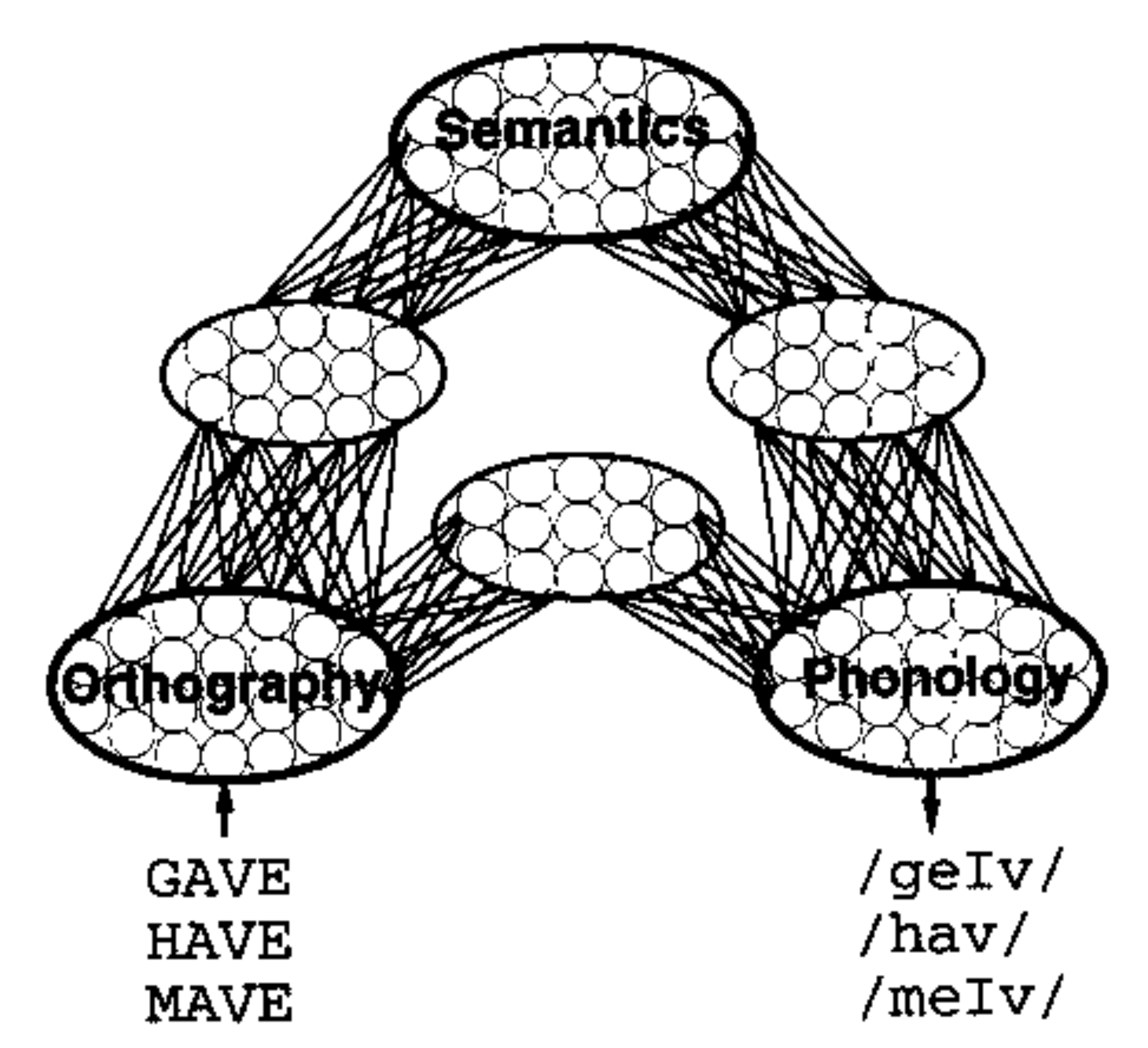
DRC originally implements the observation of a dissociation between the two dyslexias

It is now fully implemented (barring semantics)

