Functionally-distinct states of STM retention are revealed by pattern classification of fMRI

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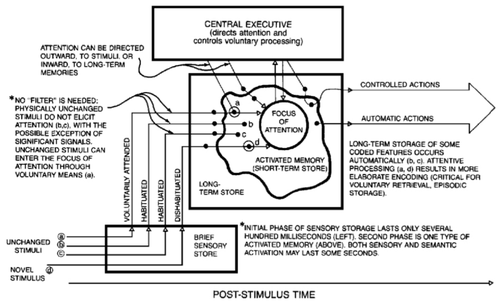
1 Theoretical framework

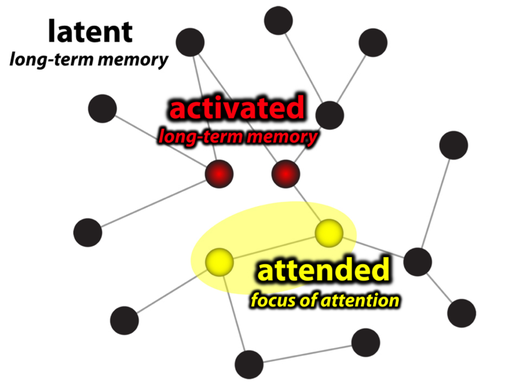
Embedded Processes model of human cognition
(Cowan, 1988)



STM ≈ activated-LTM + Attention

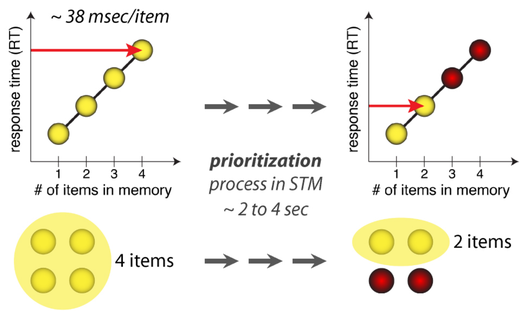
2 Distinct states of STM

(e.g., Oberauer, 2001, 2002)
(& see companion poster E110 by Drysdale et al.)



the ***load*** effect
(Sternberg, 1966)
the time required to scan STM scales with load

the ***un****load* effect
(after Oberauer, 2001)
it takes time to remove irrelevant items from STM



3 Logic & design of our study

What is the neural signature of attended vs. activated memory?

Phase 1. Scan subjects holding, in STM, a single stimulus encoded in primarily 1 of 3 unique domains of information representation (phonology, vision, or semantics)

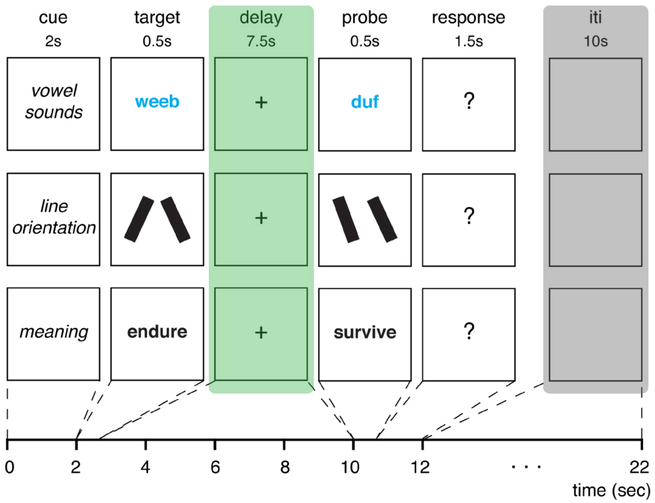
→ *train a classifier on domain-specific brain activity*

Phase 2. Scan subjects holding, in STM, multiple stimuli, with each stimulus encoded in a different domain, and then focusing on (prioritizing) a subset of those stimuli

