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Understanding Reading , Understanding Writing

Kathy Rastle

Royal Holloway, University of London



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@kathy_rastle
www.rastlelab.com



“language at the speed of sight”

Seidenberg, 2017

What is writing?



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Writing is a representation of spoken language; “rendering spoken language into a form that can be reconstructed by other humans separated by space or time.” (*Wikipedia*)

But writing isn't the same as spoken language.

Writing is not the same as spoken language



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Es ging auf Mitternacht zu, der Premierminister saß allein in seinem Büro und las einen langen Bericht, der ihm durch den Kopf strich, ohne den geringsten Sinn zu hinterlassen. Er wartete auf den Anruf des Präsidenten eines fernen Landes, und während er überlegte, wann der elende Mensch sich endlich melden würde, und zugleich unangenehme Erinnerungen an eine sehr lange, ermüdende und schwierige Woche zu unterdrücken suchte, konnte er kaum noch an etwas anderes den-

J.K. Rowling

- Writing is in some ways highly impoverished relative to spoken language...
- But it offers different forms of information: e.g. spacing, case, line breaks, disambiguating characters, semantic classifiers

I'm Nobody! Who are you?

Are you - Nobody - too?

Then there's a pair of us!

Don't tell! they'd advertise - you know!

How dreary - to be - Somebody!

How public - like a Frog -

To tell one's name - the livelong June -

To an admiring Bog!

Emily Dickinson

Writing is not the same as spoken language



...southerly veering westerly or south-westerly, 5 or 6, occasionally 7 later, slight or moderate occasionally rough later, rain then showers, moderate or good, north
utsire southerly veering westerly or south-westerly, 4 or 5, increasing 6 at times,
slight or moderate, rain then showers, good, occasionally poor at first, south utsire
southerly veering westerly ...

Writing is not the same as spoken language



<i>Sea area</i>	<i>Wind</i>		<i>Sea state</i>	<i>Weather</i>	<i>Visibility</i>
	<i>Direction</i>	<i>Speed (knots)</i>			
Viking	Southerly veering westerly or south-westerly	5 or 6, occasionally 7 later	Slight or moderate, occasionally rough later	Rain then showers	Moderate or good
North Utsire	Southerly veering westerly or south-westerly	4 or 5, increasing 6 at times	Slight or moderate	Rain then showers	Good, occasionally poor at first
South Utsire	Southerly veering westerly or south-westerly	4 or 5, increasing 6 at times	Slight or moderate	Rain then showers	Good, occasionally poor at first

Writing is not the same as spoken language



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Bloody school tomorrow!
Going back tonight ... or tomorrow
morning?
Tomorrow morning .
What early?
I'm gonna have to get up at four. Get home
by seven .
Have you hurt your eyes ?
Yeah . Rubbing it ... Got eyelash in my eye .
.. I get a funny twitch in it . The nerve goes
, phew {laugh} It's horrible when it
{laughing} A bit dodgy !

Bergen Corpus of London
Teenage Language (1993)

Deep in the forest a call was
sounding, and as often as he heard
this call, mysteriously thrilling and
luring, he felt compelled to turn his
back upon the fire and the beaten
earth around it, and to plunge into
the forest, and on and on, he knew
not where or why; nor did he
wonder where or why, the call
sounding imperiously, deep in the
forest.

Jack London
The Call of the Wild

The efficiency of reading allows this incredible quantity of
information to be packed into text!

Writing is not the same as spoken language



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- 1200 English children's books (70m tokens)
- Over 100,000 unique words
- Most frequent 100 words take up 55% of the whole corpus (e.g. the, with, a ...)
- The other ~99,900 words do not occur very frequently
- Over 20% of words do not occur on British television (probably unfamiliar)

7-9 years



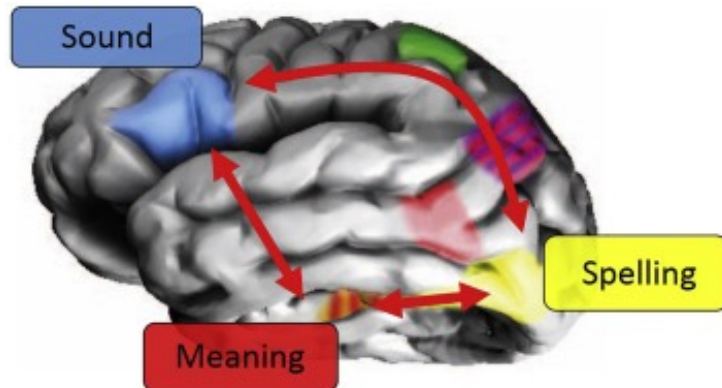
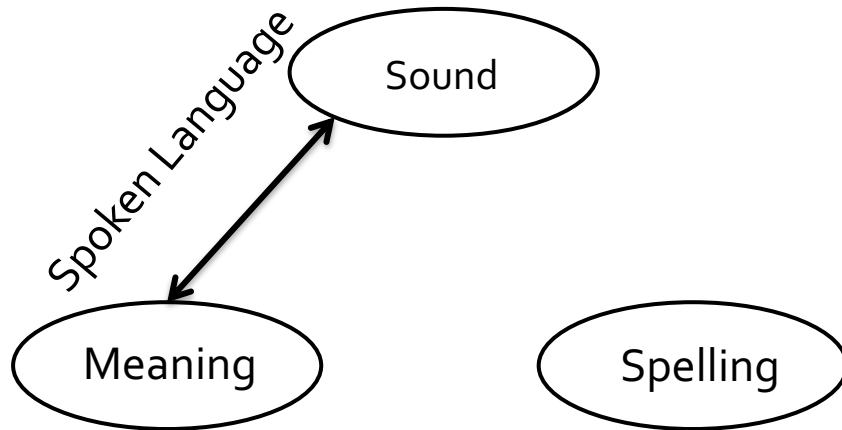
10-12 years



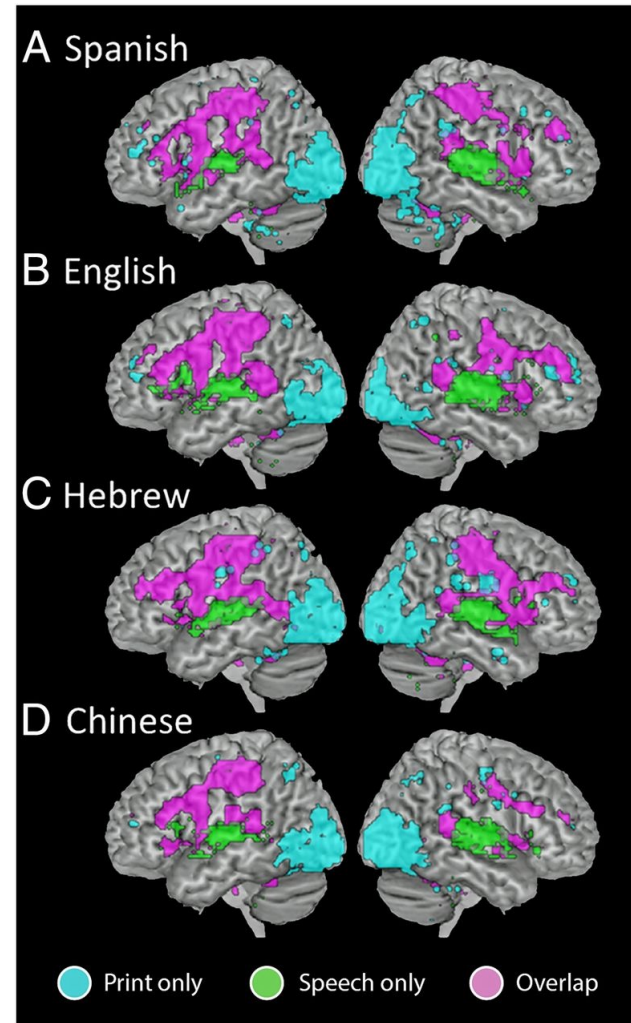
13+ years



The basic challenge of reading



Rastle, 2019, Cortex



Rueckl et al., 2015, PNAS



This carriage is beautiful

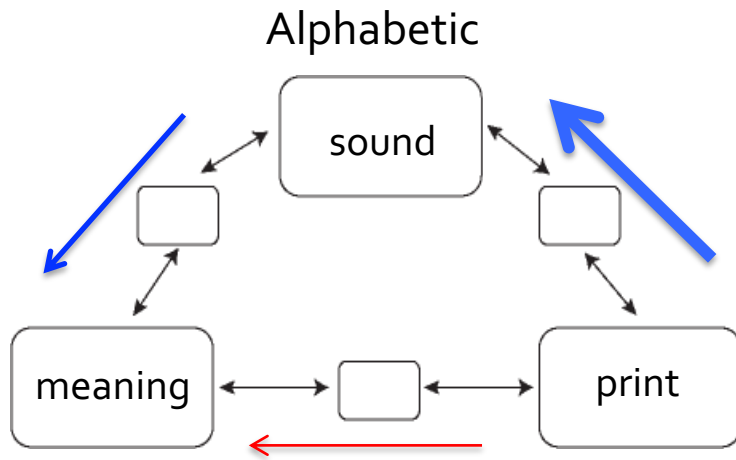
這馬車很漂亮

- Nature of the mapping
- Parafoveal preview and skipping
- Precision of position coding