Ii incorporates McLelland & Rumelhart's Interactive-Activation Model of word recognition at its initial features-letters-words stage

The two routes race each other to produce the pronunciation

Triangle model of reading



Seidenberg & McClelland (1989); Plaut, McClelland, Seidenberg, & Patterson (1996);

Connectionist modelling

Define the problem in input-output terms

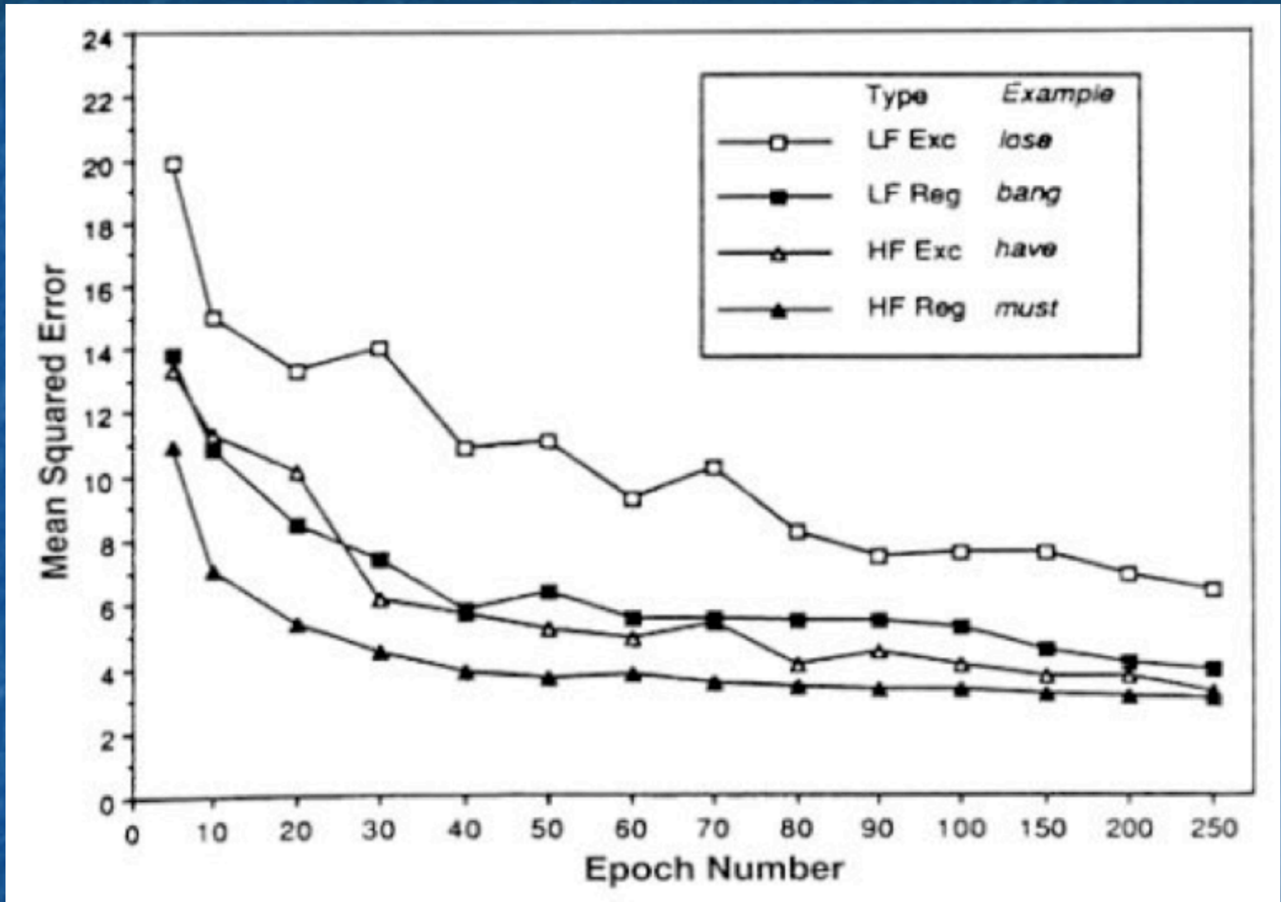
Train the model, changing the weights

A bottleneck in the architecture forces the model to encode generalizations

Freeze the weights

Test the network for generalization

Triangle model of reading



Normal readers find rare, irregular words harder to process, as do connectionist models

