Space Depends On Time: Informational Asymmetries in Visual and Auditory Short-Term Memory

Abigail L. Noyce[1], Nishmar Cestero[2], Barbara G. Shinn-Cunningham[3], David C. Somers[1]

[1]Department of Psychological and Brain Sciences, [2]Undergraduate Program in Psychology, [3]Center for Computational Neuroscience and Neural Technology, Boston University, Boston, MA, USA

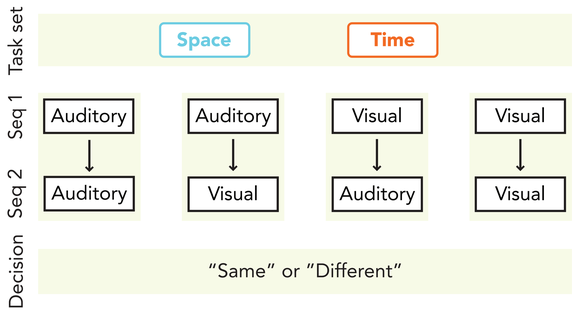
How does STM use sensory modalities? What happens in crossmodal memory?

Sensory modalities can convey different dimensions of information. Space and Time are available via multiple modalities; however, vision has an intrinsic affinity for spatial information, and audition has an affinity for timing.

What cognitive processes support change detection for sequence information?

Change detection and change identification rely on memory representations, predictive attention, and decision making.

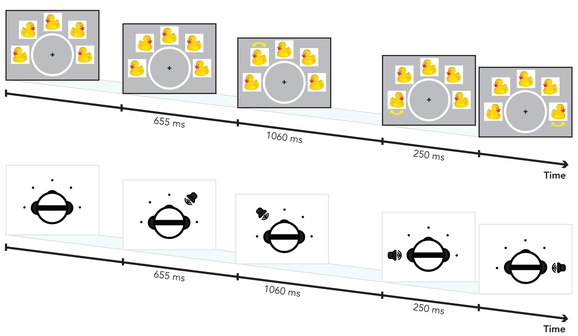
Sequence Change Detection Task



8 conditions, blocked (2 tasks x 4 modality conditions). Within-subject (n=20).

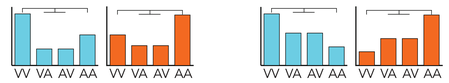
Each event in a sequence had a unique location (drawn from far-left, left, center, right, or far-right); each pair of events had a unique stimulus onset asynchrony (drawn from 250, 405, 655, or 1059 ms).

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

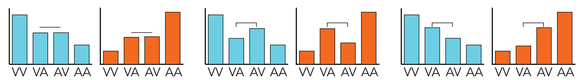


Use of these stimuli (1) allows for both unimodal and cross-modal comparisons, (2) uses the same stimuli for spatial and temporal memory, and (3) is approximately symmetric between modalities and between tasks.

Competing Predictions

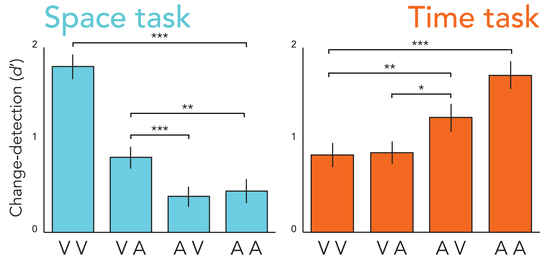


STM representations might be **modality-specific**, increasing the cost of crossmodal translation, or might be **shared** between audition and vision.



Crossmodal STM might be constrained by symmetric crossmodal **translation** costs, by task-inappropriate modality during **retrieval**, or by task-inappropriate modality during **encoding**.

Change Detection Performance



Memory representations are **shared across modalities** - crossmodal memory isn't worse than unimodal.

