Comparing and validating methods of reading instruction using behavioural and neural findings in an artificial orthography

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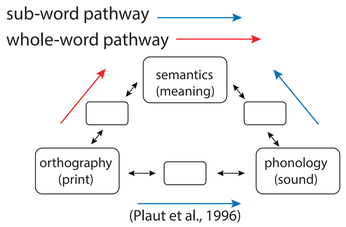
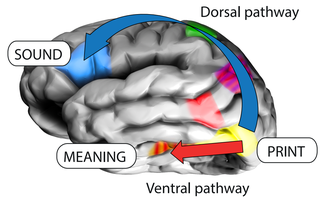
1. Background

Models of reading: Two ways to comprehend print



(Plaut et al., 1996)

Corroborated by brain imaging data



(Taylor, Rastle, & Davis, 2013)

Behavioural Questions (Box 4)

How does training focused on print–sound vs. print–meaning mappings impact on reading aloud and reading comprehension?

Neuroimaging Questions (Boxes 3 and 5)

Does initial learning of print–sound vs. print–meaning mappings depend on different systems?

Does training focus change reliance on these systems?

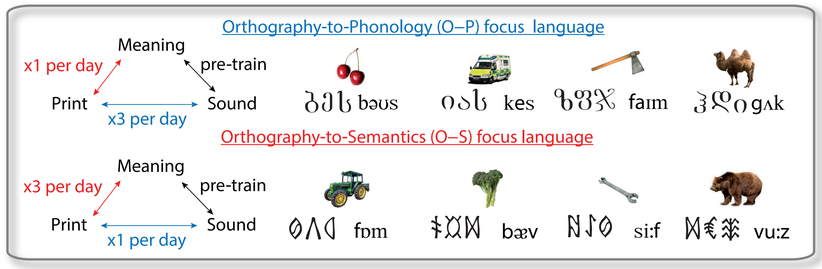
2. Method

24 adults each learn to read two different artificial orthographies, each consisting of 24 novel words

Manipulate focus of training within subjects:

Orthography-to-Phonology focus: for one orthography, more training on systematic print–sound mappings

Orthography-to-Semantics focus: for other orthography, more training on arbitrary print–meaning mappings



Training procedure

Task Details

Pre-exposure Sound–Meaning

See → Say "gʌk"
Hear "faɪm" → Say "axe"

Day 0
MRI Scan 1
Learn O–P mappings
Learn O–S mappings

Sparse imaging design - silent intervals between scans

Training Trials	Recall Trials
O–P: See Hear "fɒm"	See Say "gʌk"
O–S: See Hear "camel"	See Say "tractor"

Days 1-4 and 6-9

Print-to-sound tasks
O–P focus language x3 per day
O–S focus language x1 per day

Reading aloud: See Say "fɒm"
Spelling: Hear "fɒm" Select
Rhyme Judgement: Hear "lɒm" Select

Print-to-meaning tasks
O–S focus language x3 per day
O–P focus language x1 per day

Comprehension: See Say "camel"
Orthographic Choice: See Select from all 24
Semantic Categorisation: See Select odd-one-out
vehicle animal animal

