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Refreshing and consolidation effects in working memory

Introduction

Short-term memory consolidation is defined as a maintenance mechanism that stabilizes and strengthens novel information [4]. Refreshing, on the other hand, reactivates already existing memory traces to avoid their loss [2]. Although consolidation studies have dramatically increased over recent years, it remains unclear whether consolidation distinguishes from other working memory (WM) maintenance processes, such as refreshing.

TBRS model

The the Time-Based Resource-Sharing model (TBRS, [1]) is based on four key assumptions.

- 1 Storage and processing in working memory share the same attentional resource.
- 2 Attention can be focused either only on storage or on processing.
- 3 The focus of attention is required to constantly switch between storage and processing activities.
- 4 The activation of a to-be-stored item increases when attention is focused on it but decreases otherwise, leading thus to the inevitable loss of information.

According to the model, working memory spans are directly dependent on the cognitive load (CL) of the task at hand. CL is defined as the proportion of time during which a given task occupies attention, thus preventing maintenance of memory traces.

Or simply put :

$$CL = t_a/T \quad (1)$$

t_a = Attentional capture time

T = Total time to perform the task.

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Experiment

Hypothesis

- According to the consolidation hypothesis, the task involving the longer period of free time immediately after the letter should produce better performance in WM compared to the task where this delay is presented only after the first processing item.
- An alternative hypothesis derived from the predictions of TBRS model is that it is not the position of the delay per se that is beneficial to recall but rather the amount of uninterrupted time enabling refreshing.

Participants - 32 students

Method - All participants performed a memory load calibration task before starting the experimental trials that ensured that a constant and optimal number of letters would be presented to the participants in the complex span task. The experimental trials consisted of a reading digit span task in which we manipulated the opportunity for consolidation and refreshing with two different processing patterns A vs B. The cognitive load was constant across patterns.

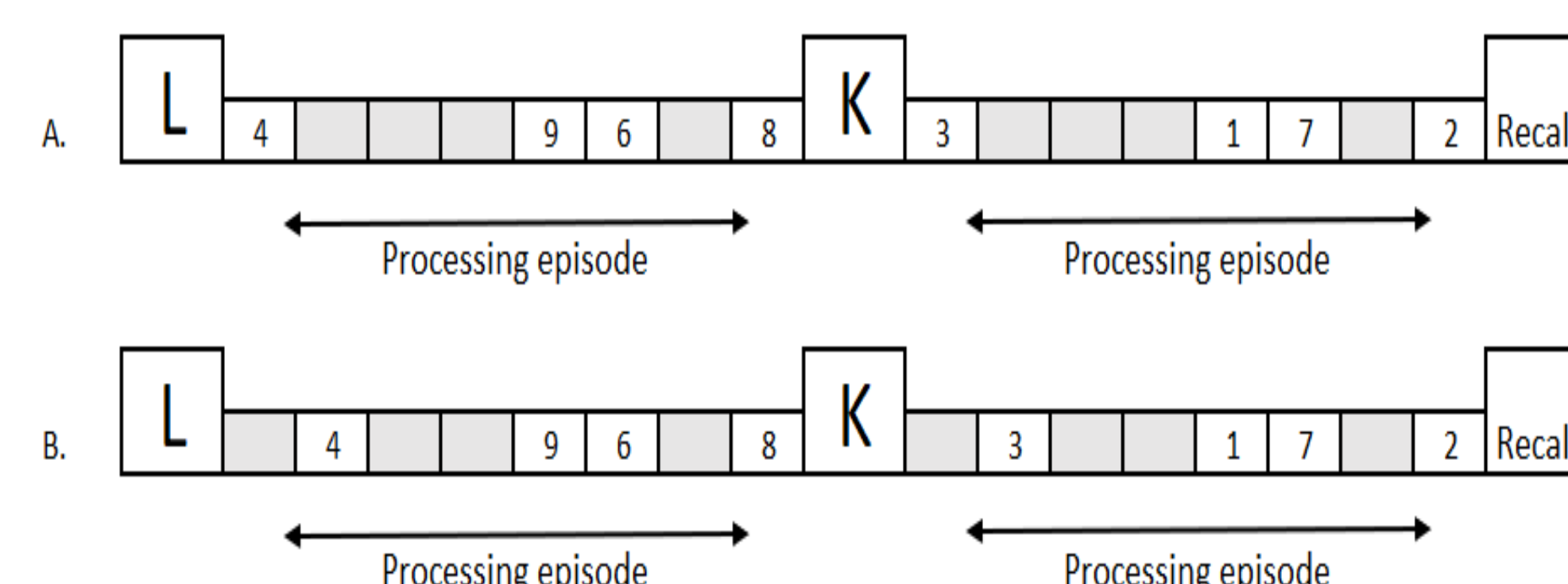


Figure 1: Patterns of the processing task for a subset of two storage items. Note. Pattern A = no consolidation opportunity with a long uninterrupted opportunity to refresh after the first processing item. Pattern B = immediate opportunity of consolidation with short opportunity to refresh after the first processing event. The letters were presented each for 500ms. The empty grey rectangles illustrate a delay of free time of 600ms. Each digit was presented for 600ms

TBRS2 Predictions

A mathematical transcription (TBRS2,[3]) of the TBRS model has been developed, which focuses on quantifying the cognitive load by strictly implementing the minimal assumptions of the original model. The TBRS2 predicts increased WM performance when the processing event is presented immediately after the letter because, a long uninterrupted refreshing opportunity is more beneficial than if this free delay is dispatched across the sequence.