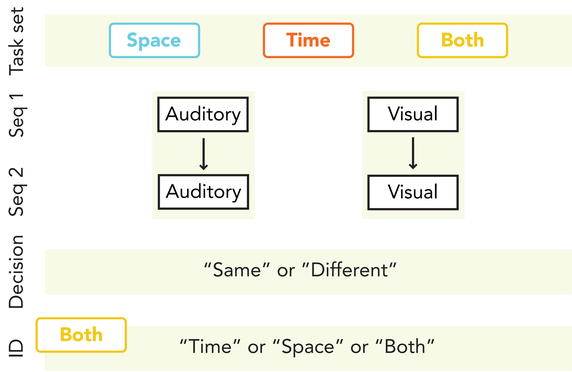
Sequence change detection requires **encoding Sequence 1** and **online, attentive comparison** to Sequence 2 - modality at encoding is critical.

Task-Irrelevant Changes

While subjects were performing one task (Space or Time), some trials also contained changes in the other dimension (Time or Space).

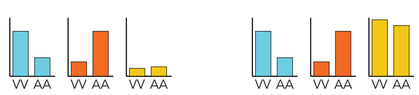
Task-irrelevant changes impair change detection, especially for locations.
Stable > Unstable, $\Delta d'_{Space}$ = .601, $\Delta d'_{Time}$ = .216

Dual-Task Variation



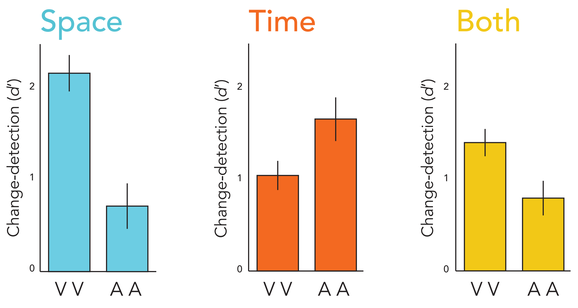
6 conditions, blocked (3 tasks x 2 modality conditions). Within-subject (n=7).

Competing Predictions



Monitoring both dimensions might impose a **dual-task cost**, as subjects now have to remember two things. Conversely, it might lead to **facitlitation**, as subjects only need to recognize a change, not discriminate its relevance.

Change Detection Performance



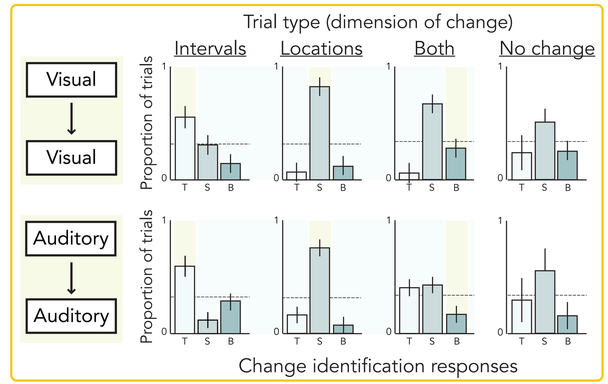
No substantial differences between change detection for single dimensions and for two dimensions.

May suggest competing **cost** and **facilitation** effects.

Change Identification Responses

Four types of trials: $Change_{Time}$, $Change_{Space}$, $Change_{Both}$, NoChange.
Three change ID responses: Time, Space, Both

On **Both** trials where subjects detected a change (**Hits** and **False Alarms**), we counted change ID responses for each type of trial.



Subjects are above chance at recognizing a single dimension of change (*i.e.* intervals-only or locations-only).

Subjects are unable to recognize when changes occurred simultaneously on both dimensions.

Conclusions

Crossmodal STM representations are shared between vision and audition.

Decreased performance in crossmodal memory arises from coarser perceptual input in the weaker modality, rather than from costs of translating between modalities.

Sequence change-detection is limited in its ability to focus on one dimension.

Changes in an unattended aspect of the stimulus impair performance, highlighting the importance of **predictively-allocated attention** and online comparison in this task. Spatial STM is particularly vulnerable.

Conversely, when two dimensions change, people only detect one of them.

Change-identification appears to be a distinct process from change-detection, with limited bandwidth for multiple changes.

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