Measuring the neural underpinnings of lingering mnemonic states

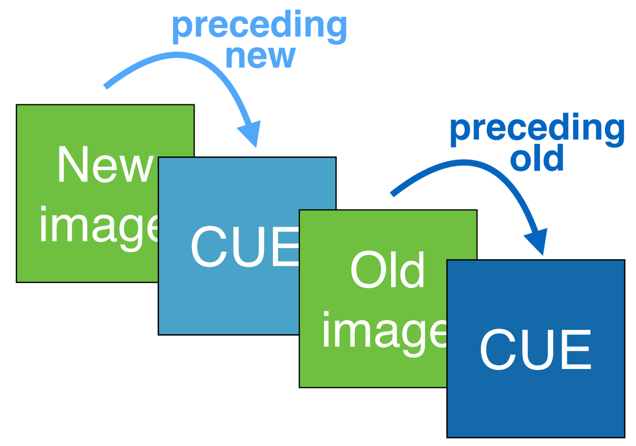
Anuya Patil & Katherine Duncan

Department of Psychology, University of Toronto

Introduction

Associative memory has been shown to benefit from preceding familiar vs. novel memory judgments[1].

Lower cholinergic input in **familiar** contexts[2] is thought to bias the hippocampus towards pattern completion[3].



Cholinergic modulation is **slow-acting** so pattern completion biases could last for seconds[4], influencing subsequent trials[1,5].

Does the effect of familiarity on associative retrieval reflect neural biases towards pattern completion?

Experiment Design

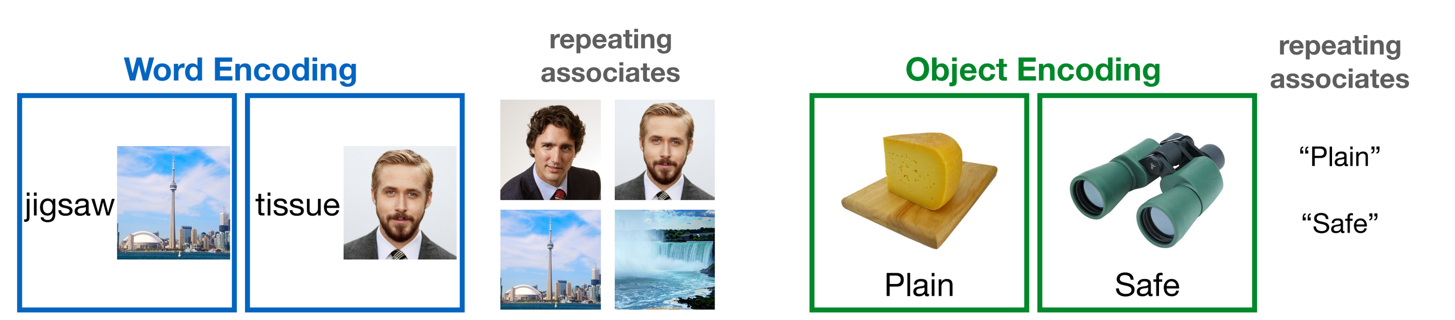
We used fMRI to investigate how mnemonic states influence **neural reactivation of memories** by using decodable **stimulus categories.**

Object encoding	Word encoding	Retrieval	Stimulus class localizer	Retrieval mode localizer

voxel size: 2.5 x 2.5 x 2.5 **distance factor:** 20% **GRAPPA:** 2 **SMS:** 2 **TR:** 1.5s **TE:** 26ms