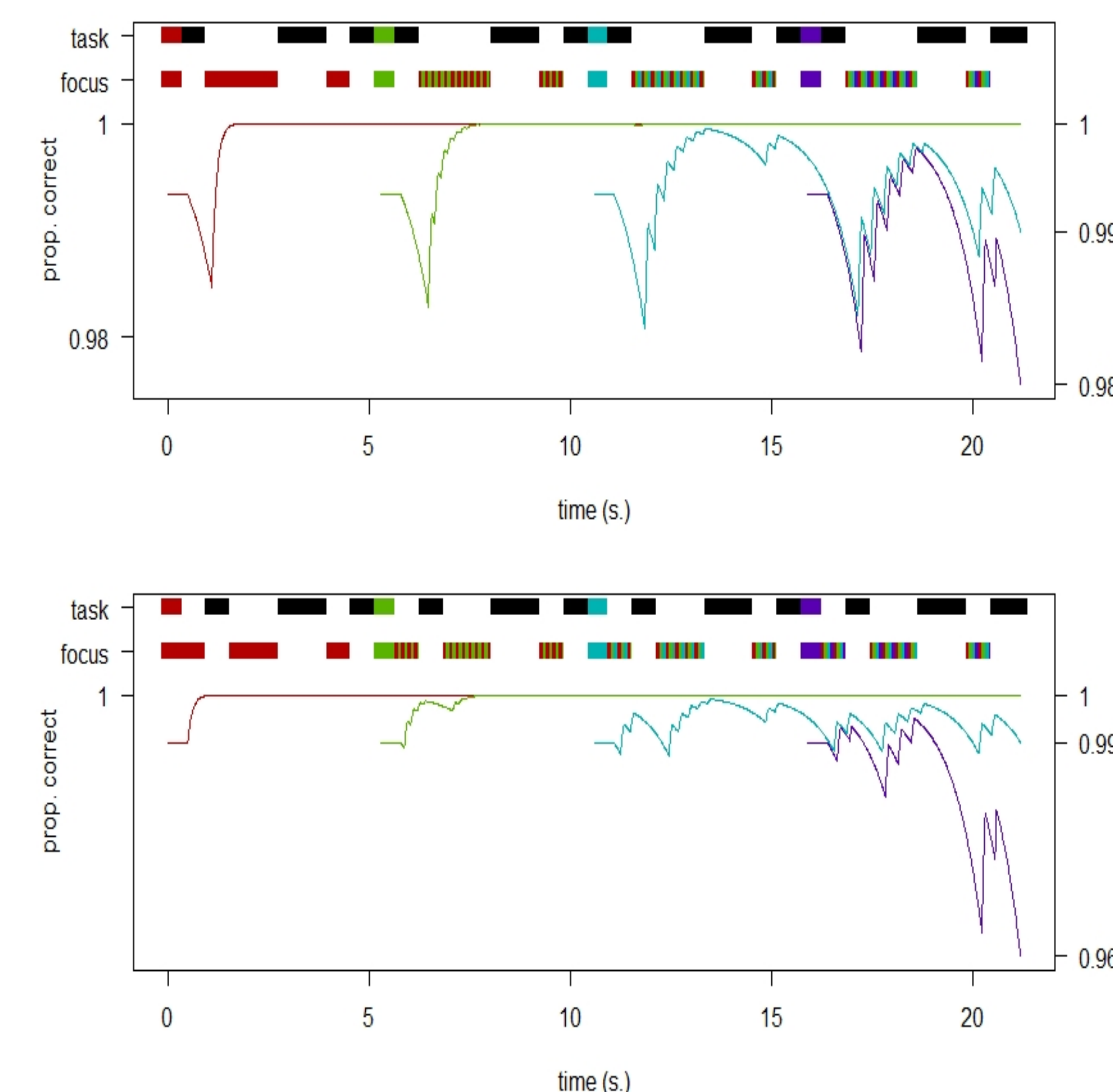


Figure 2: Top: Predictions of the TBRS2 for a sequence of four letters starting with immediately a processing episode : 1.0000000 0.9999719 0.9899293 0.9755888.