Triangle model of reading

Distributed representations, superpositional storage

Graded learning, reflecting problems that the normal population encounters

Interactivity and division of labour

“Carving nature at its joints” works; formal linguistic distinctions, such as onset, nucleus, coda, rime, are effective as inputs and outputs

… but such a connectionist account is also very abstract, particularly with respect to resource explanations of dyslexia

A “visual” account of dyslexia

Stein *et al.* (1993); Lovegrove *et al.* (1980)

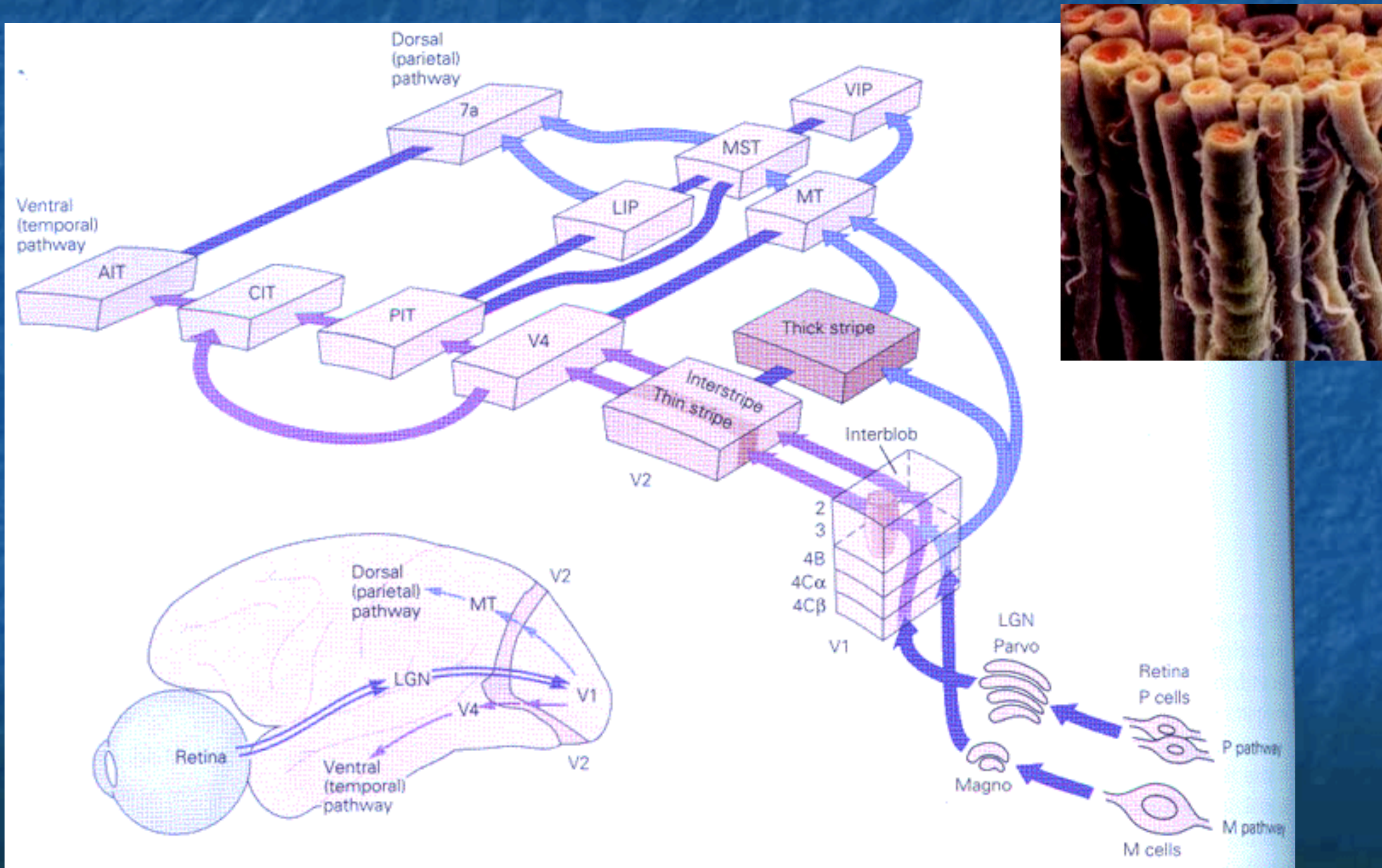
Post-mortem evidence of magnocellular (M-cell) impairment in some dyslexics

