Time vs Space

Modality-Appropriateness & Cross-Modal Recruitment in Auditory & Visual Short-Term Memory

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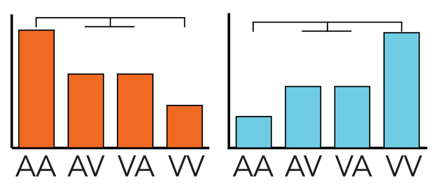
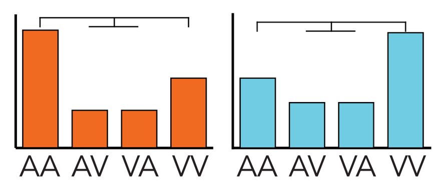
Audition has an affinity for **timing** information; vision for **spatial** information (the **Modality Appropriateness Hypothesis**, Welch & Warren, 1980). In short-term memory (STM), we predict that audition will be superior to vision in a temporal task (Collier & Logan, 2000), and inferior in a spatial task.

Q1: How is info coded in short-term memory?

In the **single-coding model**, auditory and visual inputs are encoded and stored according to information domain rather than modality, and cross-modal STM is no worse than the weaker unimodal (Collier & Logan, 2000).

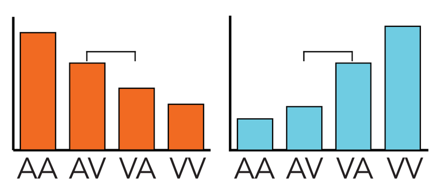


Conversely, in the **sensory-specific model**, auditory and visual inputs are encoded and stored by sensory modality, resulting in impaired cross-modal STM.



Q2: How is info retrieved in short-term memory?

Non-linguistic STM requires construction of an internal representation of previous experience, and then comparison to incoming information (Voytek & Knight, 2010). Only the first stimulus needs to be stored for **online comparison**.

