



# Effects of simultaneous vs. interleaved secondary tasks on implicit sequence learning in older and younger adults

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## Introduction

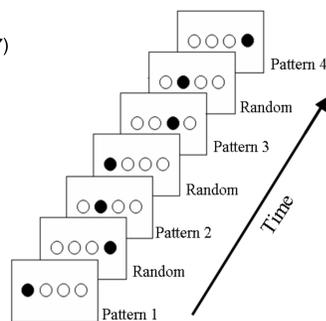
- **Implicit sequence learning** can be measured using the Alternating Serial Reaction Time task (ASRT)
  - The ASRT measures continuous probabilistic sequence learning
- Findings on the effects of a dual task on implicit sequence learning in **young adults** are mixed
  - Results can be affected by the type of dual task used, the timing of the dual task, and the type of comparison
- Studies on implicit sequence learning in the presence of a dual task in **older adults** are rare
  - Older adults have problems task-switching, so the control comparison is critical to assess dual task effects
- The present study looked at the effects of a working memory dual task on implicit sequence learning in older and younger adults
  - Participants completed the dual task (1) *simultaneously*, (2) *interleaved*, or (3) completed only the ASRT
- **Question:** Can older and younger adults learn a probabilistic implicit sequence in the presence of a simultaneous and/or sequential dual task?
  - Will a dual task impair or improve learning?

## Participants

- Control:** Young adults: 12, aged 19.67 ± 1.30 (10 female)  
Old adults: 12, aged 70.33 ± 4.64 (6 female)
- Simultaneous:** Young adults: 12, aged 19.83 ± 1.40 (8 female)  
Old adults: 12, aged 69.50 ± 3.83 (8 female)
- Interleaved:** Young adults: 12, aged 20.00 ± 1.35 (7 female)  
Old adults: 12, aged 68.92 ± 3.94 (7 female)

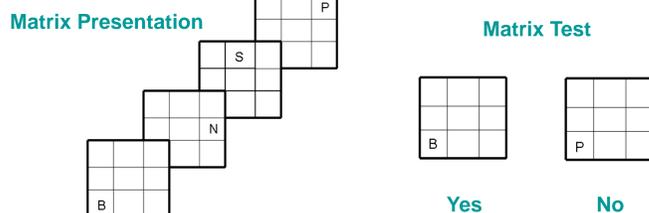
## Alternating Serial Reaction Time Task

- A probabilistic 2<sup>nd</sup> order sequence learning task (Howard and Howard, 1997)
- One event predicts the location of the event two trials later, with a randomly determined event between
- Stimuli follow a pattern, such as 1r2r3r4r, where triplets of trials would occur with High frequency, 1r2, 2r3, 3r4, 4r1, or Low frequency, eg: 1r3 or 2r4
- 50 trials/block, 5 blocks/session, 3 sessions



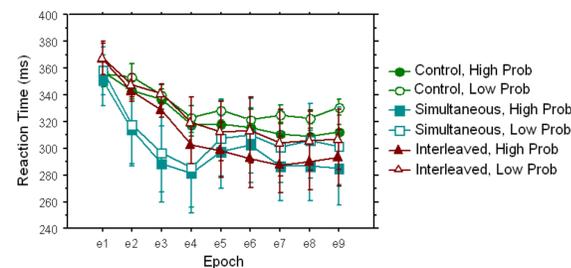
## Matrices Task

- Adapted from Mitchell et al. (2000), shown to activate the hippocampus and the PFC in young adults
- Participants saw 3 (old) or 4 (young) matrices one at a time, 1500ms each
- Participants were told to "Remember both the letter and the location"
- Memory for the letter and location together were tested – participants responded "yes" if a letter and location were exactly as seen previously, and "no" if otherwise