Days 5 and 10
Test Sessions

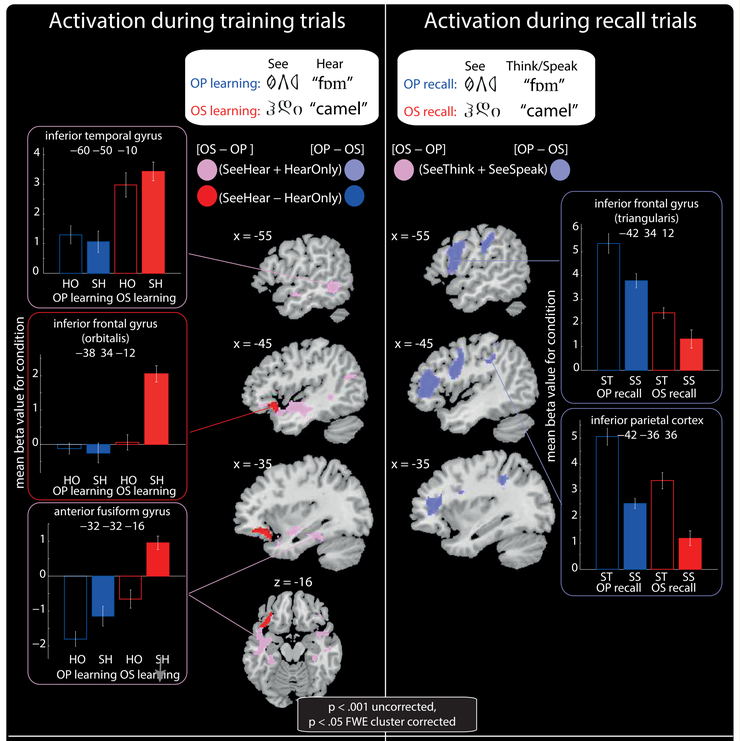
Day 11
MRI Scan 2
Reading aloud
Saying meanings
English word reading

Sparse imaging design - silent intervals between scans

O–P: See Think/Say "fɒm" O–S: See Think/Say "gʌk"
O–S: See Think/Say "camel" O–P: See Think/Say "tractor"

Read aloud English words and pseudowords

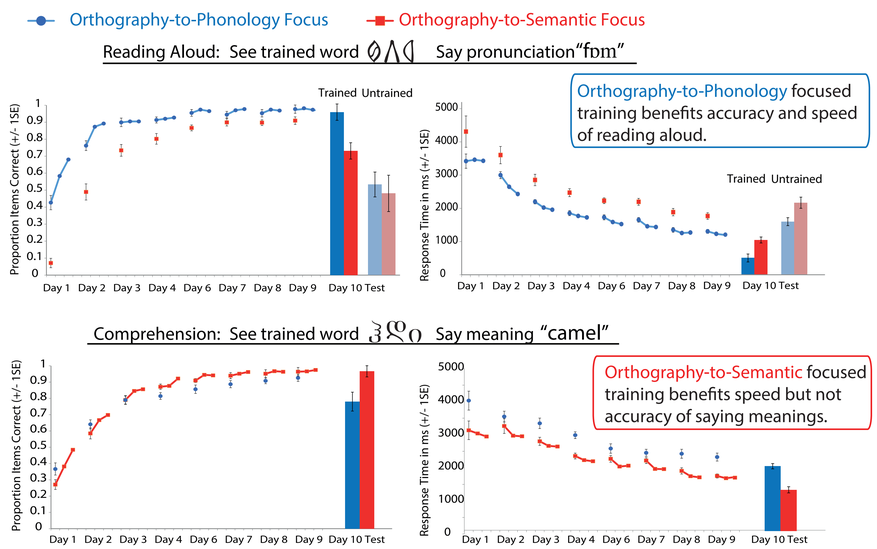
3. Brain activity during initial learning (MRI Scan 1)