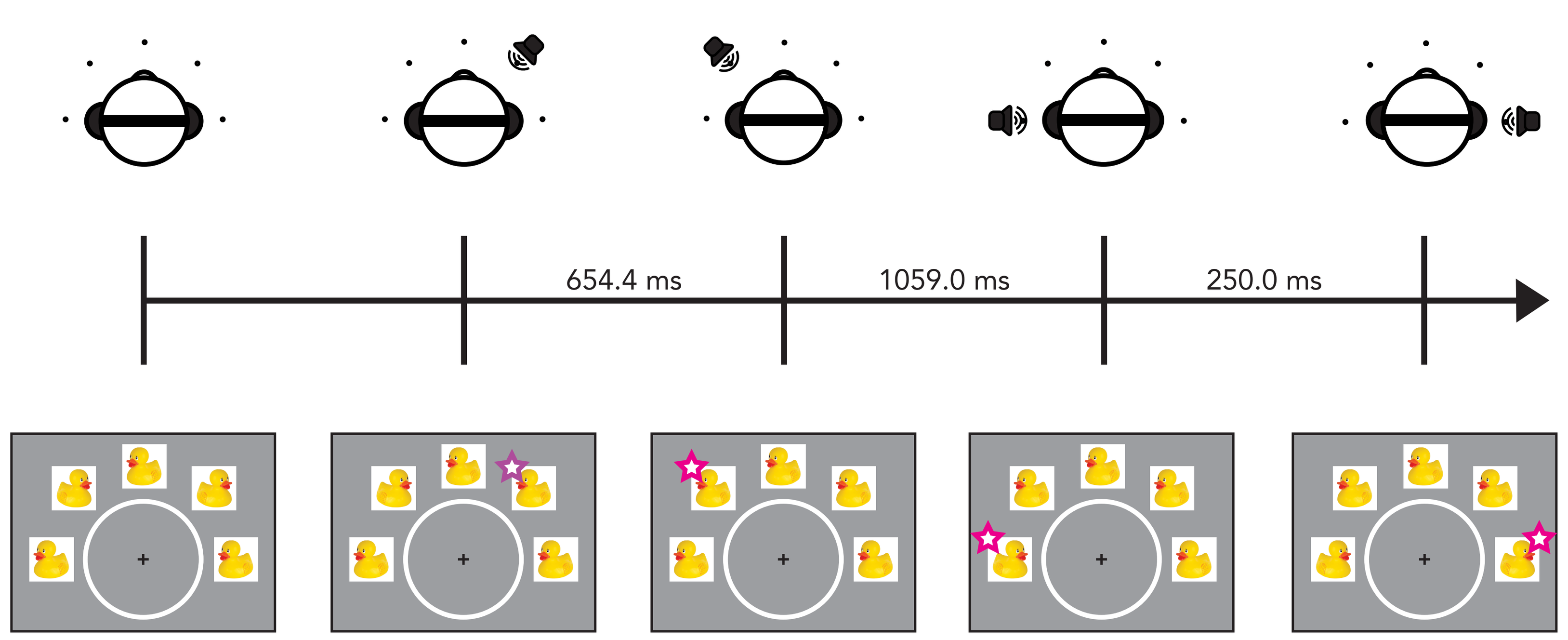


Auditory and Visual Stimuli

We created sequences of four auditory or visual events.

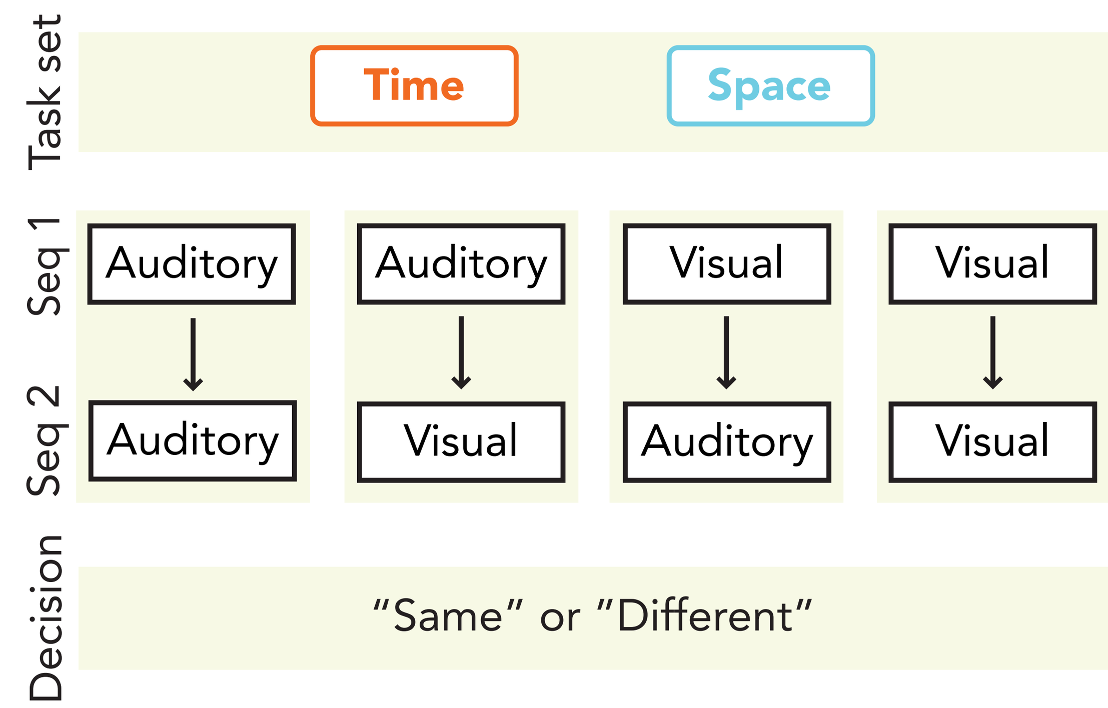
Each event in a sequence had a unique **location** (drawn from far-left, left, center, right, or far-right); each pair of events had a unique **stimulus onset asynchrony** (drawn from 250.0, 404.5, 654.5, or 1059.0 ms).