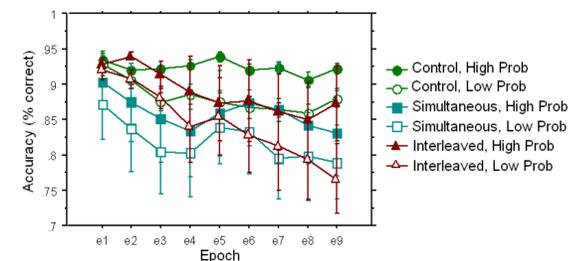


## Results: Young Adults

### Raw Scores

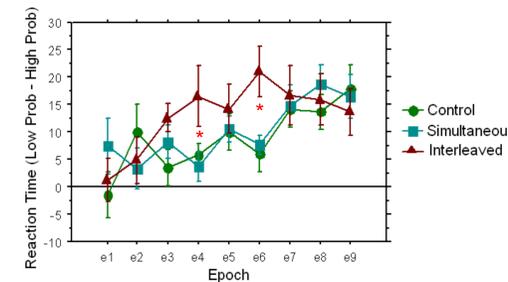


Main effects of Epoch ( $p < .01$ ) and Triplet Type ( $p < .01$ ), interaction of Epoch x Triplet Type ( $p < .01$ ), marginal 3-way ( $p = .089$ )

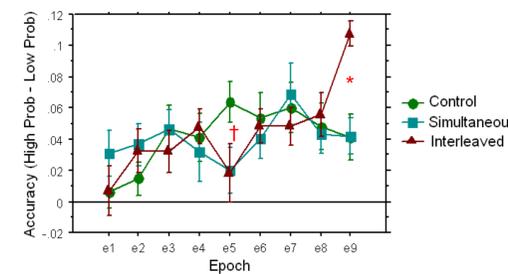


Main effects of Epoch ( $p < .01$ ) and Triplet Type ( $p < .01$ ), interaction of Epoch x Triplet Type ( $p < .01$ ), 3-way interaction ( $p = .024$ )

### Learning Difference Scores



Epoch 4:  $p = .051$   
Epoch 6:  $p = .008$

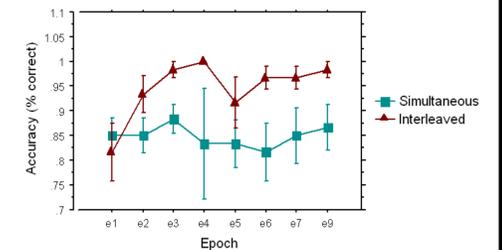


Epoch 5:  $p = .081$   
Epoch 9:  $p < .001$

## Results: Matrices Task

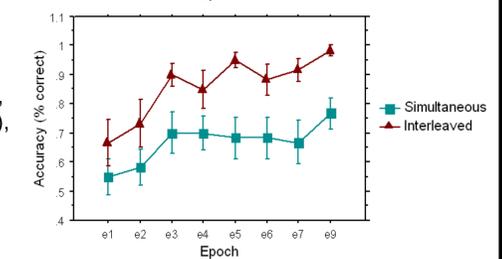
### Younger adults

Main effect of Condition ( $p = .011$ )  
no significant interaction of Condition x Epoch.



### Older adults

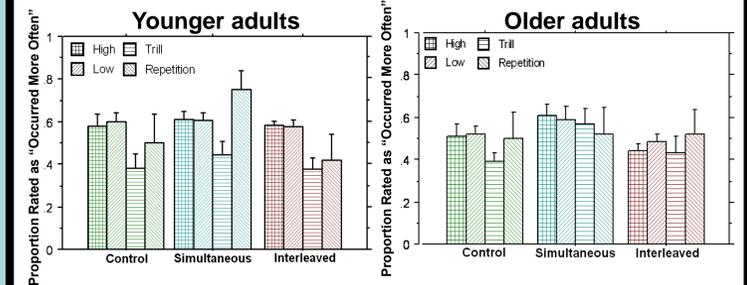
Main effects of Condition ( $p < .001$ ), and Epoch ( $p < .001$ ),  
no significant interaction of Condition x Epoch.



