Morphological decomposition in the ventral stream

Clare Lally, Lydia Vinals & Kathy Rastle Royal Holloway, University of London

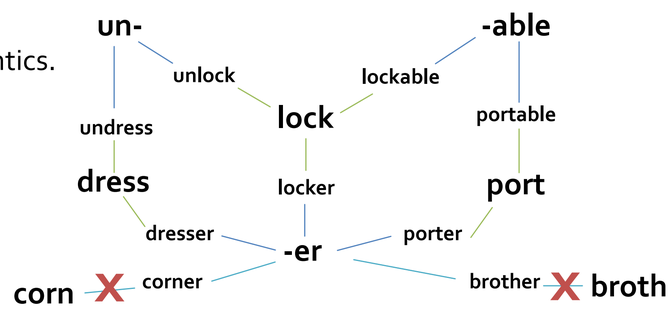
MORPHOLOGY

Morphology reflects one of the few systematic relationships between orthography (letters) and semantics (meaning), (Rastle, 2018). Priming research demonstrates that even pseudo-morphological words provide a recognition advantage for the pseudo-stem (*corner > CORN*), despite the absence of a semantic relationship (Rastle, Davis & New, 2004).

However, there was no recognition advantage for words with equivalent orthographic overlap, but no plausible morphological structure (*window > WIND*).

These results suggest that morphological processing is early and independent of semantics.

Morphology could reflect functional organisation of orthographic and semantic representations.

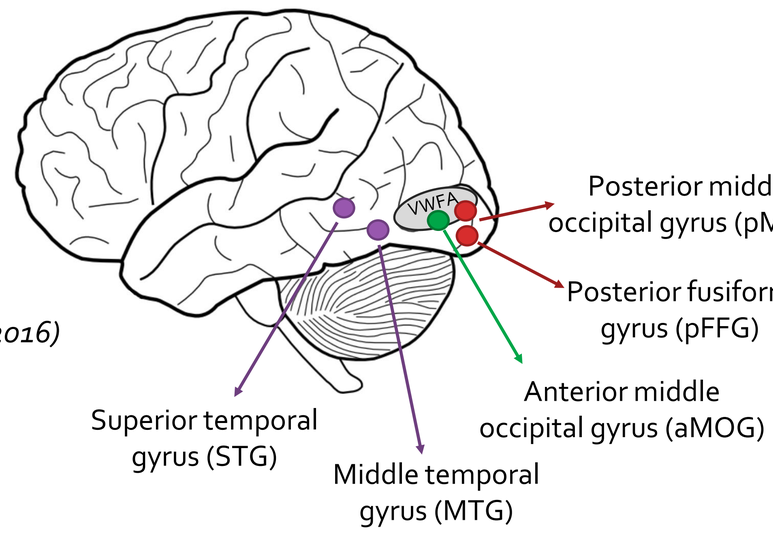


THE VENTRAL STREAM

The ventral stream extends anteriorly from the visual cortex, through the left occipital temporal gyrus to the middle temporal gyrus. Neural regions within the ventral stream are activated during word reading, which led to a proposal that this area contains a hierarchically organised pathway in which word representations become progressively more abstract as semantic meaning is extracted from the orthographic form (Dehaene et al., 2005; Vinckier et al., 2007).

"Morphological processing was not localised to one specific area but distributed across a vast network"

Cavalli et al. (2016)



Orthographic similarities (pMOG, pFFG)
Words with shared letters show similar activation (window > WIND)

Semantic similarities (MTG, STG)
Words with shared meaning show similar activation (harbour > PORT)