Auditory events were 50 ms complex tones, lateralized by interaural time delay (ITD); visual events were instantaneous mirror "flips" of static images.



Use of these stimuli (1) allows for both unimodal and cross-modal comparisons, (2) uses the same stimuli for spatial and temporal memory, and (3) is approximately symmetric between modalities and between information domains.

Task and Experiment Design



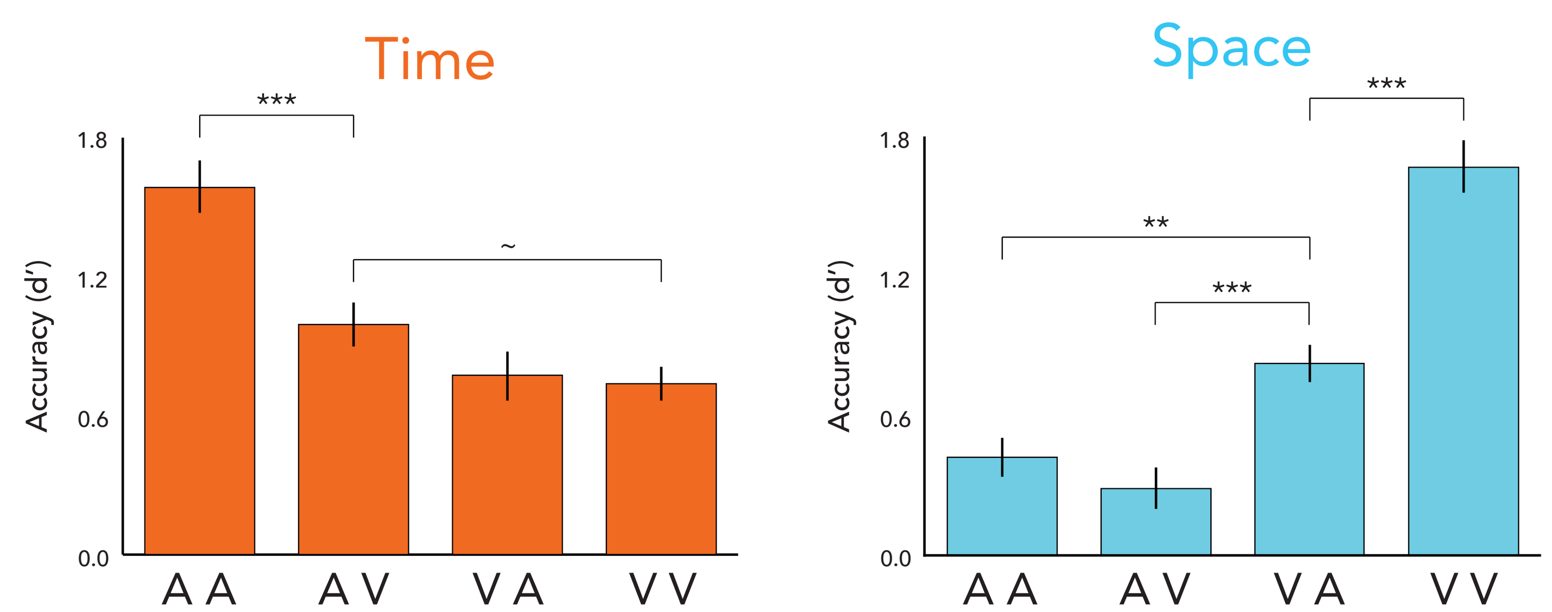
Change detection task on either the sequence of intervals, or the sequence of spatial locations.

50% of trials contained a change.

8 conditions, blocked, (2 tasks x 4 modality permutations).

n = 17.

Results: STM Coding and Retrieval



Substantial **modality appropriateness** effect, confirming the domain-specificity of auditory or visual advantages,

Time A A > V V (0.85 d'), **Space** V V > A A (1.25 d').

Cross-modal trials are no worse (and in some cases better) than unimodal trials in the weaker modality, supporting a **shared single code** between modalities.