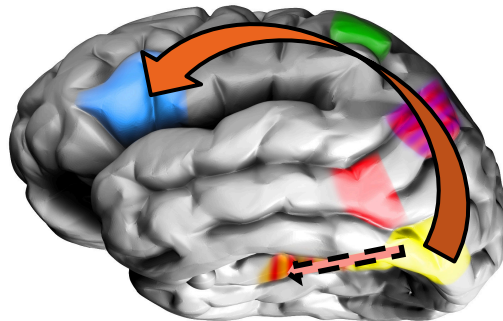
המרכבה יפה

This carriage is beautiful

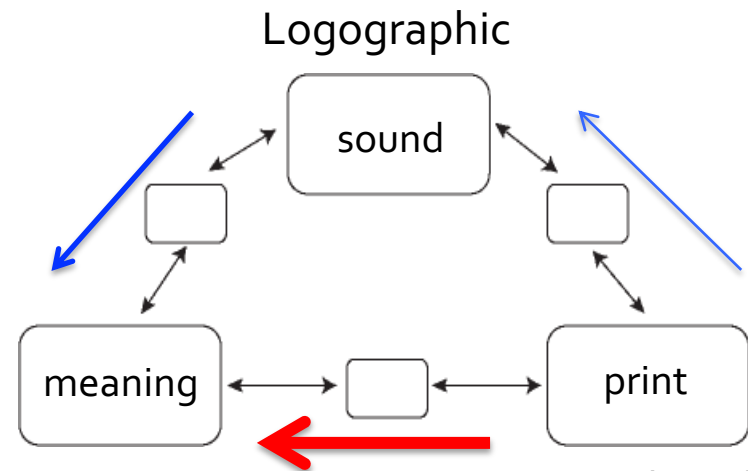
Pathways to reading for meaning in different writing systems



Dorsal pathway

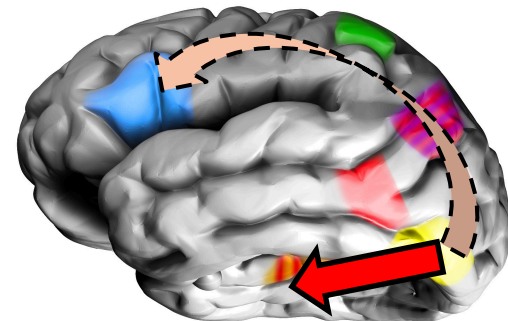


Ventral pathway



Smith et al., 2015

Dorsal pathway



Ventral pathway

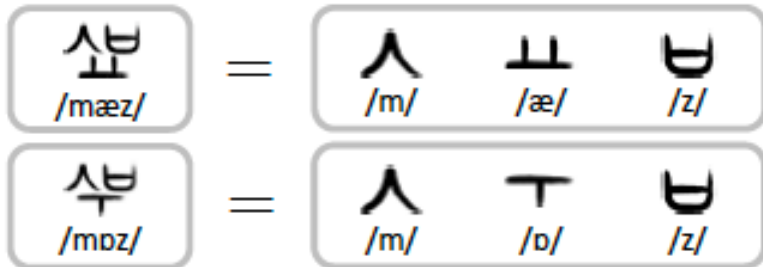
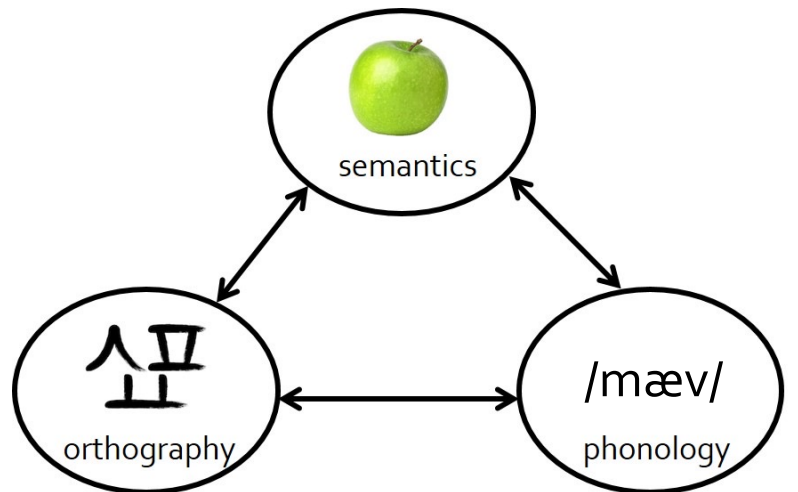
Taylor et al., 2023

Simulation study: Method



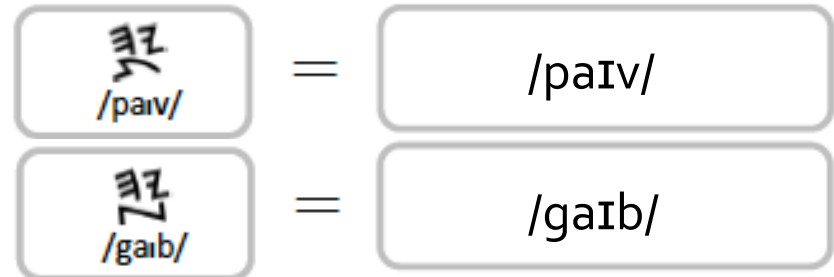
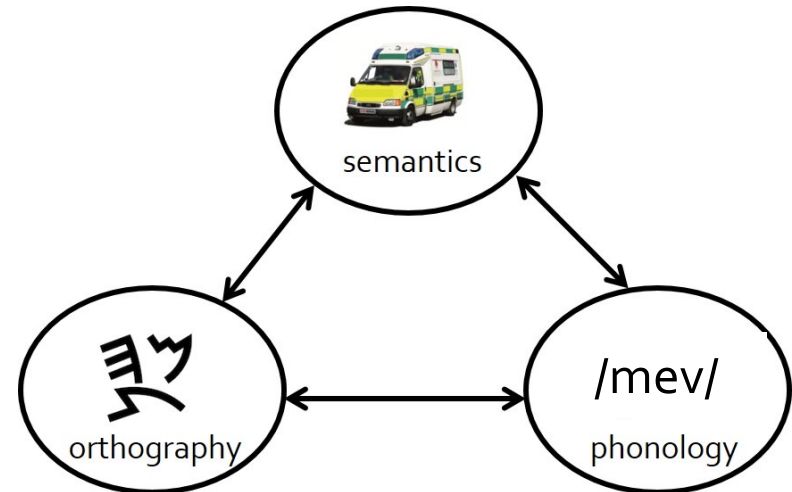
Alphabetic

Systematic mapping between symbols and sounds across items



Logographic

Arbitrary mapping between symbols and sounds across items



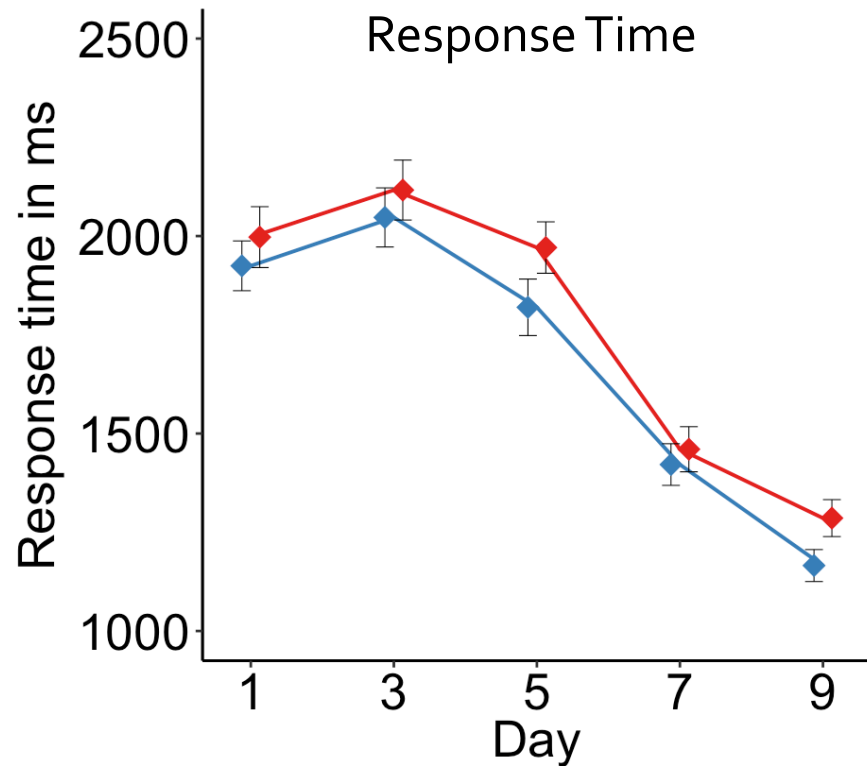
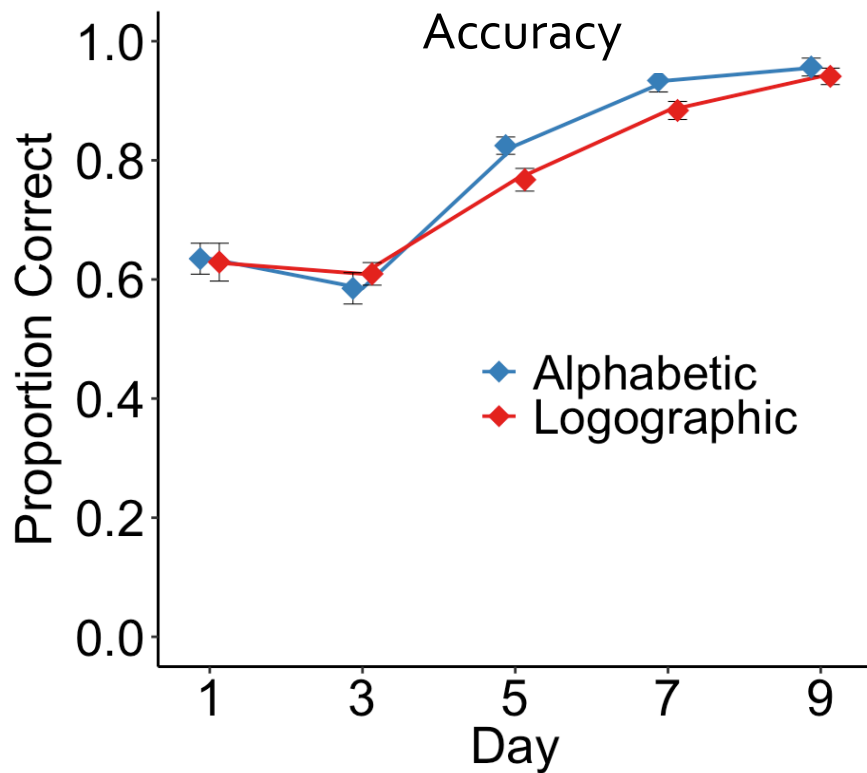
24 English speaking adults learned to read in both writing systems over 9 days (2 hours / day)