→ *decode brain activity throughout the memory delay*

4 *Phase1*: STM retention task

Phase 1 fMRI task
delayed-recognition of words, nonwords, & line segments

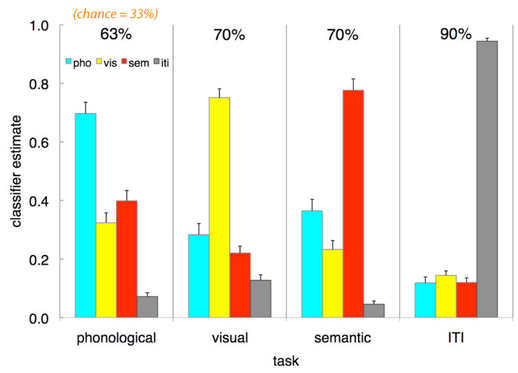


We used these data to train a classifier on brain activity associated with the short-term retention of information held *primarily* in a **phonological**, **visual**, or **semantic** code

(also trained it with inter-trial interval activity as a baseline)

5 *Phase1*: classifier training

Result - a pattern classifier, trained separately for each subject, learned to distinguish brain activity patterns

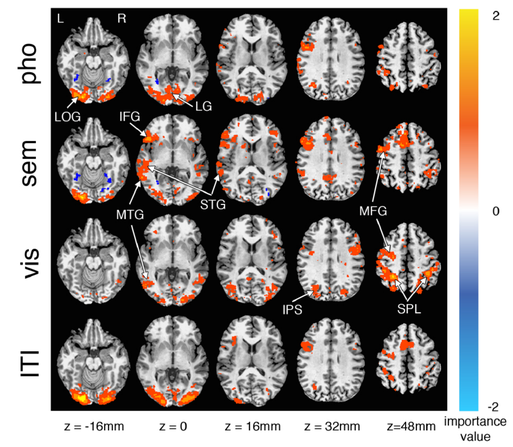


→ Next ... we applied the pattern classifier (trained on all Phase 1 data) to decode brain activity from the Phase 2 task

STM retention of multiple stimuli will be identified by estimates of domain-specific patterns of activity

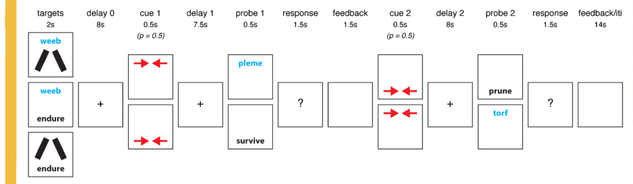
6 *Phase1*: voxel importance

We used the average BOLD signal in every voxel, and the trained classifier weights for each condition, to identify important voxels for the four conditions
(e.g., Polyn et al., 2005, Lewis-Peacock & Postle, 2008)



7 *Phase2*: prioritization task

Phase 2 fMRI task
delayed-recognition *with prioritization cues*
(a modified Sternberg task)

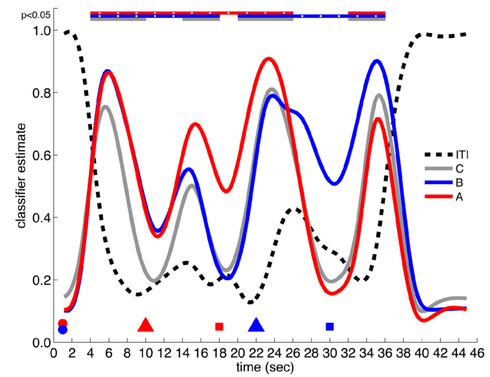


The 2 target stimuli were encoded (primarily) in different domains

The prioritization cues selected, *with p=0.5*, the representation of one target as relevant for an upcoming domain-specific recognition probe

8 *Phase2*: decoding of fMRI

cue ***switch*** trials





Result #1 - prioritization in STM was associated with different delay-period brain activity for *cued* vs. *un-cued* representations

Result #2 - although activity patterns corresponding to the un-cued stimulus ("B") became indistinguishable from baseline after the initial prioritization cue for "A" (t=10 s), these patterns were re-instated following the subsequent cue to re-prioritize stimulus "B" (t=22 s)

NOTE: See my future poster at SfN 2010 describing a follow-up study that revealed an intermediate level of activity for un-cued representations (i.e., a dissociation between attended, activated, & latent *LTM) when all the representations in STM were different codings of the same stimulus*

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