Bottom: Predictions of the TBRS2 for a sequence of four letters starting with a consolidation opportunity. The probability of correct recall for the successive four letters are: 1.0000000 0.9999574 0.9933337 0.9634557.

Results (1/2)

A Bayesian paired t -test showed moderate evidence in favor of the null hypothesis ($BF_{01} = 4.14$). The mean proportion of correct recall for each conditions were 0.77 ($SD = 0.12$) and 0.79 ($SD = 0.11$) for pattern A vs pattern B, respectively.

Results (2/2)

A linear mixed-effects regression model showed no significant interaction between serial position and processing patterns.

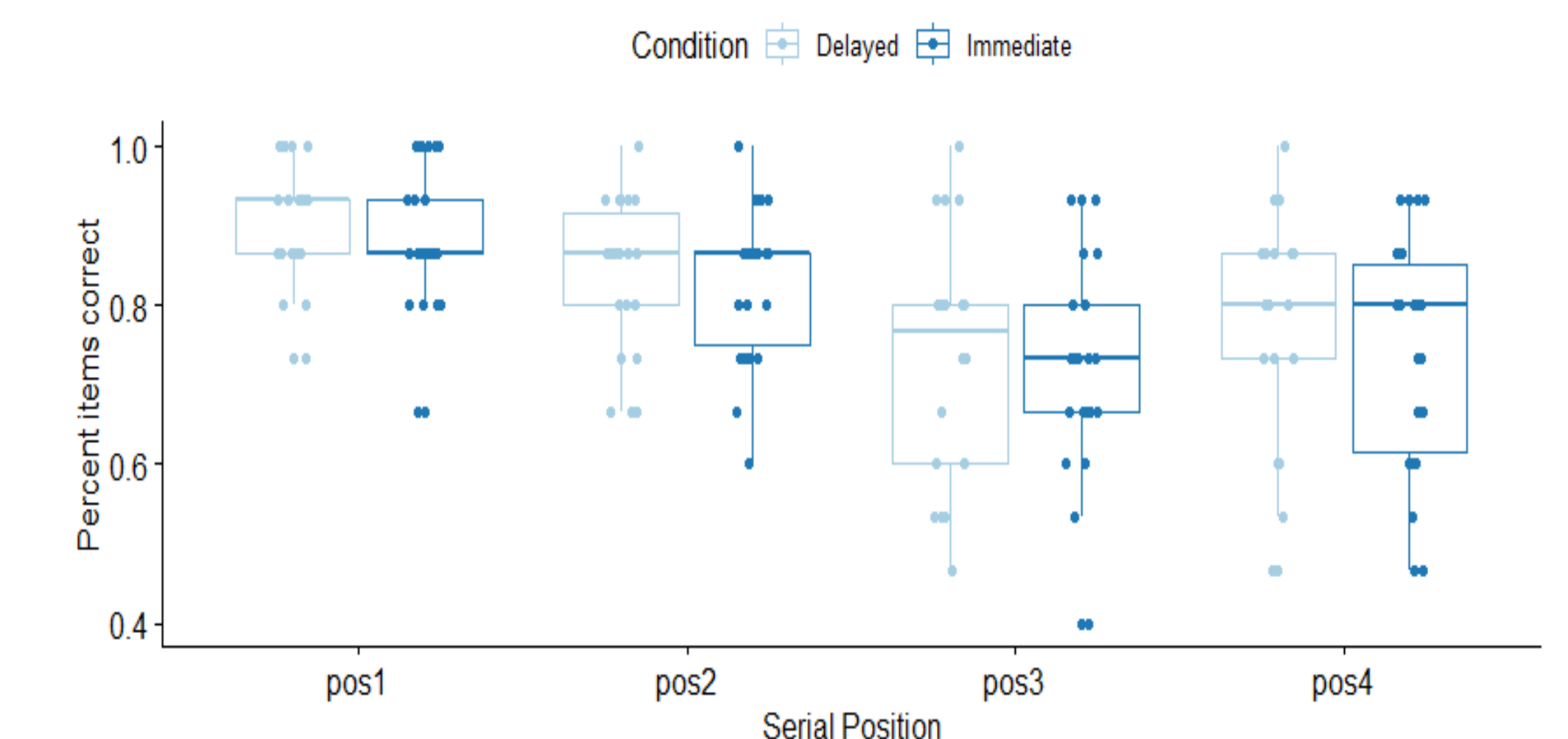


Figure 3: Mean proportion correct recall as a function of serial position and type of processing pattern. Note. Immediate refers to the 'No consolidation' pattern A. Delayed refers to the 'Consolidation' pattern B. ($N = 23$ out of 32 participants in total that had a set-size of four letters).

Conclusion

The consolidation effect can be mimicked by introducing an uninterrupted long delay of free time after the first processing item. These findings suggest that consolidation and refreshing could refer to a unique process based on the sole role of refreshing.

References

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