Behavioural & fMRI test on Day 10

Simulation study: Picture naming results



/mæv/

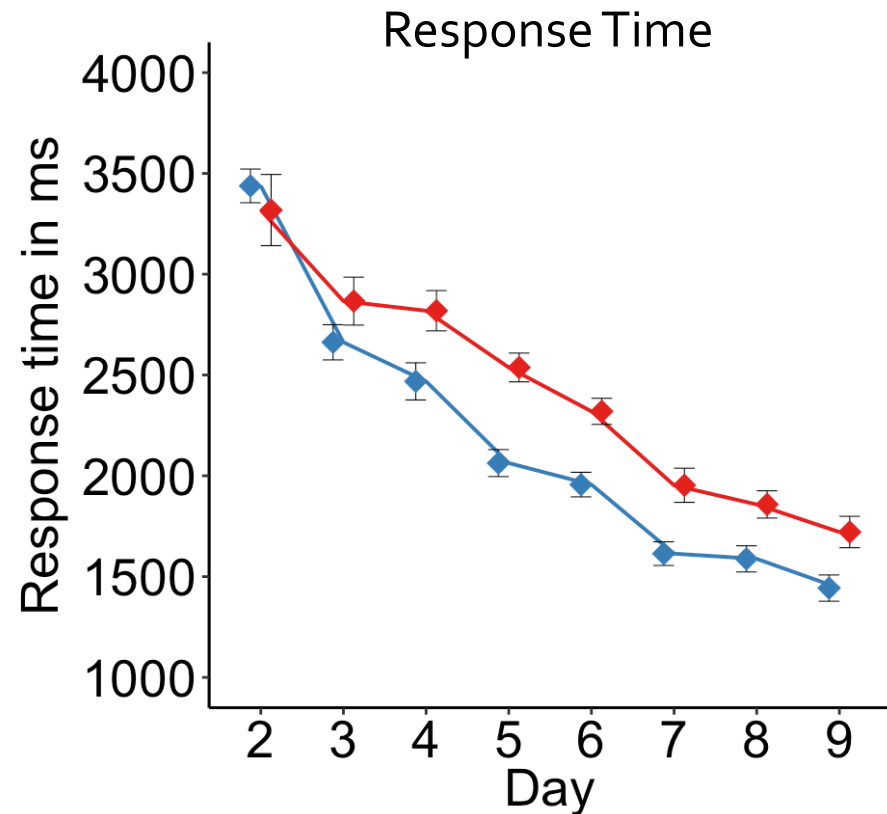
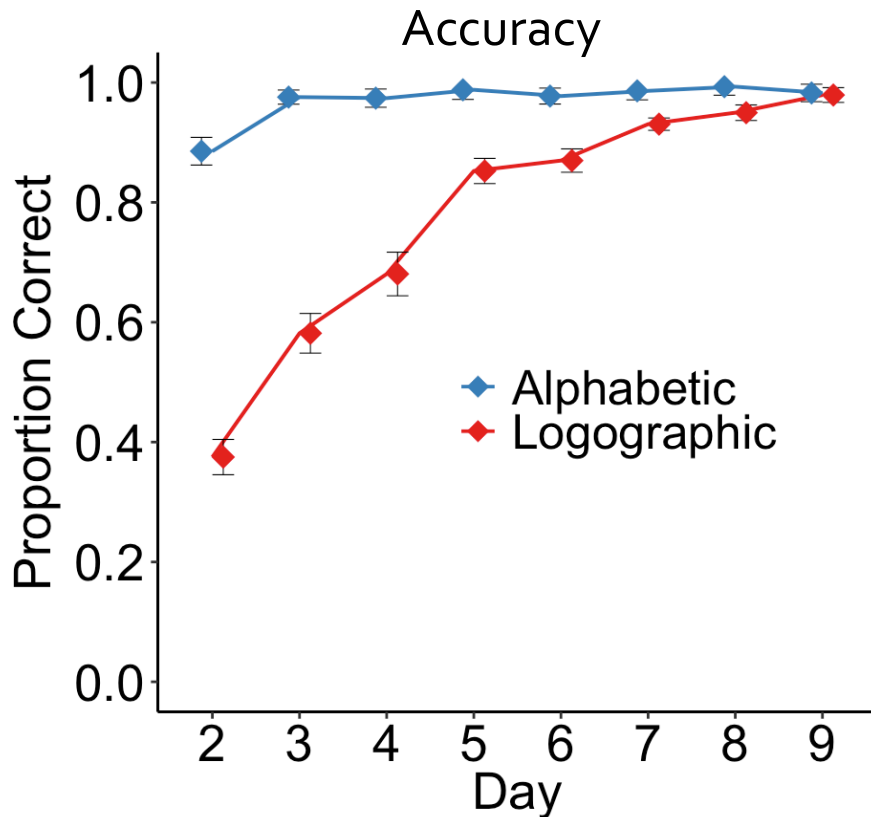


No impact of writing system on spoken vocabulary learning; pattern maintained at test.

Simulation study: Reading aloud results



ㅁㅍ → /mæv/

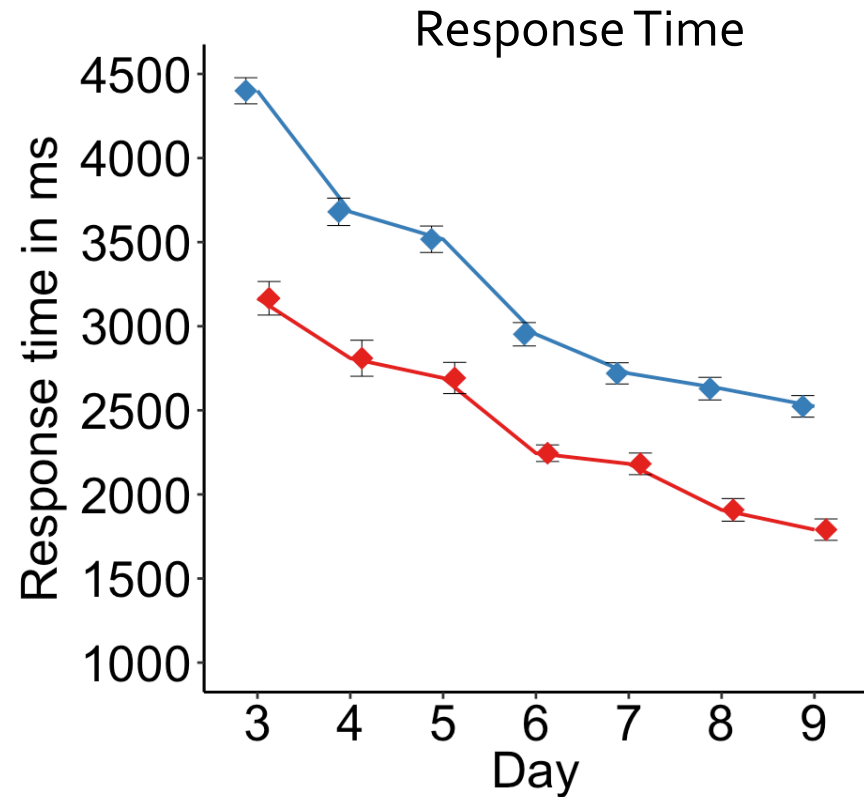
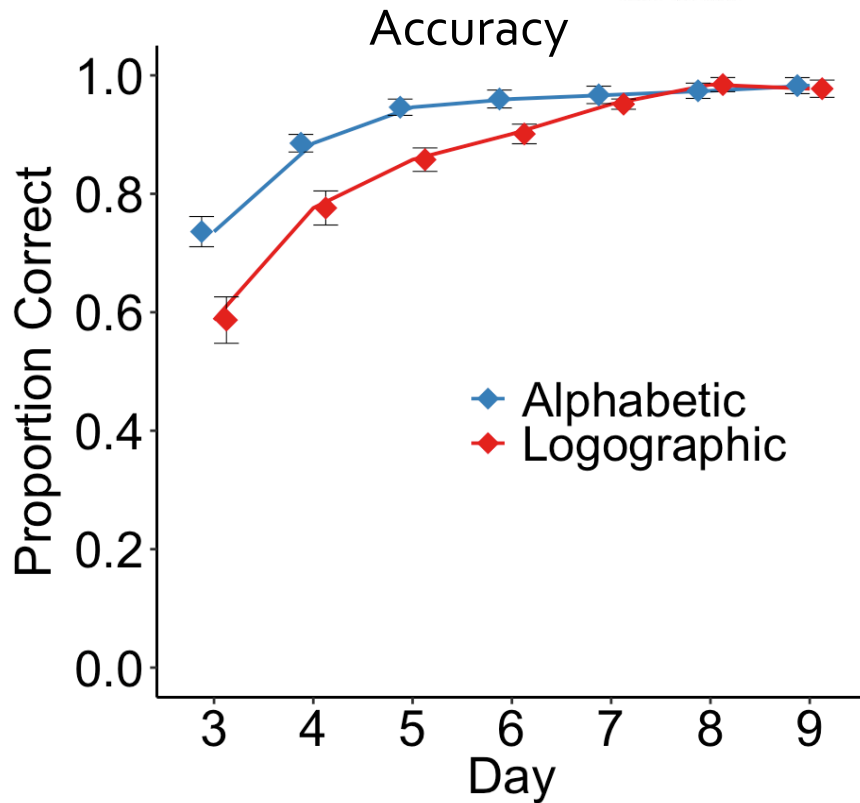


Faster and more accurate for alphabetic system during training;
pattern maintained at test

Simulation study: Saying meaning results



애플 → "apple"



Early accuracy advantage for alphabetic system but faster for logographic system; maintained at test.