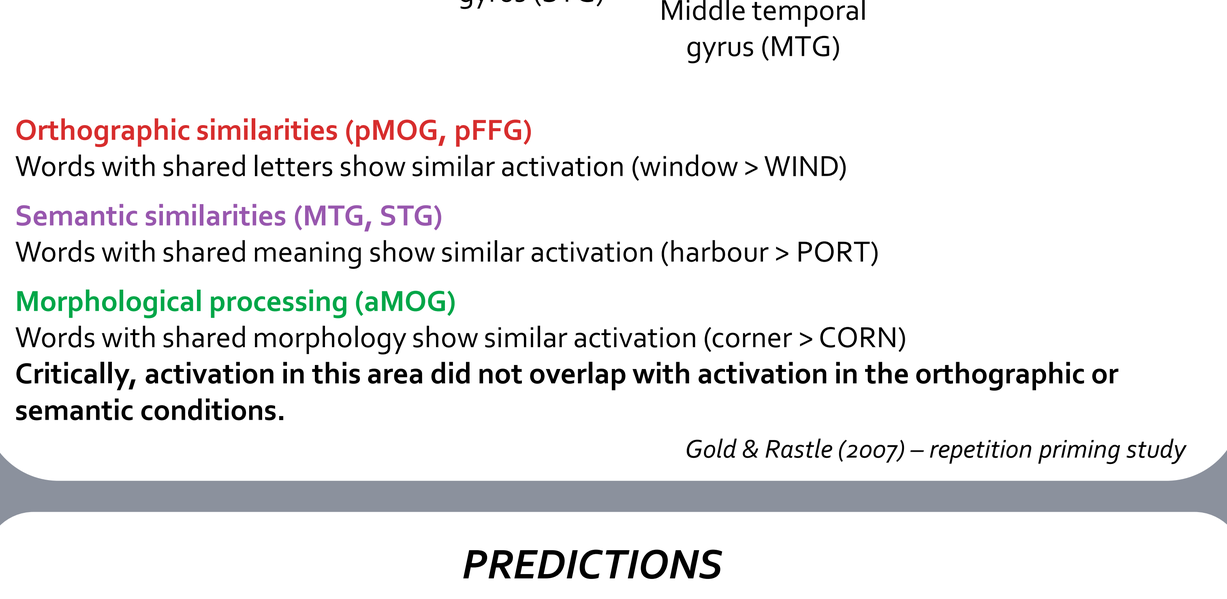
Morphological processing (aMOG)
Words with shared morphology show similar activation (corner > CORN)
Critically, activation in this area did not overlap with activation in the orthographic or semantic conditions.

Gold & Rastle (2007) – repetition priming study

PREDICTIONS

Research aim: use representational similarity analysis to investigate how the ventral stream represents different forms of morphological information

Our approach enables us to assess how the nature of representations for words are transformed at different levels in the processing hierarchy.



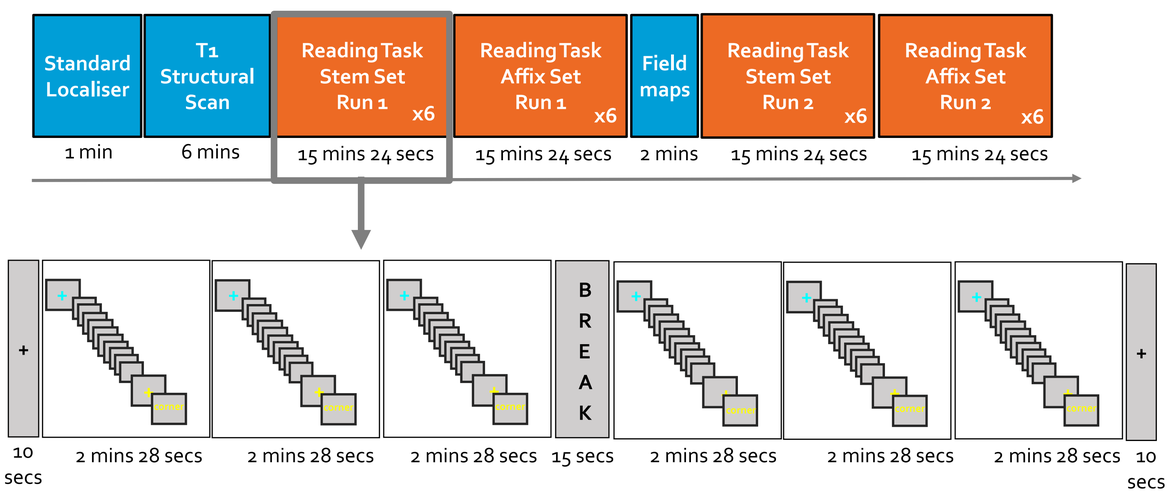
Prediction matrices showing word similarity based on different morphological properties

METHOD

- 24 participants
- Individual word reading task
  - Recall whether a test word was present in the previous sequence
  - 50 stimuli (2 sets x 25) + 60 filler items

Stem	Shared orthography	Pseudo-morphological	Morphological	
act	tract	exact	enact	action
form	platform	former	transform	conform
late	plate	relate	lately	lateness
plan	plank	planet	planner	preplan
read	thread	ready	reader	reread

Scanning procedure

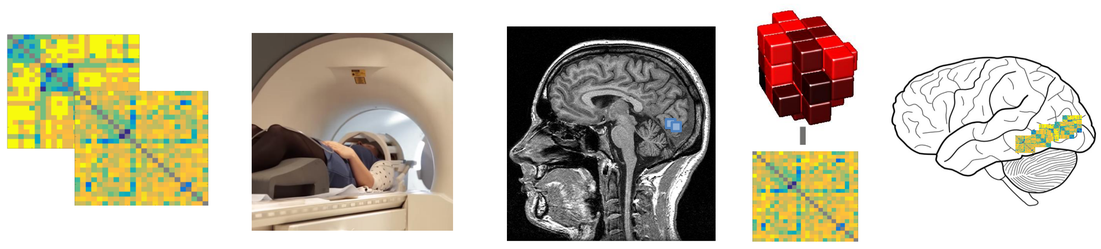


Multi-band EPI
Continuous sequence
2.5^3 mm isotropic voxels | 48 slices

TR: 2 seconds
TA: 2 seconds
750 ms trial + 2750 ms ITI

REPRESENTATIONAL SIMILARITY ANALYSIS (RSA)