Time A V > V V (0.25 d'), V A = V V (0.03 d'), **Space** V A > A A (0.40 d'), A V = V V (-0.13 d').

In cross-modal trials, performance is better when the appropriate modality occurs first, supporting **online comparison** accounts of STM.

Time A V > V A (0.22 d', weak effect), **Space** V A > A V (0.54 d').

Collier & Logan (2000). Modality differences in short-term memory for rhythms. *Memory & Cognition*.
Michalka, Kong, Rosen, Shinn-Cunningham, & Somers (under review).
Voytek & Knight (2010). Prefrontal and basal ganglia contributions to visual working memory. *PNAS*.
Welch & Warren (1980). Immediate perceptual response to intersensory discrepancy. *Psychological Bulletin*.

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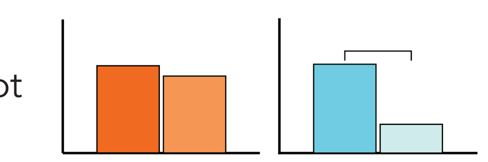
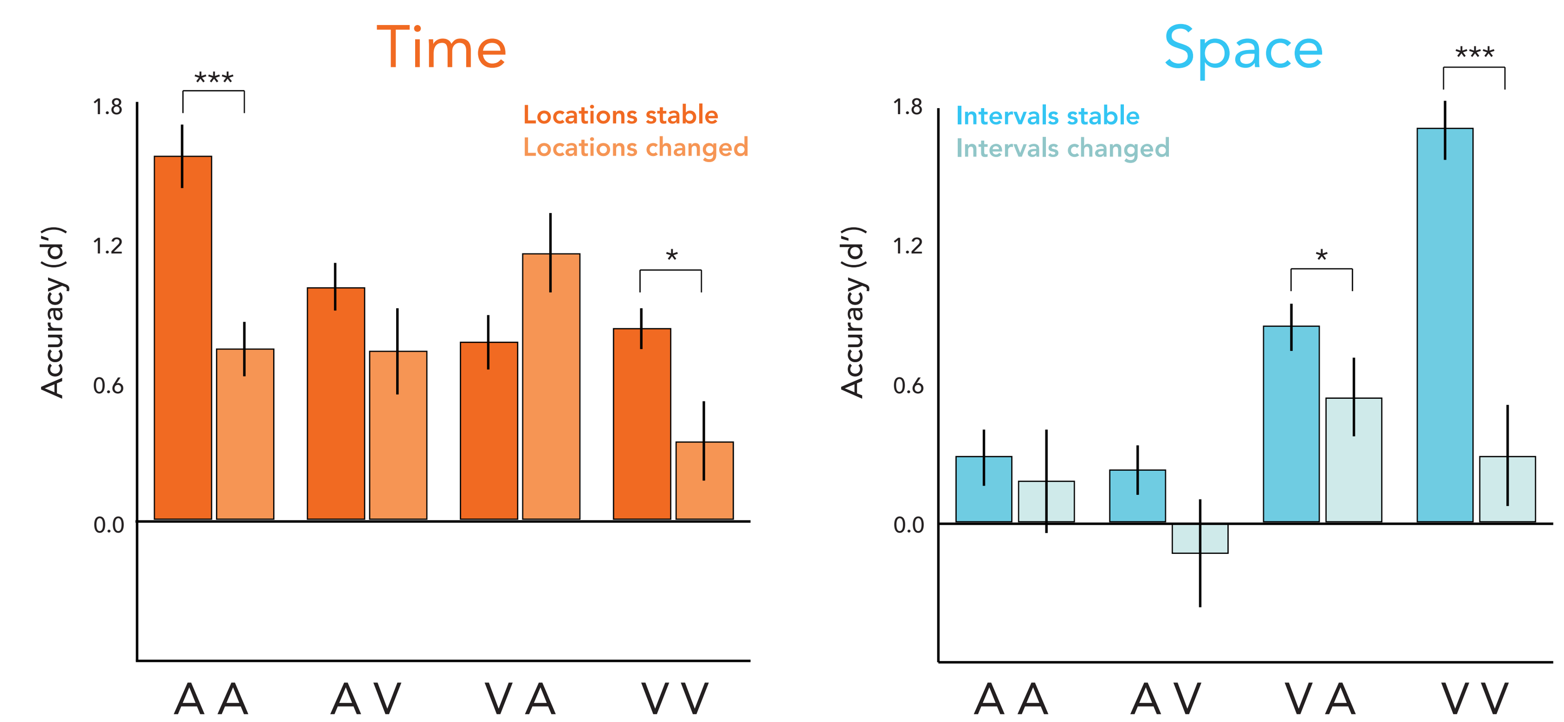
Q3: Do task-irrelevant changes interfere with STM?