Simulation study: fMRI results



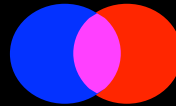
Fruit?

싹



$p < .001$ uncorrected, $p < .05$ cluster corrected

alphabetic > rest



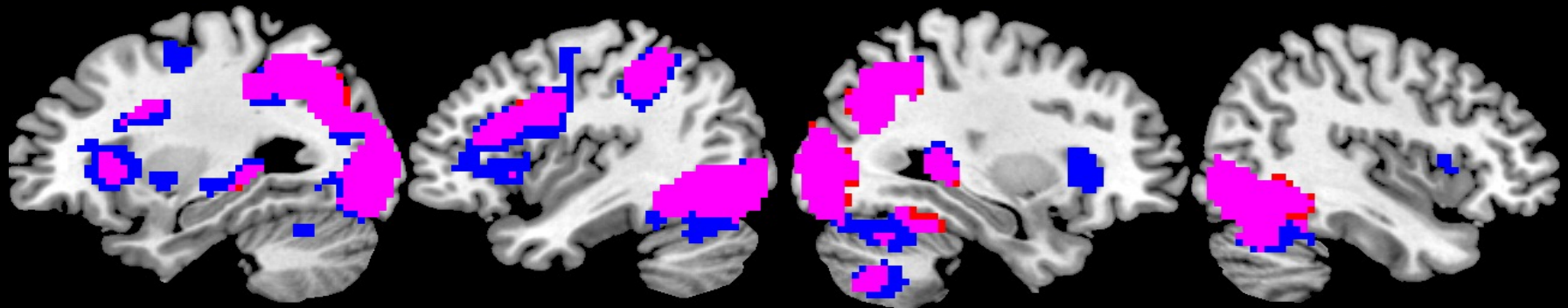
logographic > rest

-40

-30

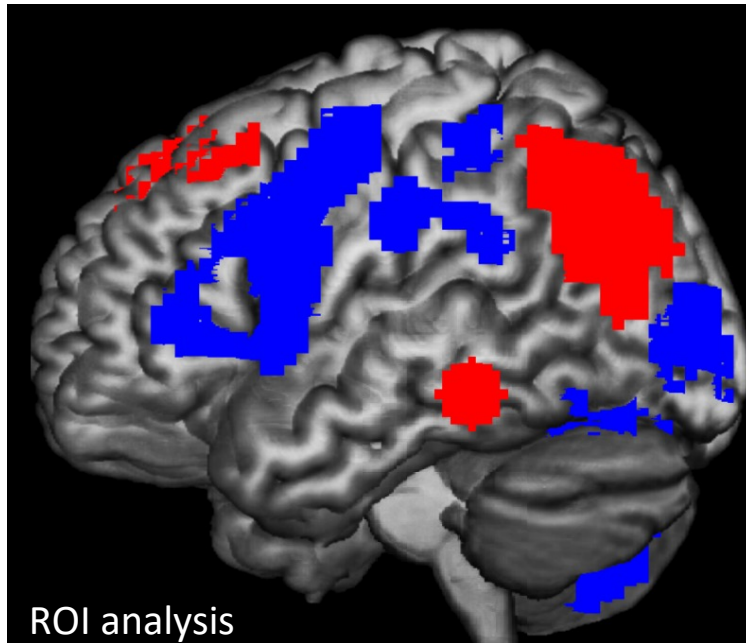
+30

+40

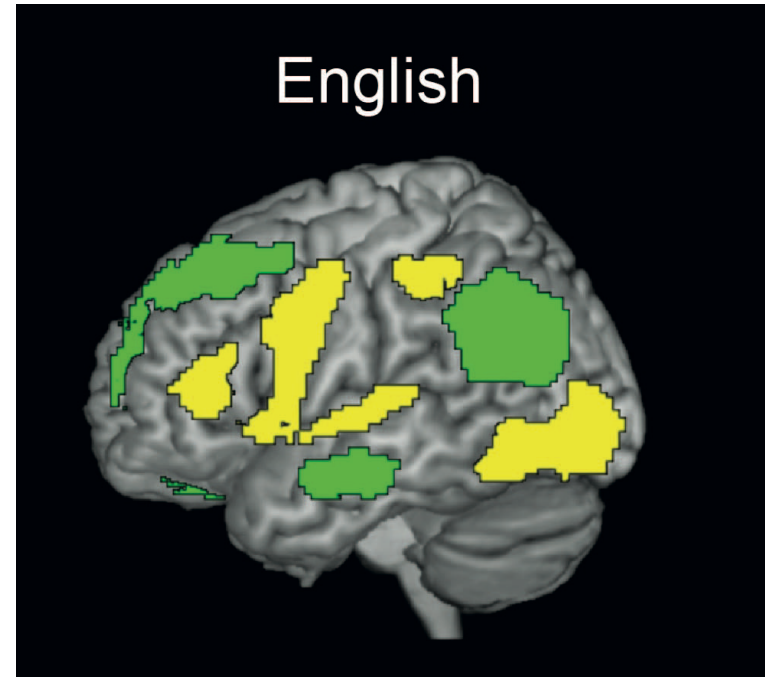


Participants using the reading network to read the artificial systems

Simulation study: fMRI results



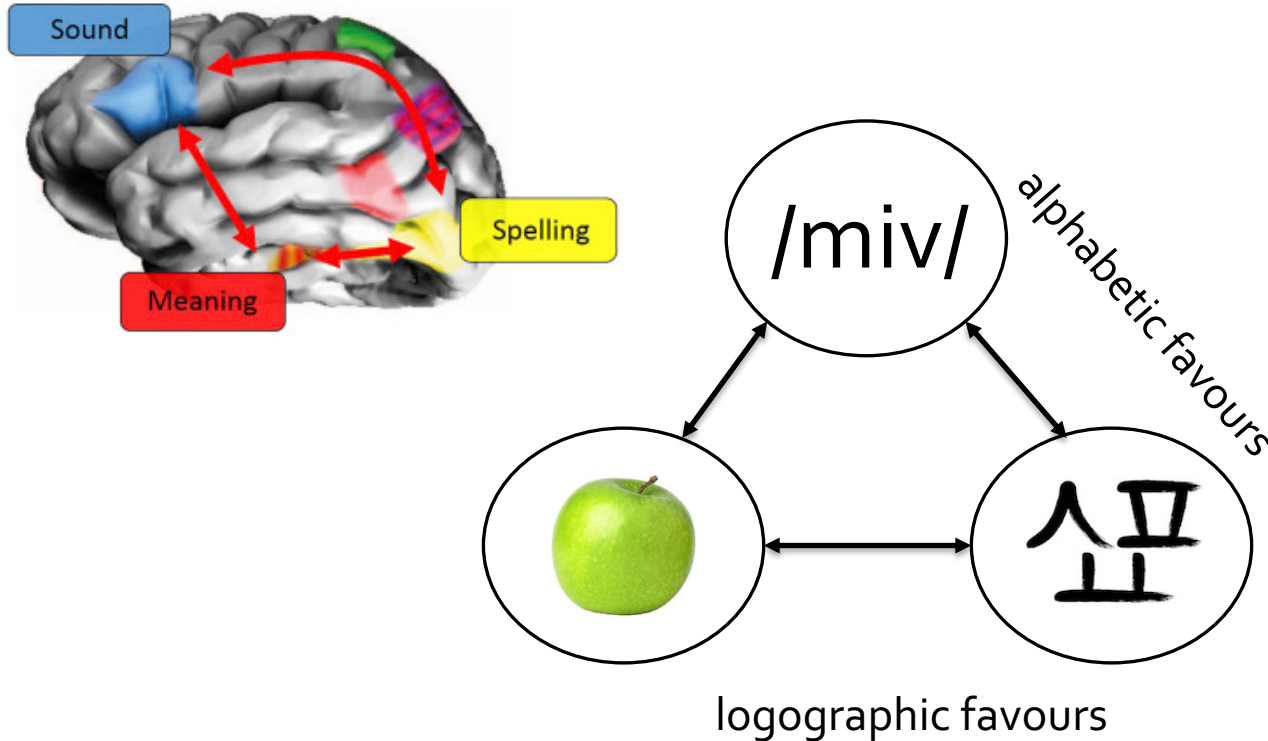
- Blue square: Alphabetic > Logographic
- Red square: Logographic > Alphabetic



- Yellow square: Nonword > Word
- Green square: Word > Nonword

Alphabetic favours subword spelling-sound information
Logographic favours whole word lexical-semantic information

Simulation study: conclusions

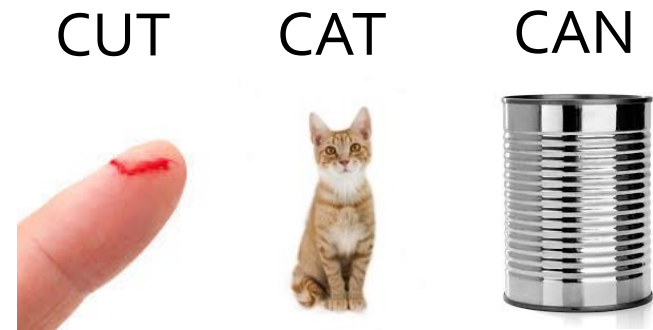
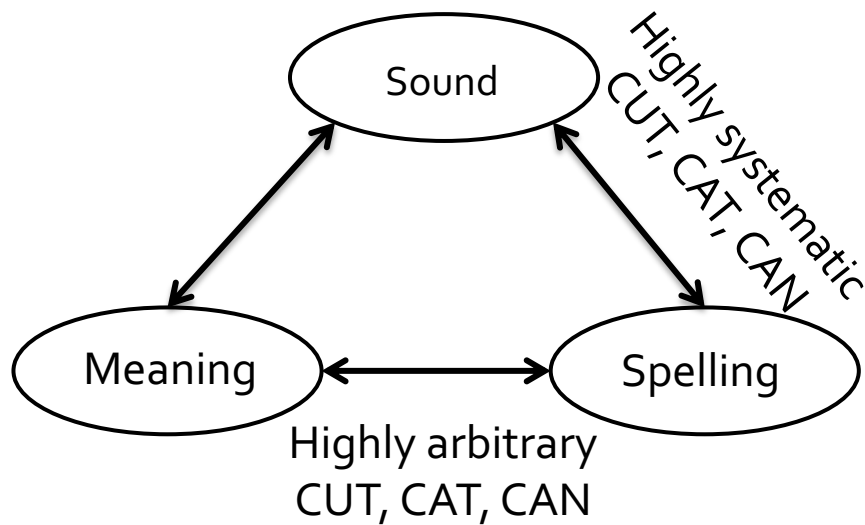


How the brain learns to read depends on nature of information in the writing system.