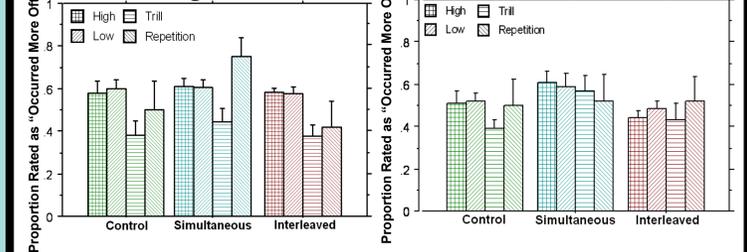
The matrices task was more challenging in the Simultaneous than in the Interleaved condition for both older and younger adults.

## Results: Explicit Awareness

### Younger adults



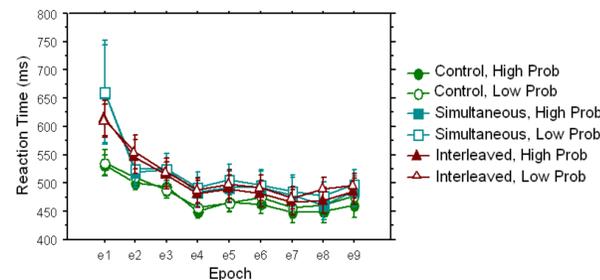
### Older adults



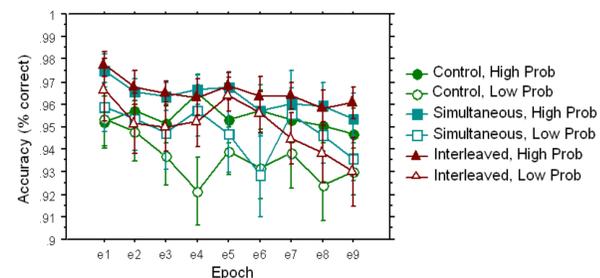
There are no significant differences between High and Low probability triplets in any condition in either young or older adults, indicating no explicit awareness of the pattern.

## Results: Older Adults

### Raw Scores

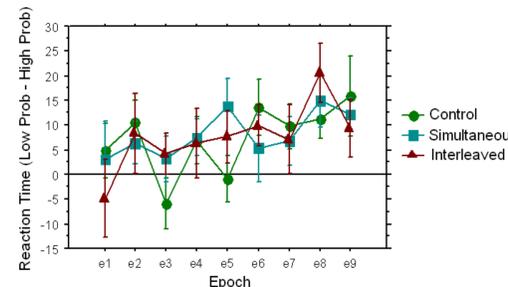


Main effects of Epoch ( $p < .01$ ) and Triplet Type ( $p < .01$ ), interaction of Epoch x Triplet Type ( $p < .01$ ), non-significant 3-way

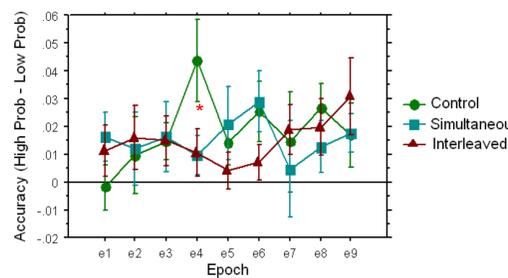


Main effects of Epoch ( $p < .01$ ) and Triplet Type ( $p < .01$ ), non-significant Epoch x Triplet Type and 3-way

### Learning Difference Scores



No significant differences at any epoch.



Epoch 4:  $p = .049$

## Conclusions & Implications

- Both older and younger adults learn an implicit probabilistic sequence in the presence of a dual task, whether simultaneous or interleaved
  - The dual task did not impair implicit learning
- Younger adults who completed the interleaved dual task had more sequence learning than those in the control or simultaneous conditions on some epochs
- Improved implicit learning in the presence of an interleaved dual task, has been shown with information integration (Filoteo, Lauritzen & Maddox, 2010), with the suggestion of a "removal" of the frontal lobes leading to enhanced performance on this implicit task
- This is fitting with activation seen in the PFC during the matrices task in young, but not older adults during binding (Mitchell et al., 2000)
- The PFC has been found to mediate the relationship between the MTL and striatum (Poldrack & Rodriguez, 2004)
- Because learning was greater when the frontal lobe was "removed" in the interleaved matrices condition, the frontal lobe may play a role in inhibiting implicit probabilistic sequence learning in young but not older adults