Planned sample size: 42

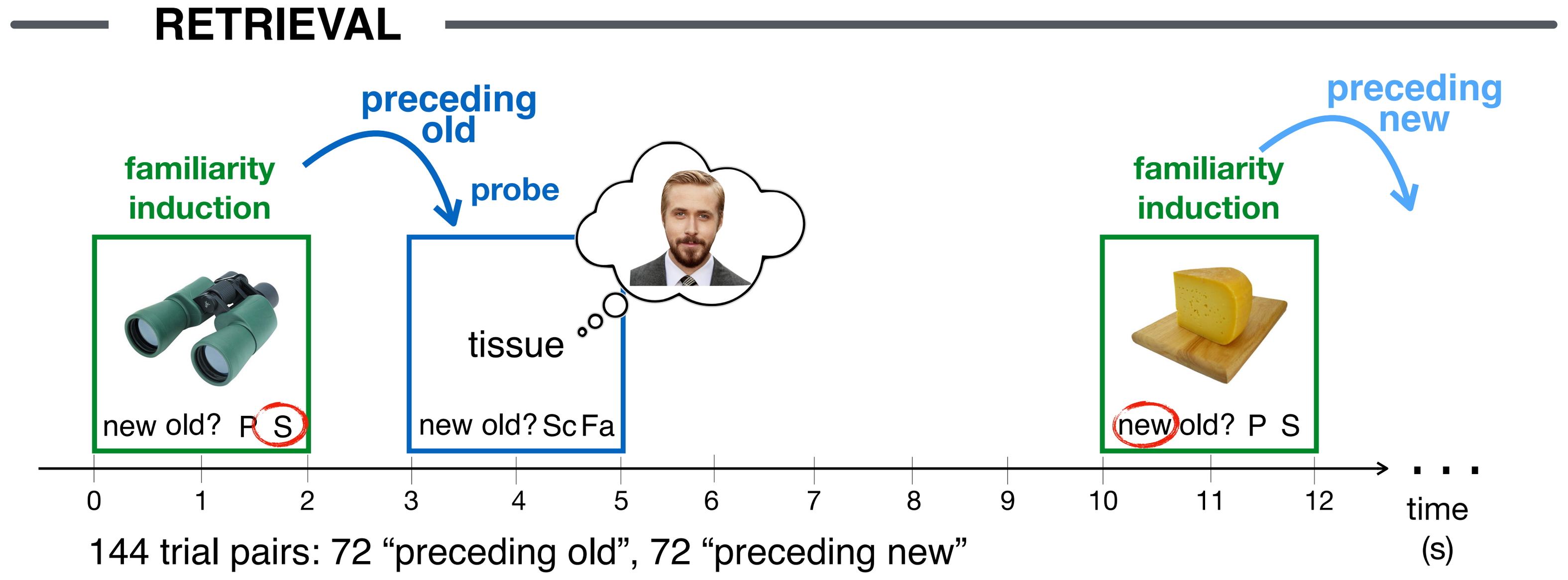
ENCODING



48 word-face pairs; 48 word-scene pairs

72 object-adjective pairs

RETRIEVAL

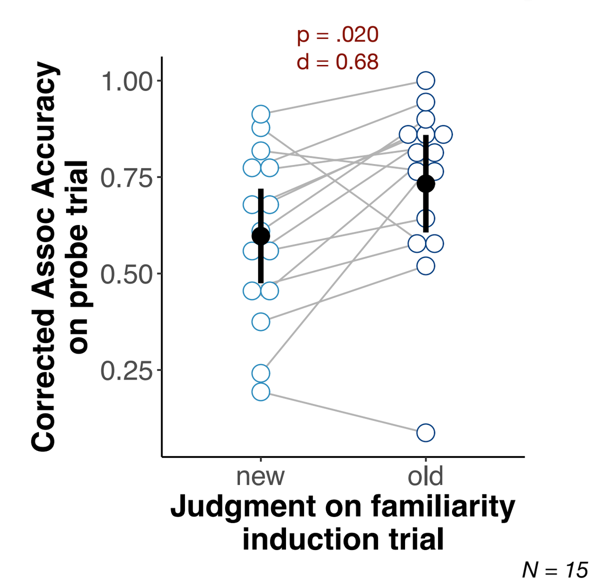


144 trial pairs: 72 "preceding old", 72 "preceding new"

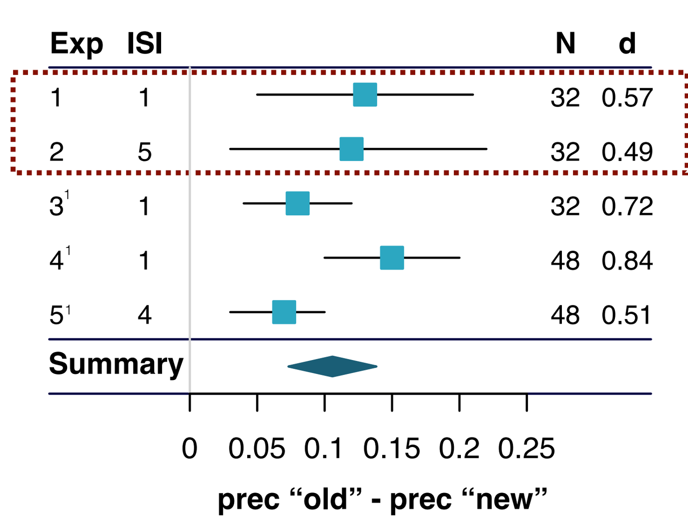
Manipulation: judgment on familiarity induction trial (old/new)
Measurement: evidence for retrieval on probe trials

Behavioural Results

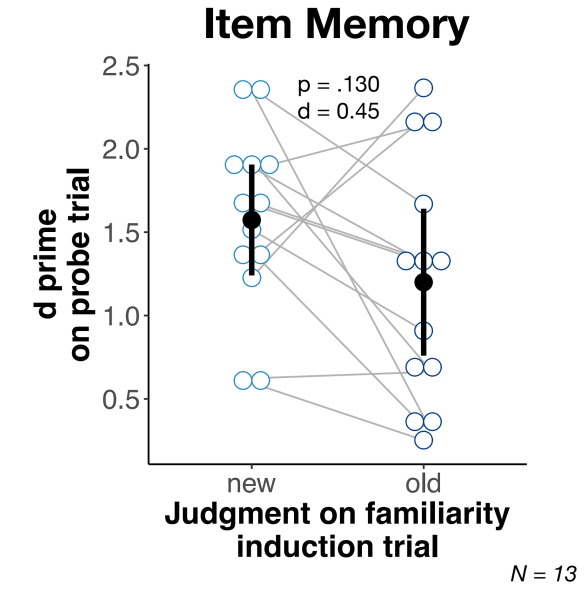
Associative Memory



Previous Demonstrations

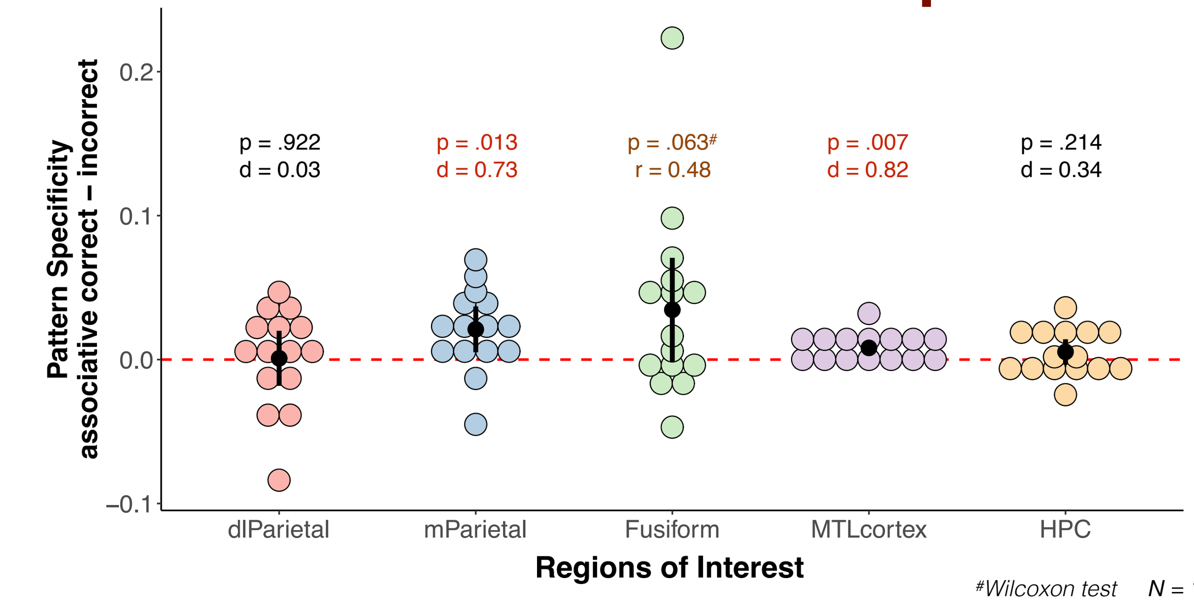


Item Memory



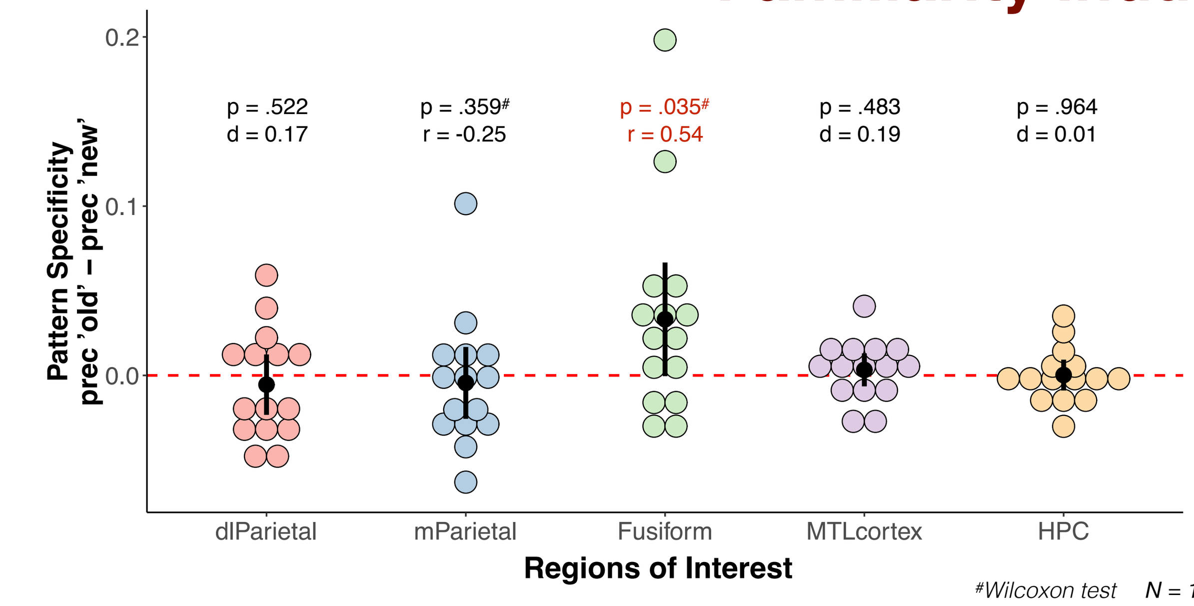
Recent familiarity did not benefit memory retrieval as a whole; **benefit was selectively observed for associative memory**, which relies on pattern completion.

Pattern Completion Index Check



Higher cortical reinstatement for **correctly recalled associations**, consistent with previous findings[9-11]

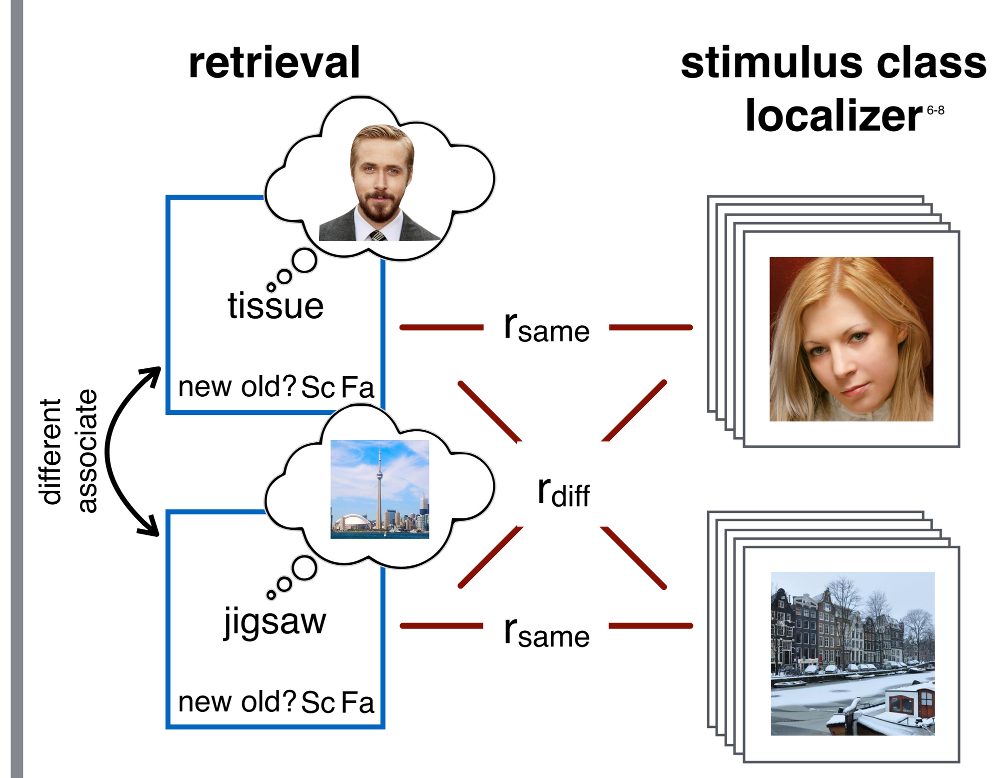
Familiarity Induction



Higher cortical reinstatement **following familiar judgments**

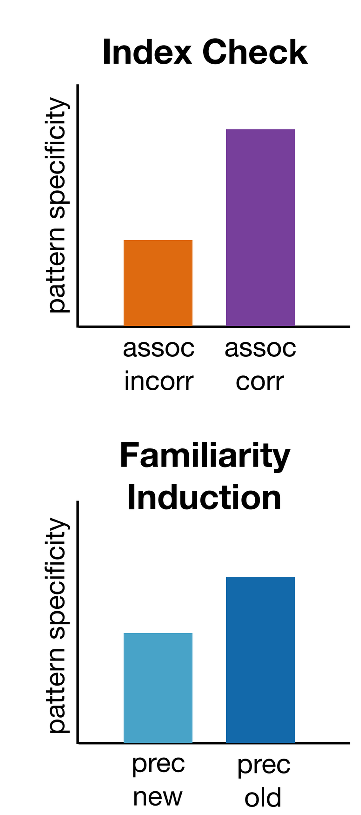
Consistent with pattern completion bias underlying familiarity's effect on associative retrieval