Reading acquisition in alphabetic systems



Over 70% of research based on English and French



Reading comprehension = decoding + oral language

Reading acquisition in alphabetic systems



Shallow

Deep



Serbian

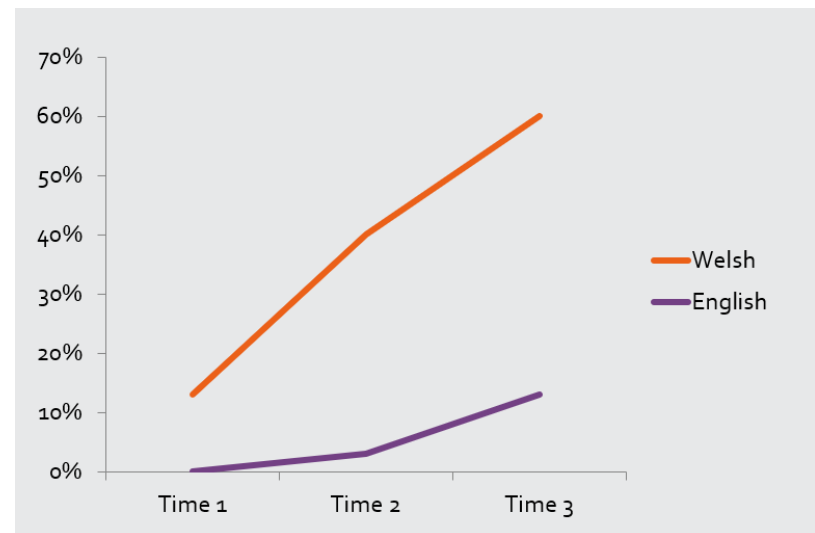
one symbol-one sound
no exceptions

French, Italian, Dutch...

English

one symbol-to-many sounds
many symbols-to-one sound
many exceptions

Language	Reading Accuracy
Austrian	97%
German	98%
Norwegian	92%
Icelandic	94%
Swedish	95%
Dutch	95%
Danish	71%
English	34%





09:08 Sun 18 Apr

85%

THE SUNDAY TIMES

NEWS | NEWS

New spelling rools to make English more predictable for pupils

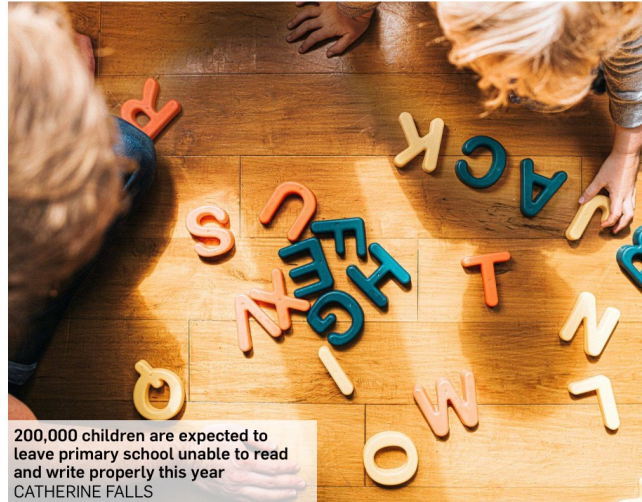
Sian Griffiths, Education Editor

“We shall fight on the beaches, we shall fight on the landing grounds, we shall fight in the feelds and in the streets, we shall fight in the hills; we shall never surrender...”

This is how Churchill’s famous speech should be spelt, according to reformers who have voted on a new system after deliberating for nearly three years.

The new system, Traditional Spelling Revised (TSR), will now be promoted in the hope that if it gains support “it will eventually become the new norm, thereby accelerating access to literacy,” the International English Spelling Congress said.

The congress was set up by The English Spelling Society, a UK-based group that has campaigned to “repair our broken spelling” for 113 years, and the American Literacy Council. The society argues that English



200,000 children are expected to leave primary school unable to read and write properly this year
CATHERINE FALLS

spelling has been so “chopped and changed” by invaders, scribes and printers over the centuries that the result is “crazy”.

Owing to its irregularity, English spelling takes up to three years longer to master at

primary school than other languages, according to the society. This year 200,000 children are expected to leave primary school unable to read and write properly, many because they have never mastered spelling.

Stephen Linstead, the former civil servant who designed the new system, says it is “a handicap that can stay with them for life”.

TSR changes up to 18 per cent of words in the language: wash becomes wosh, love is luv and educate becomes eddicate. Linstead said the result is as predictable as modern French spelling and will ease the burden of tens of thousands of children.

The system was selected from a shortlist of six put forward by an expert commission. Among other simplifications it eliminates silent letters such as the w in wrong and the g in gnash and cuts irregular spellings to just 60.

Jack Bovill, chairman of the English Spelling Society, said: “Parents on the front line teaching their children over the pandemic at home will have become familiar with how difficult it can be to teach English spelling.”

“The highly irregular English spelling system has significant economic and social costs compared with those of other languages. The search has gone on for many years to find

English spelling needs reform



Initial Teaching Alphabet (ITA)

Consonants

b	c	d	f	g	h	j	k	l	m	n
b	k	d	f	g	h	dʒ	k	l	m	n
bib	cake	dad	fife	gag	hat	judge	kick	lull	mime	noon
<hr/>										
ŋ	p	r	s	ʒ	t	v	w	y	z	ʒ
ŋ	p	r	s	z	t	v	w	j	z	ʒ
sing	pipe	roar	sauce	is	tot	valve	will	yes	zoo	vision

Joined consonants

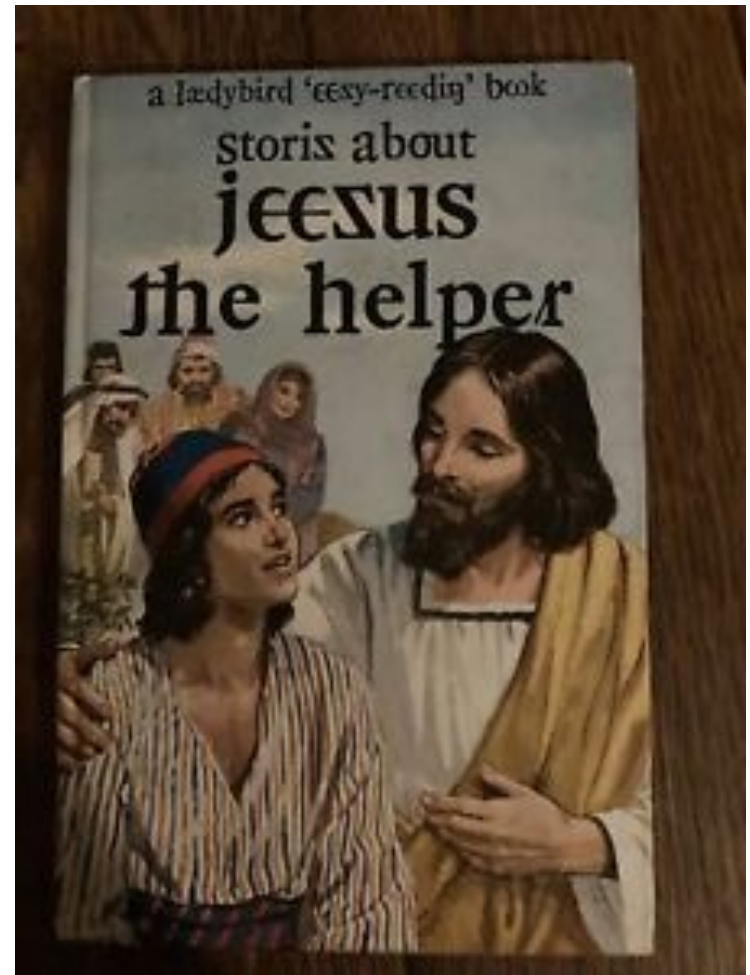
Short vowels

ch	sh	th	th	wh	a	e	i	o	u	ω
tʃ	ʃ	θ	ð	ɹ	æ	ɛ	ɪ	ɒ	ʌ	ʊ
church	shush	thin	then	whale	at	egg	in	odd	up	book

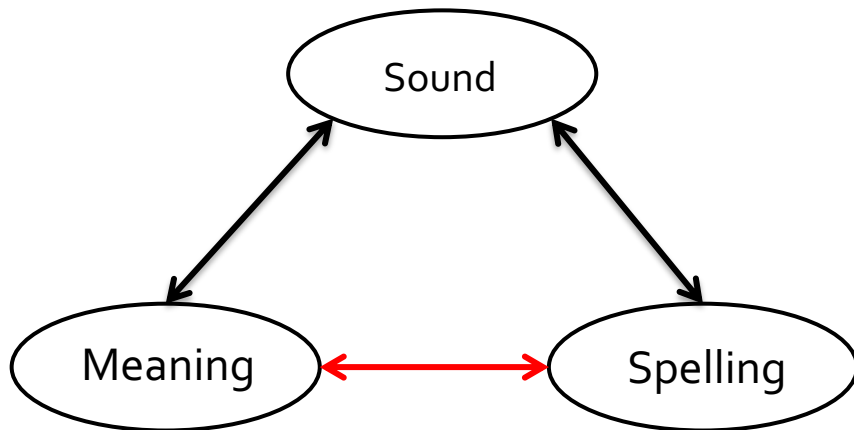
Long vowels / diphthongs

ɑ	æ	au	ɛɛ	œ	ω	ue	ie	oi	ou
ɑː	eɪ	ɔː	iː	oʊ	uː	juː	aɪ	ɔɪ	aʊ
father	ape	all	eat	oak	ooze	use	ice	oil	owl

Also, **ŕ** is used following a vowel letter to write the sound in "earn" etc



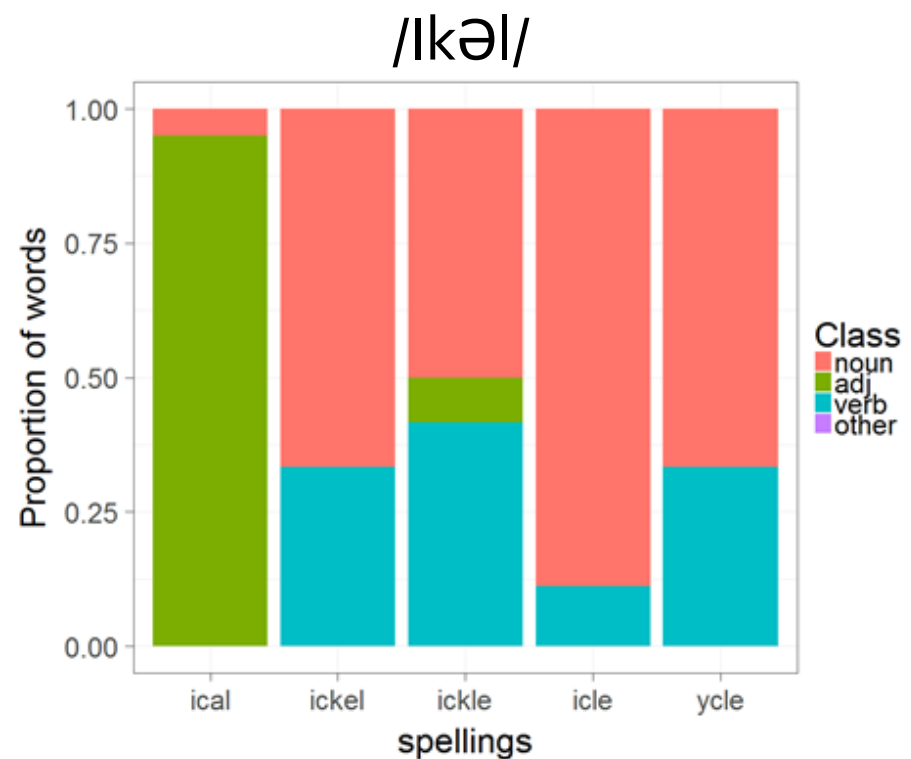
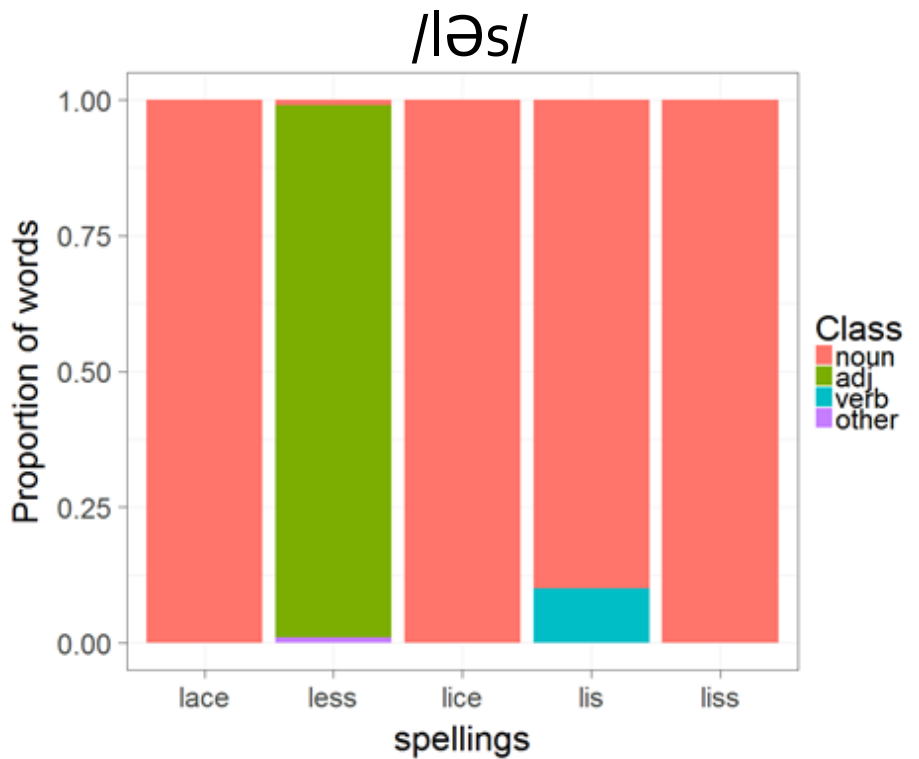
There's more to English spelling!



Initial experiences with short words with a single morpheme; but most words are complex

- Morphemes are “islands of regularity” in spelling-meaning mapping
 - Stems (e.g. unclean, cleaner, cleanly)
 - Affixes (e.g. teacherer, builderer, cleanerer)
- Trade-off between spelling-sound and spelling-meaning regularity (e.g. busted, snored, kicked vs bustid, snord, kict).

Meaningful information in English spelling

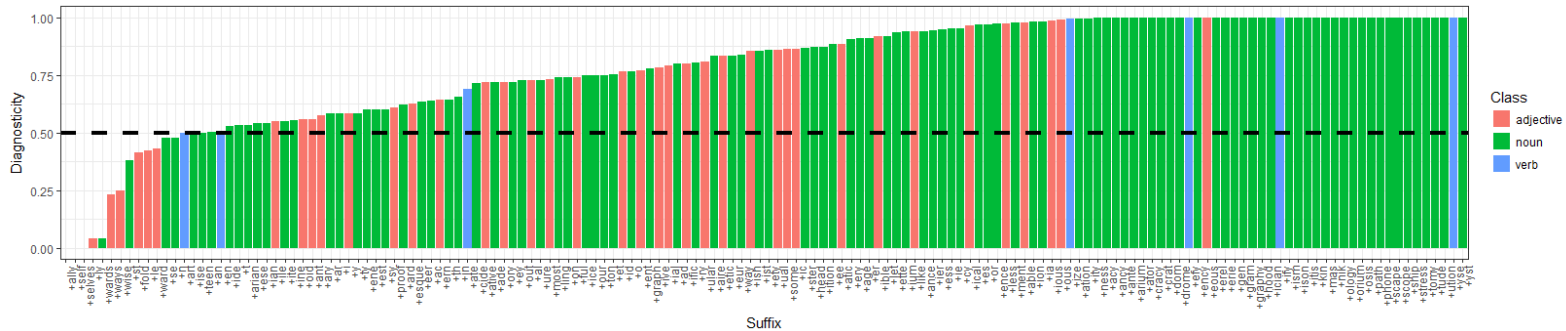


- Letter clusters in English become “reserved” for communicating meaning
- Information not available in spoken language