N.B. There are visual and auditory M-cells (*cf.* Tallal, 1980)

<u>Some</u> dyslexics show impaired processing of low-spatial frequency gratings

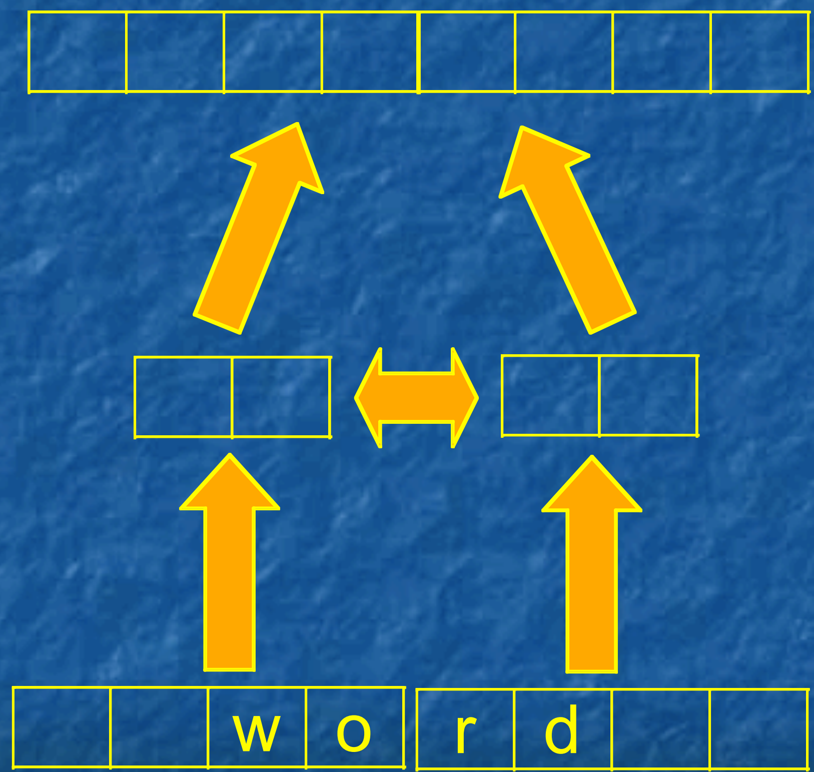
M and P cell pathways

Mishkin & Ungerleider (1982)