Pattern Completion Index



Pattern Specificity = r_{same} − r_{diff}

Predictions



Future Directions

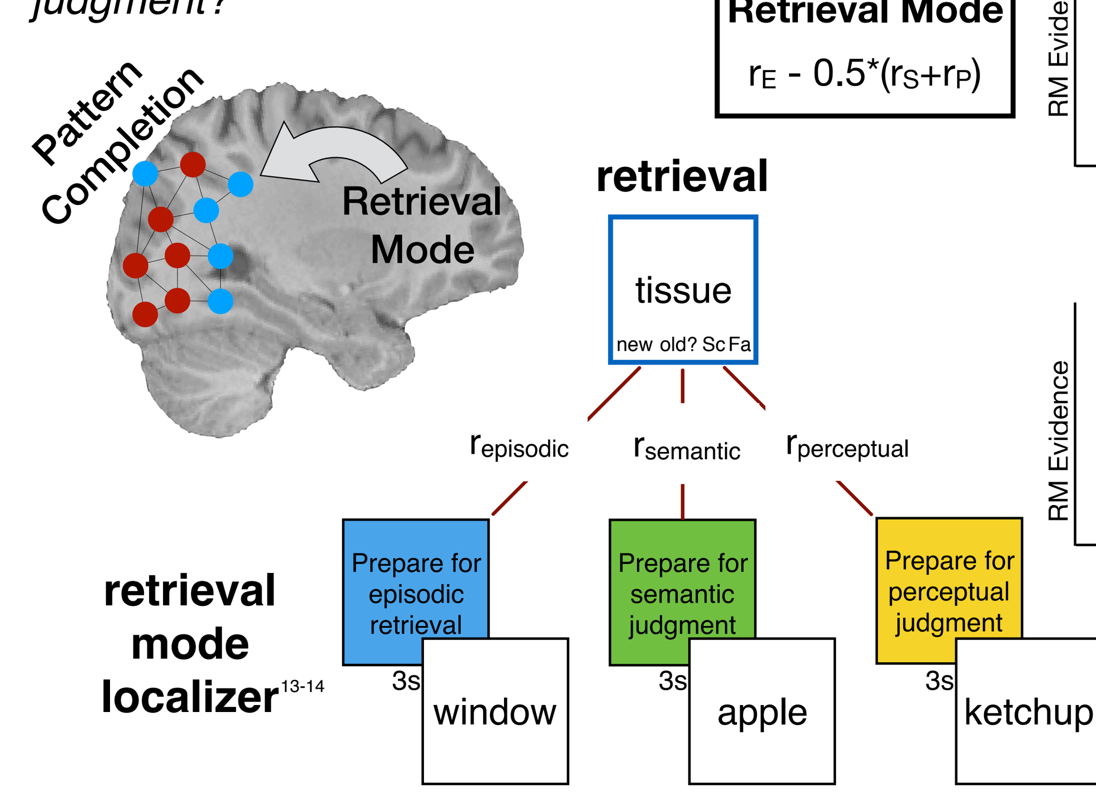
Retrieval Mode Account

A neurocognitive attentional state toward reactivated memories[12].