Change-detection may require precise expectation of incoming stimuli. Changes in the unattended information domain would disrupt this **predictive deployment** of attention.



Results: Task-Irrelevant Changes

While subjects were monitoring changes in one information domain (Time or Space), some trials also contained changes in the other domain (Space or Time).



In both tasks, performance is disrupted by unexpected changes in the unattended domain. The effect is larger for the **Space** task (Stable > Change (0.55 d')) than the **Time** task (0.30 d').

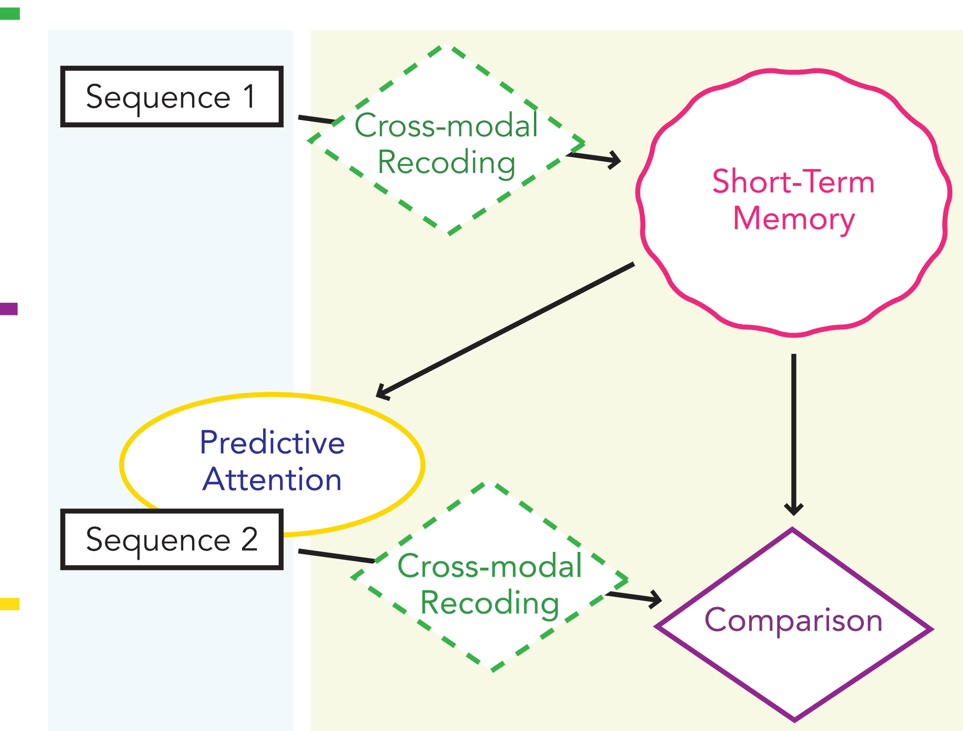
Answers and Conclusions

STM is most effective when the stimulus modality and task domain are well-matched, Audition/Time and Vision/Space.

Temporal and spatial information in STM are extracted from sensory input and encoded in a modality-general representation.

Sequence change-detection stores the first stimulus, but assesses the second "online," comparing it to the remembered information.

Task-irrelevant changes impair performance, most likely by thwarting the predictive attention strategy.



This recoding likely draws on the domain-appropriate modality (Michalka et al, under review).