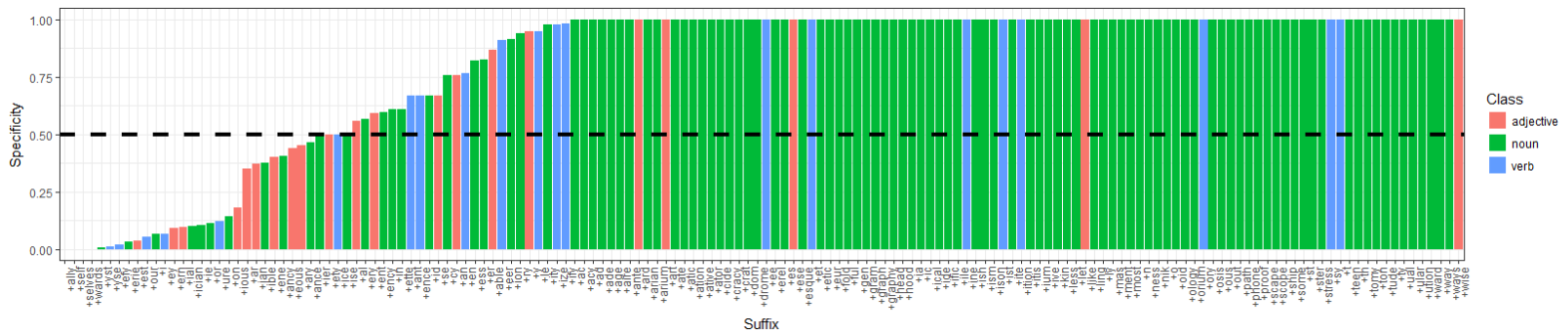


Meaningful information is *highly visible* in English spelling

Most English suffix spellings are highly diagnostic of grammatical category



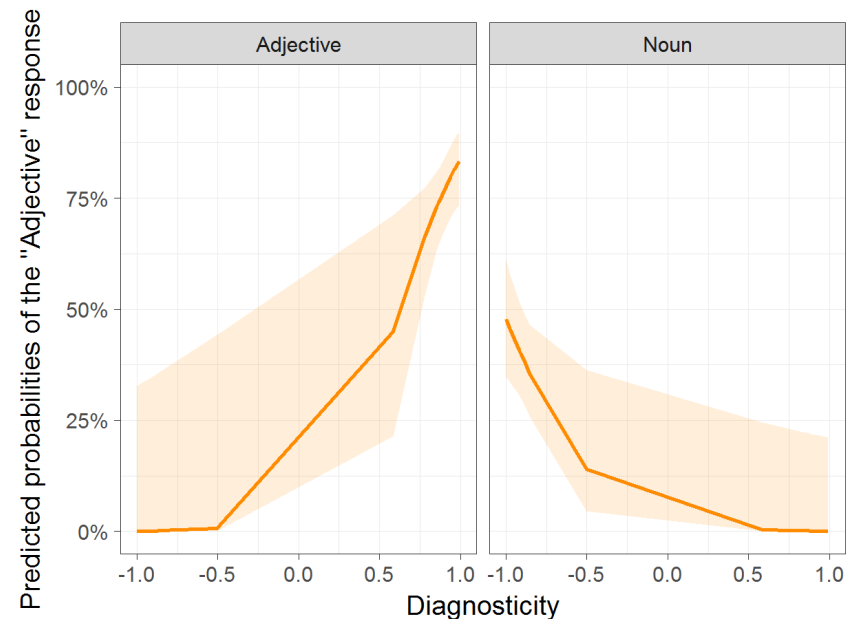
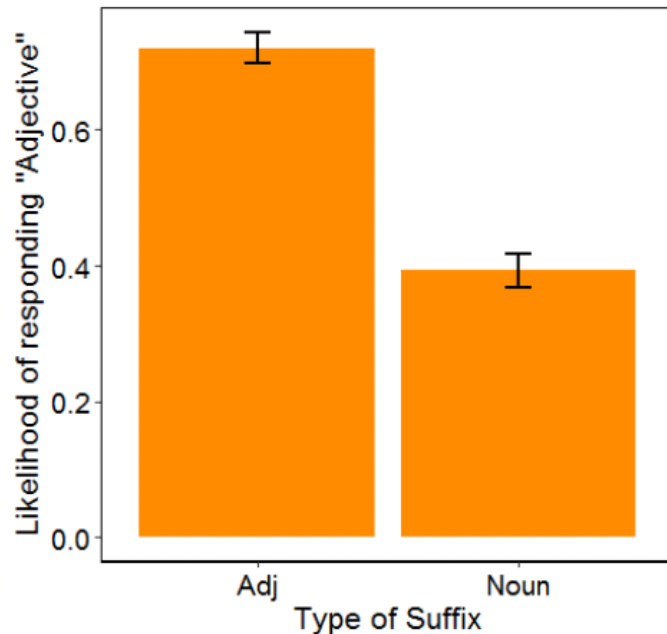
Most English suffix spellings provide the *only* means of expressing a sound sequence for a particular grammatical category



Sensitivity to meaningful information



Is it an adjective or noun?
DOMOUS, JIXLET, TERISH, RABNESS ...



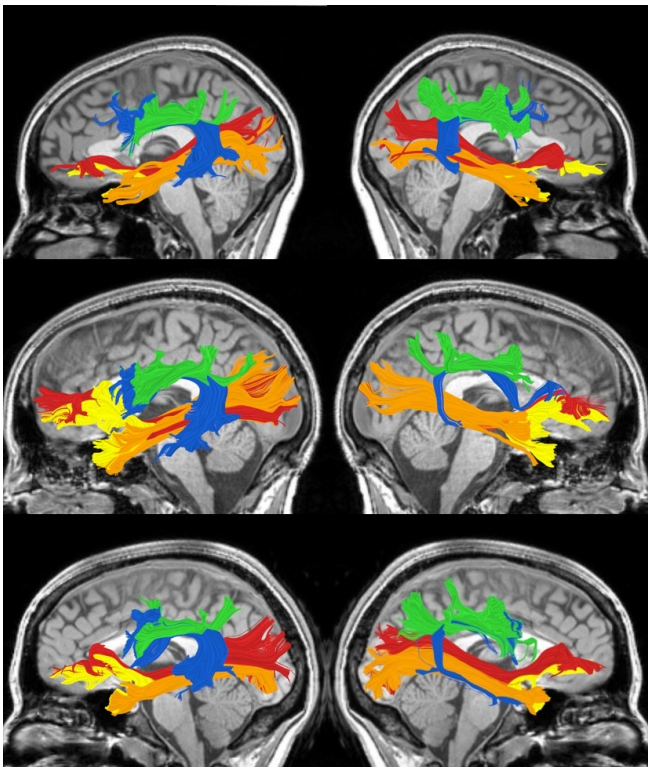
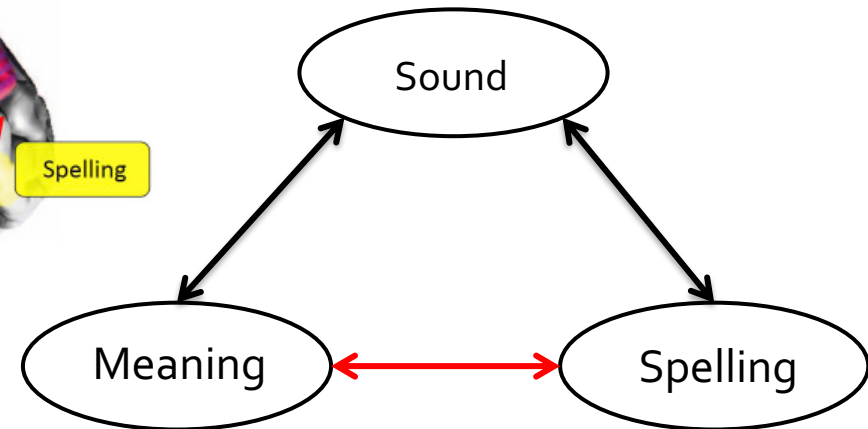
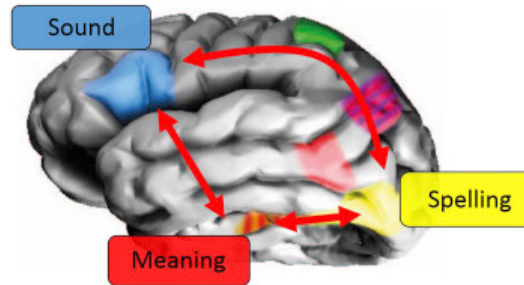
- Explicit knowledge of object / property / act status, linked to strength of cue
- Knowledge superior for adults with higher vocabulary & spelling
- Similar, graded effects in eye-tracking and spelling

Spelling-meaning knowledge mirrors the writing system

Sensitivity to meaningful information



- IFOF
- ILF
- UF
- AF fronto-temporal
- AF fronto-parietal

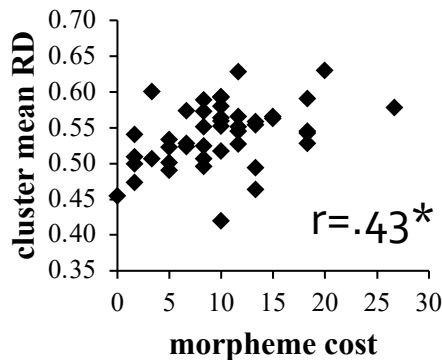


- Behavioural measure of sensitivity to morpheme information in adults (N=45)
- Significant correlations with diffusion properties in all **ventral** tracts in left hemisphere
- Relationship remains after controlling for phonological processing (nonword repetition and nonword reading aloud)

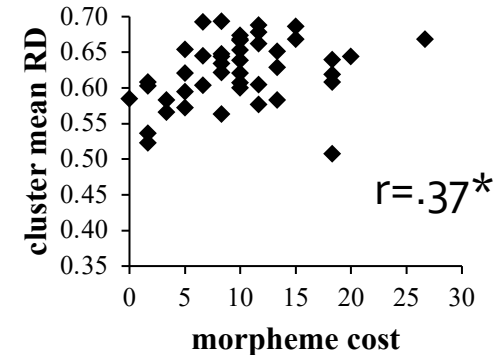
Sensitivity to meaningful information



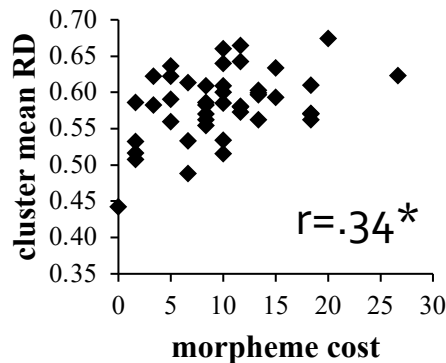
Left IFOF



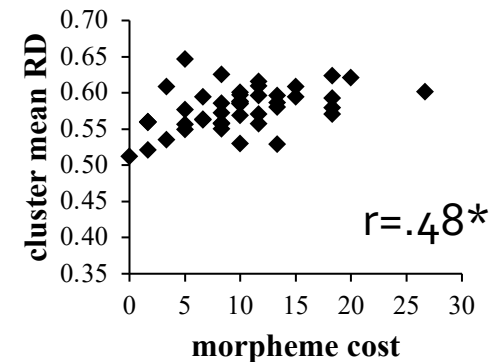
Left ILF



Right IFOF

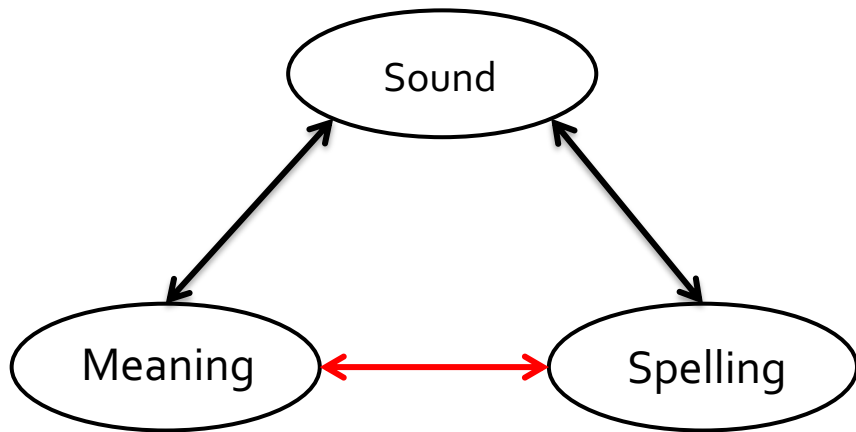


Left UF



Variation in morphological knowledge in adults associated with diffusion properties of ventral white matter pathway; consistent with work using MEG and fMRI