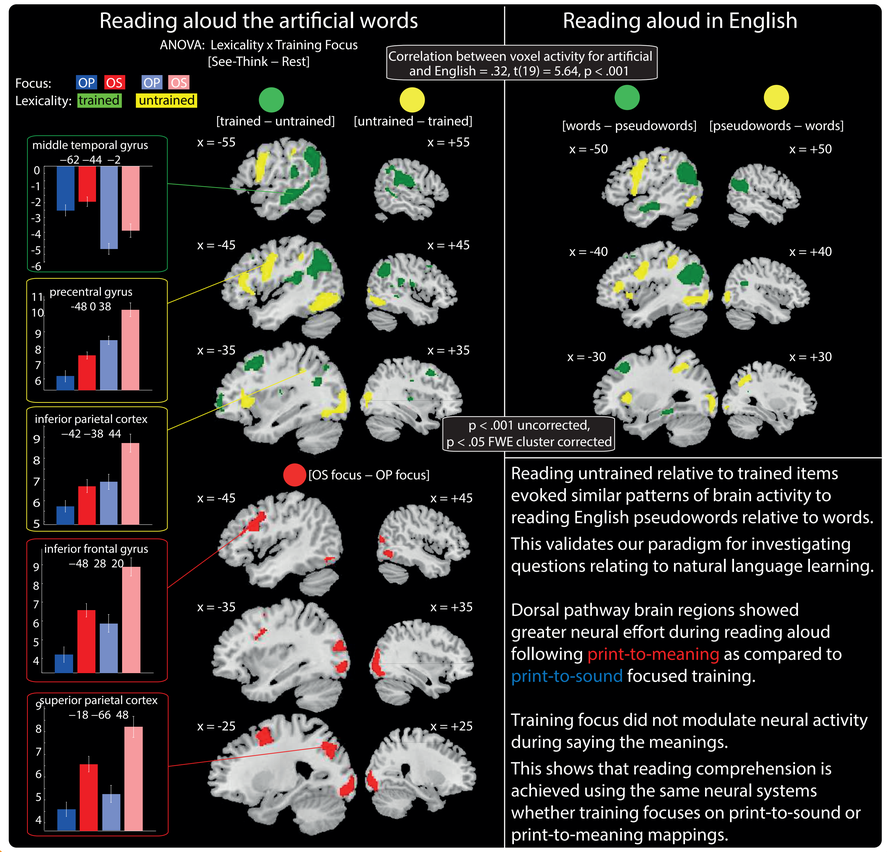
During training trials, left IFG orbitalis and anterior fusiform were more active for learning meanings than pronunciations.
No brain areas were more active for learning pronunciations than meanings.

Conversely, left IFG triangularis and inferior parietal cortex were more active for recalling pronununciations than meanings.
No brain areas were more active for recalling meanings than pronunciations.

4. Learning to read aloud and comprehend



5. Brain activity at the end of training (MRI Scan 2)



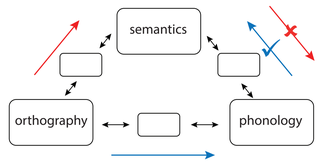
Reading untrained relative to trained items evoked similar patterns of brain activity to reading English pseudowords relative to words.
This validates our paradigm for investigating questions relating to natural language learning.

Dorsal pathway brain regions showed greater neural effort during reading aloud following print-to-meaning as compared to print-to-sound focused training.

Training focus did not modulate neural activity during saying the meanings.
This shows that reading comprehension is achieved using the same neural systems whether training focuses on print-to-sound or print-to-meaning mappings.

6. Conclusions

Asymmetric benefits of print–sound and print–meaning training



Print–sound training was beneficial for both reading aloud and comprehension.
Print–meaning training was a slower way to learn to comprehend and was detrimental for learning to read aloud as well as generalising to untrained words.

Neuroimaging data extend this by showing that, during reading aloud, processing effort was greater in dorsal pathway brain regions following print–meaning than print–sound training.
In contrast, during reading comprehension, activity was equivalent for both training types.

To improve reading aloud and/or comprehension accuracy in the early stages we should focus on the systematicities present in alphabetic letter-sound mappings rather than teaching learners to guess at the meanings of whole written words.

7. References

Plaut, D. C., McClelland, J. L., Seidenberg, M. S., & Patterson, K. (1996). Understanding normal and impaired word reading: Computational principles in quasi-regular domains. *Psychological Review*, 103(1), 56-115.

Taylor, J. S. H., Plunkett, K., & Nation, K. (2011). The influence of consistency, frequency, and semantics on learning to read: An artificial orthography paradigm. *Journal of Experimental Psychology: Learning Memory and Cognition*, 37(1), 60-76.

Taylor, J. S. H., Rastle, K., & Davis, M. H. (2013). Can cognitive models explain brain activation during word and pseudoword reading? A meta-analysis of 36 neuroimaging studies. *Psychological Bulletin*, 139(4), 766-791.

Taylor, J. S. H., Rastle, K., & Davis, M. H. (2014). Distinct Neural Specializations for Learning to Read Words and Name Objects. *Journal of Cognitive Neuroscience*, 26(9), 2128-2154.