# *Long-term learning and forgetting of conjunctive binding in free verbal recall*

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## Introduction

- **Conjunctive binding** (CB): Visual short-term memory for arbitrary feature combinations (e.g. coloured shape), typically with feature combinations changing from trial to trial. (e.g. Allen et al., 2006; Zhang & Luck, 2009).
- Logie et al. (2009) repeated feature combinations across 60 trials of change detection. CB showed no learning. Learning occurred with verbal recall of feature names, and with reported awareness of a repeated array across 120 trials (Shimi & Logie, 2019). Interpreted as initial use of limited capacity visual short-term memory (visual cache – Logie, 1995) and gradual strengthening of a weak episodic memory trace.
- **Hypotheses: (1)** Learning may occur, even if performance fails to improve across repeated recall of a visual array.
  **(2)** Evidence of learning will be apparent even after extended delays.
- **Aims**: **(1)** Assess learning by delayed testing after 24 trials of verbal free recall of the same repeated array
  **(2)** Assess patterns of forgetting over 1 day, 1 week, 1 month when participants did or did not report becoming aware of repetition.

## Methods

- 120 participants 18-35 years (M= 25.2, SD = 4.01), education 12 to 18 years (M= 16.82, SD= 1.52)
- 60 participants initially tested in the laboratory. 60 tested online.
- Participants randomly assigned to follow-up testing after 1-day (40), 1-week (40) or 1 month (40)

- Participants presented with the same six coloured shapes for 24 trials with verbal free recall of the colour-shape combinations for each shape
- Shape-colour combination of each item was fixed but their location was randomized across trials.
- Articulatory suppression was performed by every participants to minimize verbal rehearsal during each trial
- When asked by experimenter, after the last trial **61 participants reported becoming aware of repetition and 59 did not**
- Analyses with linear mixed modelling implemented with R (lmer)

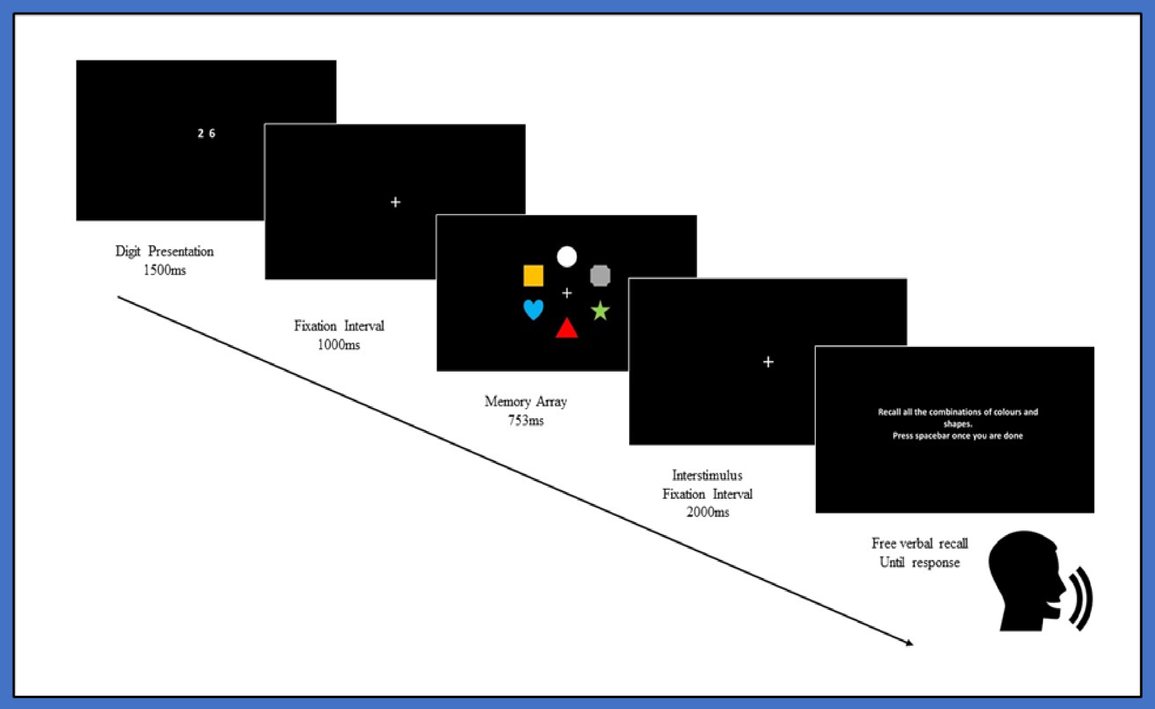


*Figure 1*. Illustration of the experimental procedure. This procedure was repeated 24 times during the whole learning session.

## Results

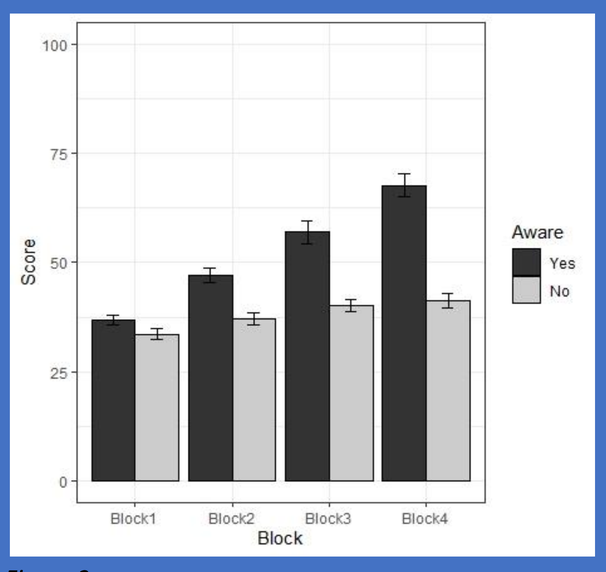


*Figure 2.*

**Long-term learning**

- Being tested online vs onsite did not predict memory performance from block 1 (trials 1-6) to block 4 (trials 19-24) ($p$ = 0.16), so **testing modality did not influence the results**
- Memory scores of aware participants increased more rapidly than for unaware participants from block 1 to block2 ($p$ <.001), to block 3 ($p$ <.001) and to block 4 ($p$ <.001), so **learning increased as a function of awareness** (*Figure 2*)

**Forgetting (3x2 mixed design)**

- Memory scores did not decrease after 1-day ($p$=0.20), while they significantly decreased after 1-week ($p$=0.02) and 1-month ($p$<.001) without considering awareness (*Figure 3*).