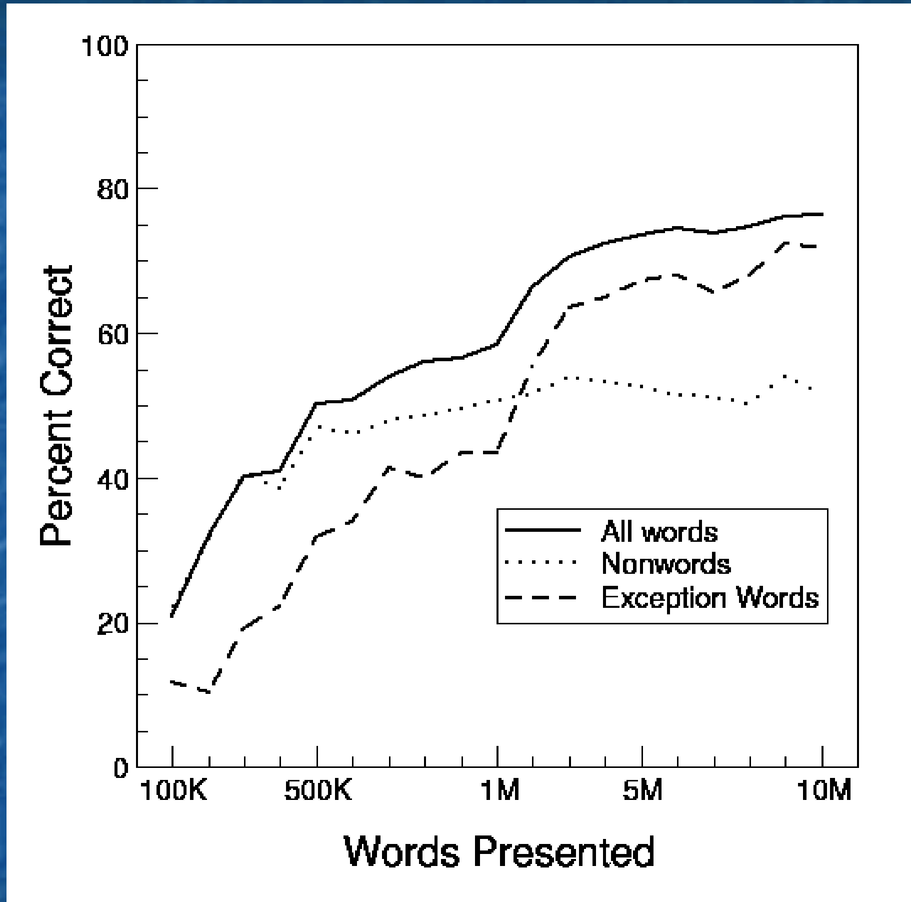


The split fovea model

Shillcock, Ellison & Monaghan (2000)



The split fovea model



The training of the model captures the developmental data from Manis *et al.* (1996)

Consistency in pronunciation

Jared, McCrae & Seidenberg (1990)

-ile (*pile, mile, rile, bile, stile, tile, …*)

-ave (*cave, rave, save, … have*)

-ove (*love … prove … cove*)

Peereman & Content (1997)

"Phonographic neighbours" share most of the orthography and phonology of a word and facilitate naming

A shared rime is critical

“Dysfluent” surface dyslexia

Marshall & Newcombe (1973)

Patient MP

Errors on exception words

Some regularization errors, also “visual” errors

Also errors on regular words

Errors not frequency sensitive

Nonword reading impaired

Latencies abnormally long

Semantics is largely intact

“Fluent” surface dyslexia

Marshall & Newcombe (1973)

Patient JC

Errors on exception words

Errors almost all regularizations

Very accurate on regular words

Errors are frequency sensitive

Nonword reading is accurate

Latencies within normal limits

Semantics is grossly impaired

... or "pure" surface dyslexia

Castles & Coltheart (1996)

MI (ten years old) has a high IQ, no known neurological problems, and very poor performance on irregular/exception words

He is normal reading nonwords and regular words

He seems normal regarding phonological awareness and visual memory

Such "pure" surface is not readily generated by connectionist models of dyslexia

Effects of imageabiltiy

Strain, Patterson & Seidenberg (1995)

Low frequency irregularly pronounced words (*yacht*) show effects of imageability

There therefore appear to be semantic effects

Dyslexia and binocularity

Monocular reading can ameliorate dyslexia (Stein *et al.* 2000); binocular instability may contribute to dyslexia

Frequently, binocular fixations are not conjoint in normal reading; dyslexics may be less good at depth percpetion

There are little-understood, task-specific ocular dominances in play in reading

Dyslexic comorbidities may be complex

Conclusions

Connectionist models provide scope for varied patterns of impairment, but may need further (possibly anatomical) constraints

Even then, deficits are not robustly "pure" (but, then, neither are the observed behaviours)

Interaction with semantics may afford more scope for connectionist modelling

Causal argumentation needs to be subtle