Is RM modulated by preceding judgment?

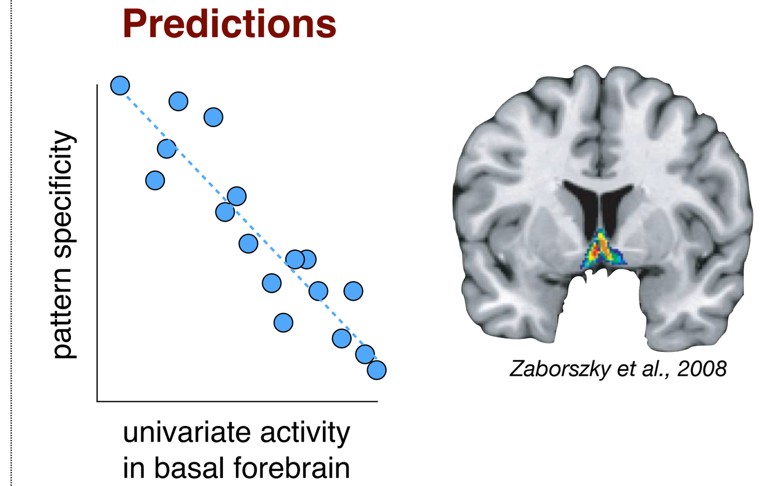
Evidence for Retrieval Mode

$r_E - 0.5^*(r_S + r_P)$



Cholinergic Account

Novelty triggers the release of **acetylcholine** into the hippocampus from the **basal forebrain.**



Similar analyses will be run for other neuromodulatory centres (SN/VTA and locus coeruleus), which are also influenced by novelty.

Summary

We used a subtle, biologically motivated manipulation to shape memory retrieval and investigate the existence of mnemonic states.

Preliminary fMRI analyses show some evidence that stronger cortical reinstatement occurs following familiarity.

These results will take us one step closer to determining if these recently discovered mnemonic biases are in fact supported by the physiological mechanisms which inspired the investigation.

References

1. Patil, A., & Duncan, K. *Psychological science* **29**,1 (2018).
2. Giovannini, M. ., Rakovska, A., Benton, R. ., Pazzagli, M., Bianchi, L., & Pepeu, G. *Neuroscience* **106**, 1 (2001).
3. Hasselmo, M. E., Schnell, E., & Barkai, E. *The Journal of neuroscience* **15**,7 (1995).
4. Meeter, M., Murre, J. M. J., & Talamini, L. M. *Hippocampus* **14**, 6 (2004).
5. Duncan, K., Sadanand, A., & Davachi, L. *Science* **337**, 6093 (2012).
6. Zeithamova, D., Dominick, A. L., & Preston, A. R. *Neuron* **75**, 1 (2012).
7. Kuhl, B. A., Rissman, J., & Wagner, A. D. *Neuropsychologia* **50**, 4 (2012).
8. Favila, S. E., Chanales, A. J., & Kuhl, B. A. *Nature communications* **7** (2016).
9. Ritchey, M., Wing, E. A., LaBar, K. S., & Cabeza, R. *Cerebral Cortex* **23**, 12 (2012).
10. Wing, E. A., Ritchey, M., & Cabeza, R. *Journal of cognitive neuroscience* **27**, 4 (2015).
11. Tompary, A., Duncan, K., & Davachi, L. *Hippocampus* **26**, 8 (2016).
12. Tulving, E. *American Psychologist* **40** (1985).
13. Simons, J. S., Gilbert, S. J., Owen, A. M., Fletcher, P. C., & Burgess, P. W. *Journal of Neurophysiology* **94**, 1 (2005).
14. Evans, L. H., Williams, A. N., & Wilding, E. L. *NeuroImage* **108** (2015).

NSERC CRSNG
NSERC Discovery #500491