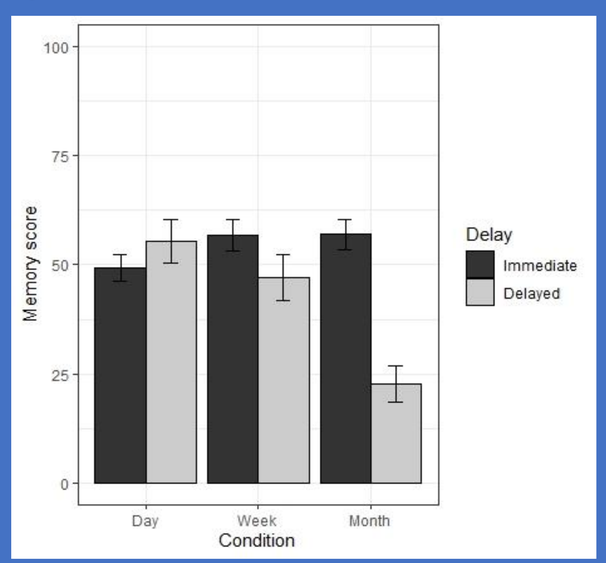


*Figure 3.*

**Forgetting (Aware vs Unaware participants)**

- **Memory scores of both aware and unaware participants did not decrease after 1-day** ($p$ = 0.46), while **they significantly declined after 1-week** ($p$ <.05) **and a month** ($p$<.001), as in *Figure 4*.
- **Both groups** showed that they **retained some details even after a month** of not viewing the array, and **neither group showed forgetting after 1 day.** So **unaware participants** clearly **learned some details** of the array, **but did not increase what they learned across repetitions as much as aware participants.**
- **Performance after one month for both groups was** approximately **the same as** it was on **Trial 1** of the learning session *(Figure 5).*

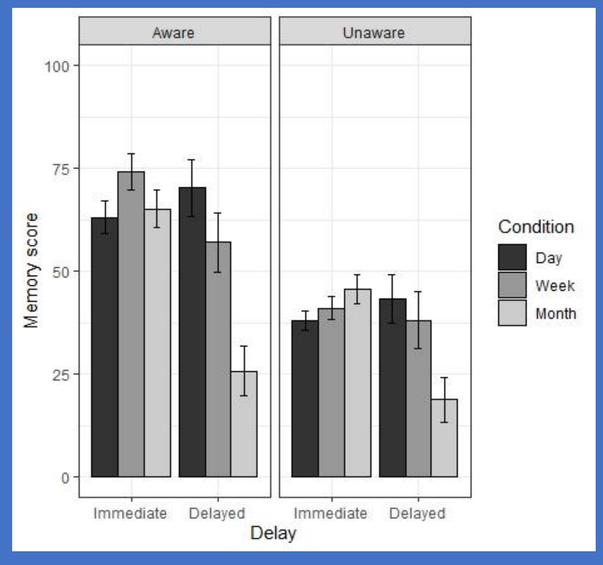


*Figure 4.*

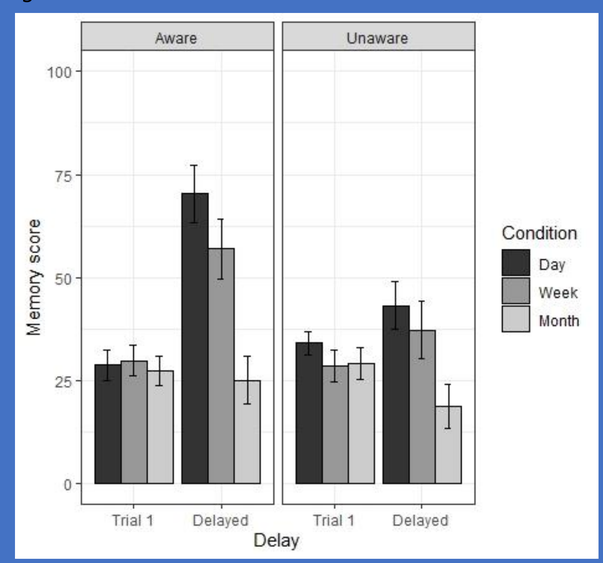


*Figure 5.*

## Discussion

- Results are consistent with Shimi & Logie's (2019) proposal that in early trials, before learning, all participants rely on a capacity-limited **Visual Cache**, for 2-3 items, but a weak episodic trace strengthens in **Long-term Memory** across repeated trials.
- Long-term memory is more rapid for participants who report awareness of the repetition. **The episodic trace after 24 repetitions is resistant to forgetting a day** after learning, while it decays after one week and one month.
- After one month, performance is same as Trial 1. However, delayed recall must rely on having learned and retained some information from the array. Trial 1 occurred before learning was possible, so could only be a temporary representation.
- Results are consistent with a **short-term, limited capacity visual cache**, and **episodic long-term memory** both contributing to performance in visual short-term memory tasks (Logie, 2016)

## References

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