



# EXPLICIT AND IMPLICIT PROBABILISTIC SEQUENCE LEARNING IN AGING: DIFFERENTIAL EFFECTS OF STIMULI AND EXPLICIT AWARENESS ON IMPLICIT LEARNING

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## ABSTRACT:

The interaction between explicit and implicit sequence learning in aging was studied using a novel version of the probabilistic Alternating Serial Response Time (ASRT).

In the ASRT, predictable pattern trials alternate with unpredictable random ones, causing certain triplets of trials to occur at a higher frequency than others. These triplet sequences are learned implicitly, and this is revealed in reaction time and accuracy, with differences between high and low frequency triplet sequences increasing with practice (Howard & Howard, 2004). In the Explicit/Implicit ASRT (ei ASRT) used here, the pattern trials are made grey for certain blocks to encourage explicit learning. Half of the subjects are given intentional instructions and can learn the pattern explicitly, whereas half are given incidental instructions, and exhibit only implicit learning.

The results show that 100% of younger adults given intentional instructions gain explicit knowledge of the pattern, but only 70% of older adults do so. However, older adults who do gain explicit knowledge do so as quickly as younger adults. Using the standard ASRT (without grey events) as comparison, it was also found that the presence of gray events in the eiASRT disrupted performance of implicit learning in older adults, but not learning itself. This may be due to perceptual problems, or a problem of suppression of interfering information in older adults. For both age groups implicit learning was the same for the incidental and intentional instruction groups, suggesting that explicit knowledge does not influence implicit learning of probabilistic sequences.

## METHODS:

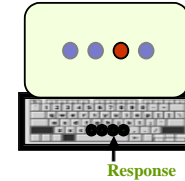
### Alternating Serial Response Time Task (ASRT)

- Repeating sequence every other trial, alternating with random events (e.g. 1r2r3r4r...).
- 9 epochs of 5 blocks each, 80 trials per block.

### Explicit/Implicit Alternating Serial Response Time Task (ei ASRT)

- CUED epochs 1, 2, 4, 5, 7, 8:
  - Event colors alternate
  - Gray trials follow a pattern and black trials do not.
- Intentional Group: subjects told the nature of the regularity
- Incidental Group: subjects not told of any regularity
- UNCUED epochs 3, 6, 9:
  - All trials black.
  - No subject is told of the regularity, although it is identical to that in the cued epochs.

**Tests of Explicit Awareness:** Sequence Generation Task, Interview, Post-test Generation Task, Card Sorting



Participants

Group	Number of Subjects	Average Age	Average Education
Older Intentional	24	71 +/- 5	17 +/- 3
Older Incidental	24	70 +/- 5	17 +/- 3
Older Standard	12	71 +/- 4	17 +/- 2
Young Intentional	12	20 +/- 1	14 +/- 1
Young Incidental	12	19 +/- 1	14 +/- 1

## RESULTS: SEQUENCE LEARNING

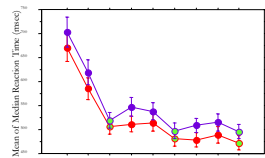


### Effects of instructions and stimuli on implicit sequence learning in older adults:

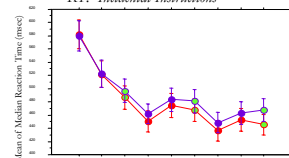
- Measure of sequence learning: Difference (in accuracy or in RT) between high versus low frequency "triplets" of trials (Howard et al. 2004). (i.e., triplet type effects)

#### Older Adult Data Only: Split by instruction

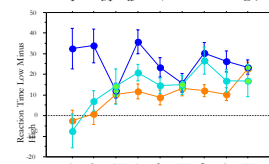
RT: Intentional Instructions



RT: Incidental Instructions



Triplet Type effects (RT Low - High)



#### Explicit Awareness influences reaction time performance.

- Cued epochs: overall effect of instruction
  - a triplet type by instruction interaction ( $p < 0.01$ )
  - a triplet type by epoch by instruction interaction ( $p < 0.03$ )

#### Stimuli (grey vs black) affect performance but not sequence learning.

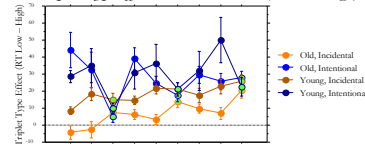
- a triplet type by stimulus interaction ( $p < 0.05$ ) for cued but not uncued blocks

#### Implicit learning unaffected by instruction or stimuli in older adults.

- Uncued epochs: no main effects or interactions with instruction nor stimulus type

### Older adults show deficits in implicit learning:

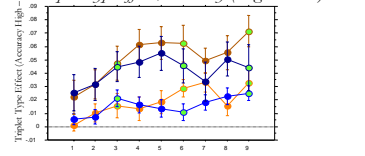
Triplet Type effects, Reaction Time (Low - High)



#### Reaction Time does not reveal age deficits in implicit learning

- For uncued epochs, ANOVAs on triplet type effects reveal only an effect of epoch ( $p < 0.01$ ).

Triplet Type effects, Accuracy (High - Low)



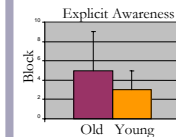
#### Accuracy measures reveal age deficits in implicit learning.

- For all epochs, ANOVAs on triplet type effects revealed an effect of age and of epoch ( $p$ 's  $< 0.01$ ) and for uncued epochs there was a significant effect of age ( $p < 0.01$ ).

### Explicit Awareness: Age deficits

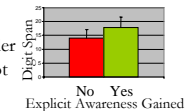
1. Intentional instruction groups, percent who figured out the correct pattern:

Older	Younger
70.1%	100%



2. However, for older adults who learned the pattern, they reached awareness as quickly as younger adults ( $p = 0.14$ ).

3. Digit Span measures significantly differ between older adults who can and who cannot figure out the pattern ( $p < 0.04$ )



## CONCLUSION:

1. Older adults less likely than young to gain explicit knowledge of sequences.
2. Older adults show less implicit learning than young.
3. Implicit learning unaffected by explicit knowledge in both young and old.
4. Separate implicit and explicit sequence learning systems are both affected by aging.