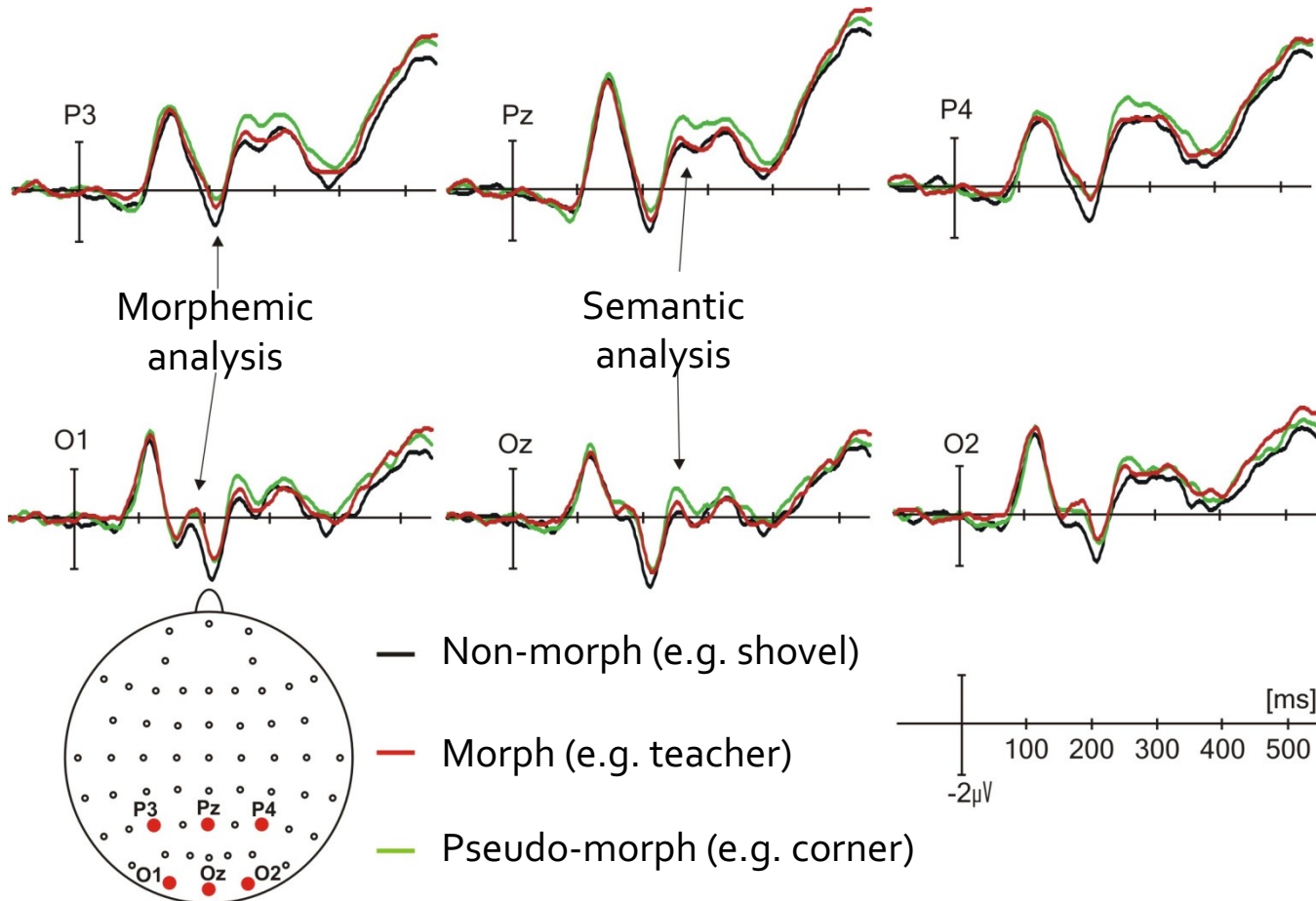
Link to rapid, skilled reading



- Dramatically reduces the learning challenge (~70,000 English words -> ~11,000 base words).
- Skilled readers use this information for very rapid, superficial analysis of meaning (also, corner and quickify)
- Hidden information; would be lost through spelling reform.

develop
develop s
develop ing
develop ed
develop er s
un develop ed
un develop able
develop able
develop ment
develop ment al
develop ment al ly
anti develop ment
re develop
pre develop
pre develop ment

Rapid morpheme segmentation in reading



- Rapid morphological analysis ~190 ms; sublexical
- Semantic analysis / integration ~250 ms
- Converging evidence from priming tasks
- Dependent on reader skill and experience

Rapid, superficial analysis; only possible because of nature of the writing system

Is writing “optimal” for reading?



“Every language gets the writing system it deserves.”

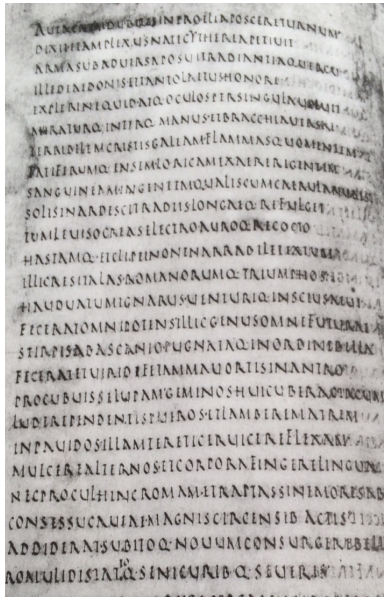
(Halliday; Mattingly; Frost, Seidenberg)

“Every writing system ... is a living, breathing organism that must adapt to the ever-changing needs of its users, their culture, and the technology of communication.” (Share, 2012)

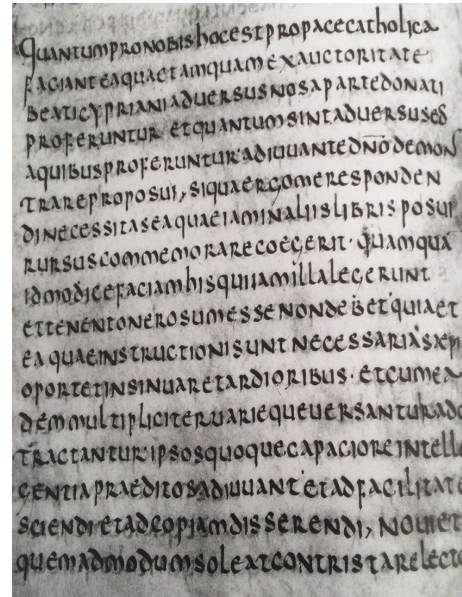
“Writing systems evolve to provide *optimal* information by weighting the need for maximal cues about the spoken words and their specific meanings while using minimal orthographic load.” (Frost, 2012)

“The writing systems that have survived support comprehension about equally well. Reading comprehension is a constant that is maintained via trade-offs between orthographic complexity ... and spoken language complexity.” (Seidenberg, 2011)

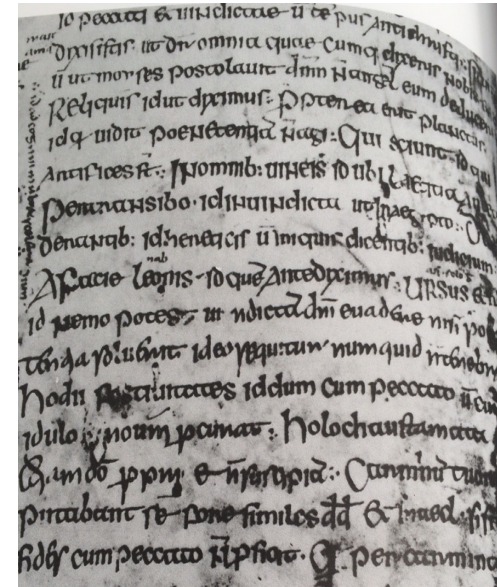
Writing (and reading) across timescales



Italy, 5th
century



Spain, 7th
century



Ireland, 7th
century

Innovations in writing allowed us to do something different with reading; and the increasing efficiency of reading allowed us to do more with writing (??)



Helsinki Corpus of English Texts

Band	Number of texts	Number of tokens	Number of types	Number of lexemes
Before 1150	150	395,524	49,506	3461
1150-1500	144	595,310	58,416	8433
1500-1710	138	530,965	35,501	9717

helsinki.corpus.arts.gla.ac.uk

besenes
besines
besinesse
bessyness
besynes
besyness
besynesse
bisines
bisynes
bisynesse
buisnesse
buisness
busenes
business
business
businessse
bussines
busynes
bysynesse



- Writing is a form of information that allows us to experience language through the visual modality.
- Spoken language is represented through writing but written language carries different information to spoken language.
- The way that the brain learns to read depends on the writing system; the reading system is a mirror of the writing system.
- Understanding the nature of writing and its relationship to spoken language is at the heart of understanding our capacity for rapid, skilled reading.



Maria Korochkina, Jon Carr, Anastasiya Lopukhina, Ana Ulicheva, Jo Taylor, David Crepaldi, Jakke Tamminen, Betty Mousikou, Clare Lally, Sam McCormick, Maria Ktori, Nicky Dawson, Adam Jowett, Benedetta Cevoli, Chloe Newbury, Becky Crowley, Oxana Grosseck



The Leverhulme Trust



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