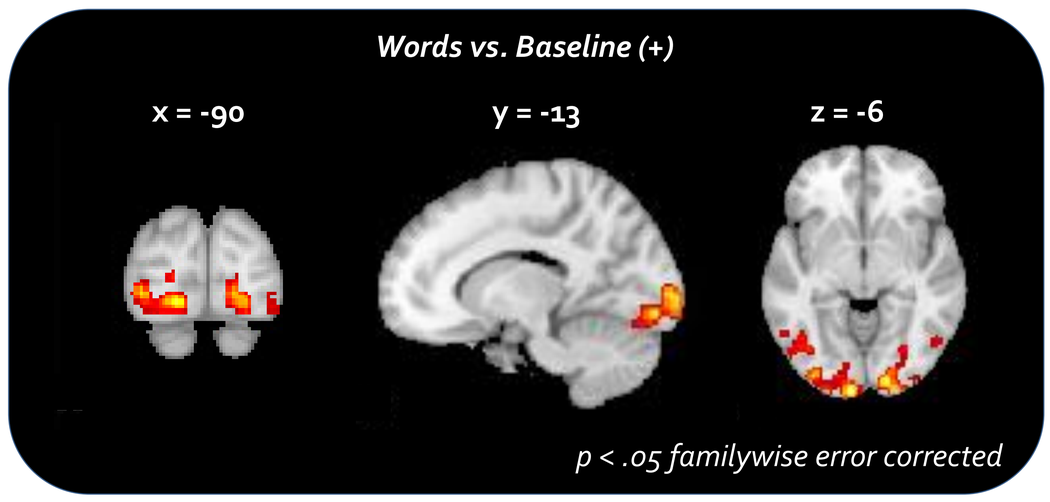
1. Construct similarity prediction matrices based on morphological properties
2. Collect data
3. Searchlight analysis
4. Correlate observed activation patterns of stimuli
5. Correlate the fit of prediction matrices with observed stimuli



Kriegeskorte et al. (2008)

PILOT RESULTS

First-level activation maps from five subjects display activation in the visual cortex (VC1 – VC5), left occipital temporal cortex (LOTC), middle temporal gyrus (MTG) and superior temporal gyrus (STG). This aligns with our predicted ventral stream activation during word reading. Below is an example from one subject:



Next step: apply RSA to investigate changes in neural patterns within the ventral stream

Univariate results processed using automatic analysis - Cusack et al. (2015)

References

Cavalli, E., Colé, P., Badier, J. M., Zielinski, C., Chanoine, V., & Ziegler, J. C. (2016). Spatiotemporal dynamics of morphological processing in visual word recognition. *Journal of Cognitive Neuroscience*, 28(8), 1228-1242.

Cusack, R., Vicente-Grabovetsky, A., Mitchell, D. J., Wild, C. J., Auer, T., Linke, A. C., & Peelle, J. E. (2015). Automatic analysis (aa): efficient neuroimaging workflows and parallel processing using Matlab and XML. *Frontiers in Neuroinformatics*, 8(90), 1-13.

Dehaene, S., Cohen, L., Sigman, M., & Vinckier, F. (2005). The neural code for written words: a proposal. *Trends in Cognitive Sciences*, 9(7), 335-341.

Gold, B. T., & Rastle, K. (2007). Neural correlates of morphological decomposition during visual word recognition. *Journal of Cognitive Neuroscience*, 19(12), 1983-1993.

Kriegeskorte, N., Mur, M., & Bandettini, P. A. (2008). Representational similarity analysis-connecting the branches of systems neuroscience. *Frontiers in Systems Neuroscience*, 2(4), 1-28.

Rastle, K. (2018). The place of morphology in learning to read in English. *Cortex*. 3, 1-10.

Rastle, K., Davis, M. H., & New, B. (2004). The broth in my brother's brothel: Morpho-orthographic segmentation in visual word recognition. *Psychonomic Bulletin & Review*, 11(6), 1090-1098.

Vinckier, F., Dehaene, S., Jobert, A., Dubus, J. P., Sigman, M., & Cohen, L. (2007). Hierarchical coding of letter strings in the ventral stream: dissecting the inner organization of the visual word-form system. *Neuron*, 55(1), 143-156.

CONTACT

Clare.Lally.2017@live.rhul.ac.uk
@Clare_Lally

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL