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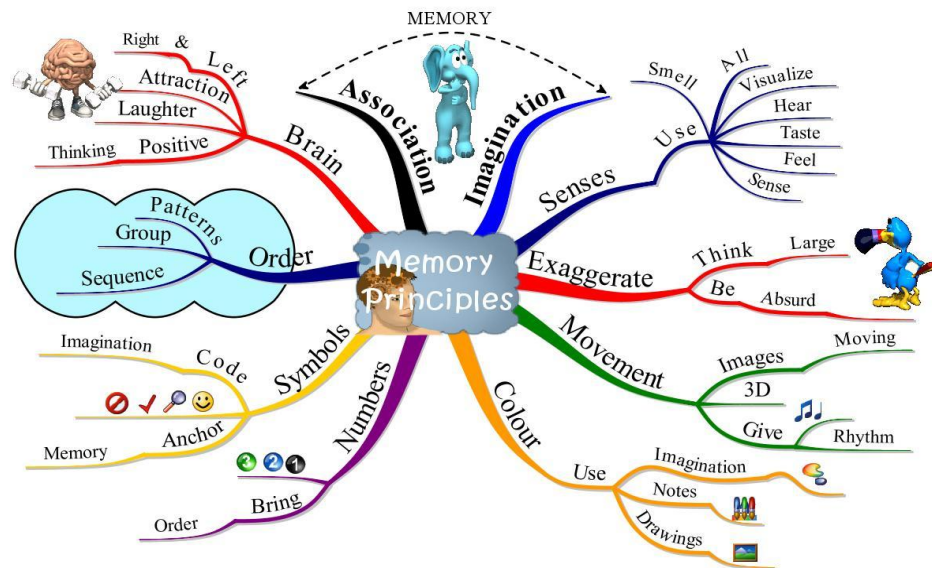
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Cognitive mechanisms in visual associative learning & retrieval: Insights from synaesthesia and old age

Gaby Pfeifer



Synaesthesia

- **Stable perceptual phenomenon** in about 5% of the population
(*Simner et al., 2006*)
- **Enriched sensory experiences** in response to certain stimuli
 - Most common is grapheme - colour synaesthesia



SYNESTHESIA
0123456789

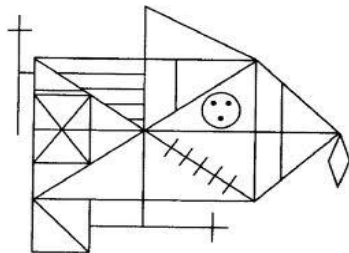
- **Neural basis of Synaesthesia**

Structural brain differences (*Rouw et al. 2011, Review*)

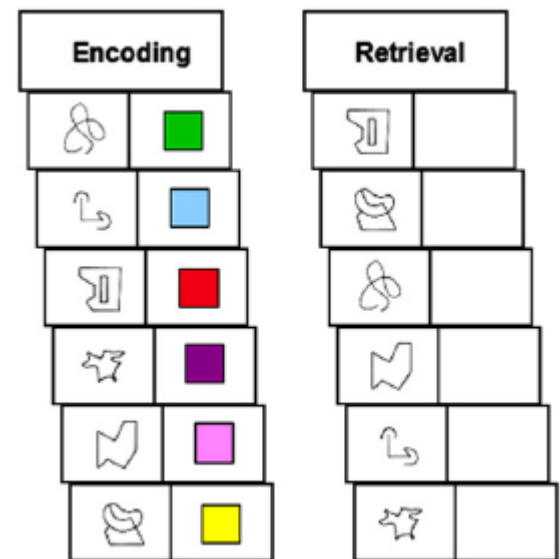
- increased GM - volume
- greater WM - connectivity

Synaesthesia and Memory

- Memory advantage for verbal stimuli (*e.g. Yaro & Ward, 2007; Radvansky et al., 2011*)
- Memory advantage for visual stimuli is less consistent:
- Enhanced associative memory found for stimuli containing **colour** (*Pritchard et al., 2013; Rothen & Meier, 2010*).
- When colours were replaced by achromatic shapes, the memory advantage disappeared (*Gross et al., 2011*).
- **But:** Synaesthetes do have greater visual memory for single abstract shapes (*Rothen & Meier, 2010; Gross et al., 2011*)



Wechsler Memory Scale



The present study

Question: Do perceptual advantages (as found in synaesthesia) contribute to a general associative memory advantage?

- Synaesthetes' memory advantage for *achromatic abstract stimuli* might be too subtle to be detected against young controls.
- **Differences might emerge in comparison to a third group of older adults**
 - reduced GM-volume (*Oh et al., in press*)
 - increased WM-injury (*Lockhart et al., 2012*)
 - visuo-perceptual decline (*Fjell & Walhovd, 2004*)
 - reduced activation in memory-related brain areas (*Gutchess et al., 2005*)
 - *All have been related to a visual associative memory deficit.*

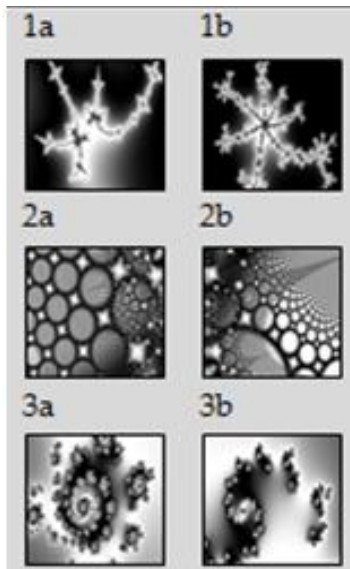
Participants

- 14 young adults with grapheme-colour synaesthesia, 19 – 31 years of age (M=22.50)
- 14 young adults, 19 – 29 years of age (M=22.64)
- 14 older adults, 62 – 83 years of age (M=68.79)

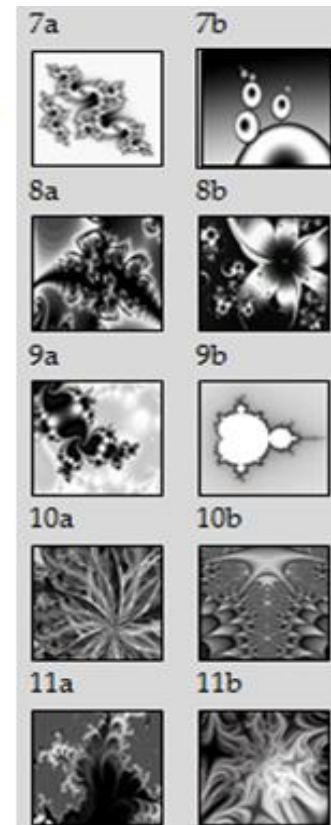
Methods

- **Tasks:** 1) self-paced learning paradigm with performance criterion
2) associative retrieval, immediate & delayed
- **Stimuli:** 8 pairs of achromatic fractals

similar pairs,
low memory load

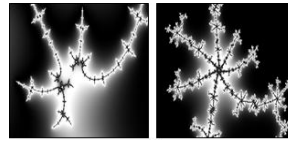


dissimilar pairs,
high memory load

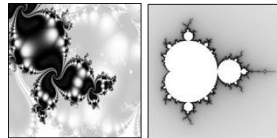


Hypotheses

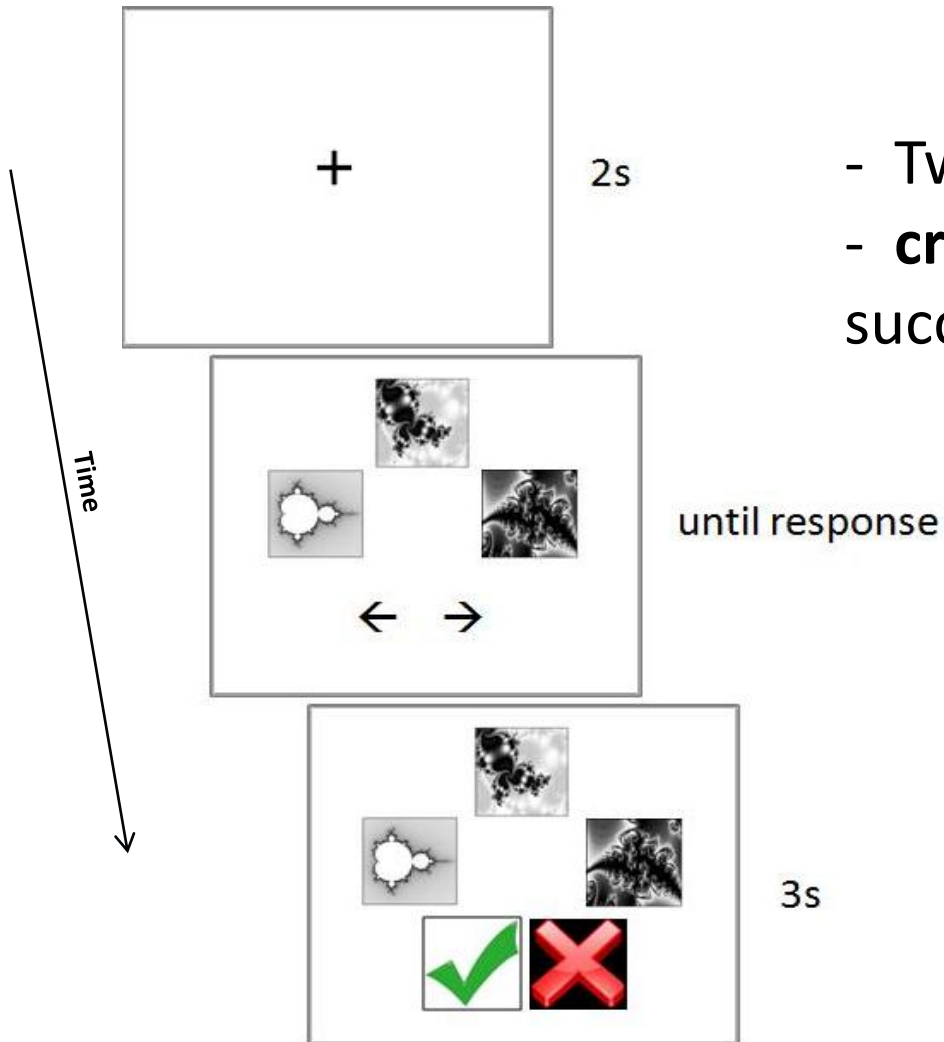
- **Similar pair-associates** should benefit *all* participant groups during learning & retrieval.



- **Dissimilar pair-associates** should bring out enhanced memory performance in synaesthetes, provided that their *enhanced perceptual mechanisms* contribute to better memory. This effect might only be seen in comparison to older adults.

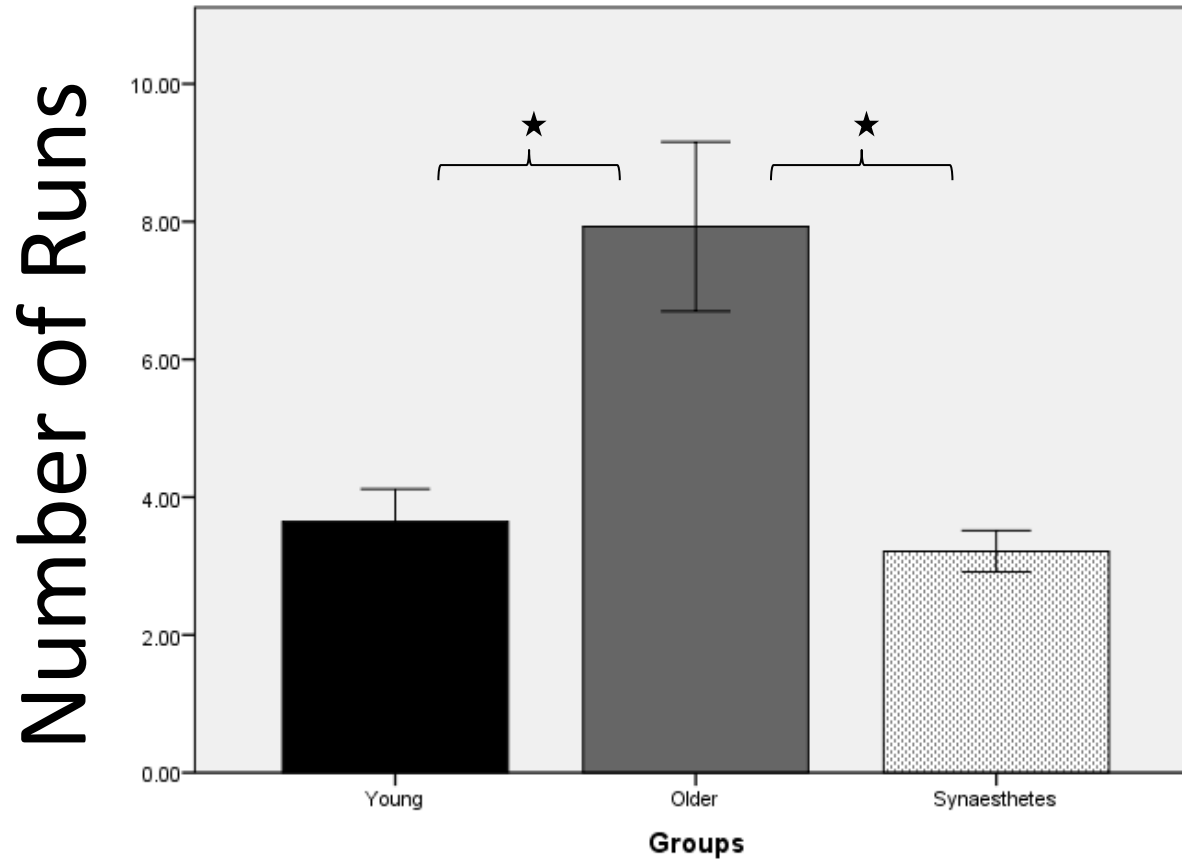


Pair-associative learning



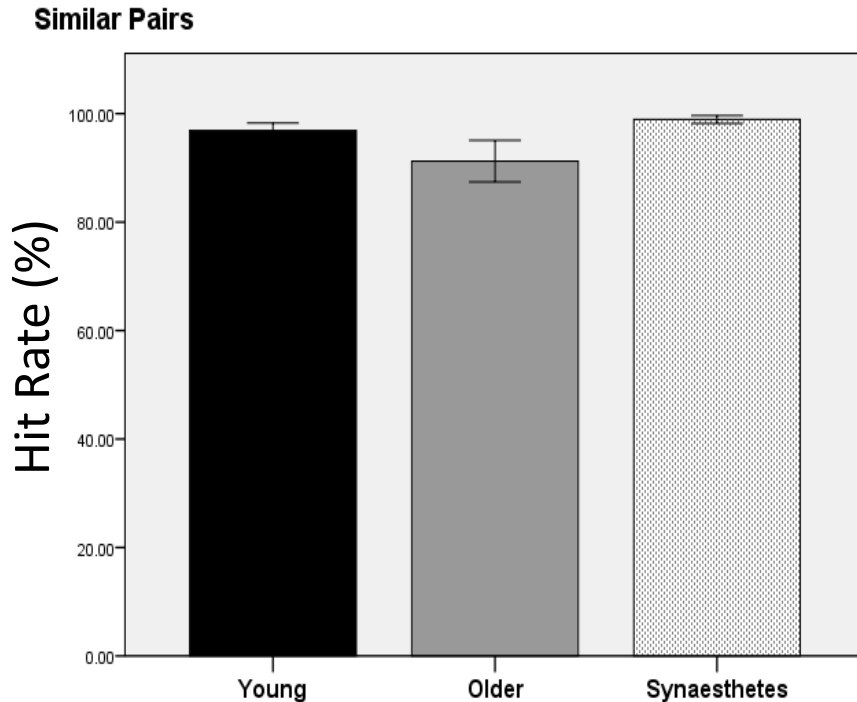
- Two alternative forced choice
- **criterion:** 7 out of 8 Hits in two successive Runs

Results



Error Bars: +/- 1 SE

Similar & Dissimilar pairs



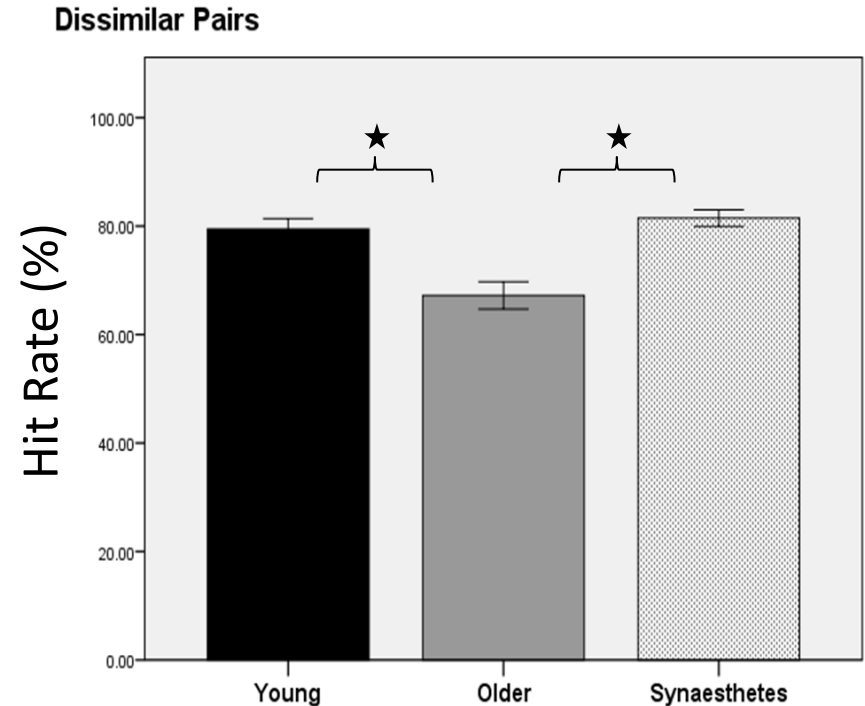
Error Bars: +/- 1 SE

No sign. difference

Syns - Young, $p = .815$

Young - Older, $p = .231$

Syns - Older, $p = .071$



Error Bars: +/- 1 SE

→ Sign. effect, $F[2,39] = 14.42, p < .001$

Syns - Young, $p = .762$

Young > Older, $p < .001$

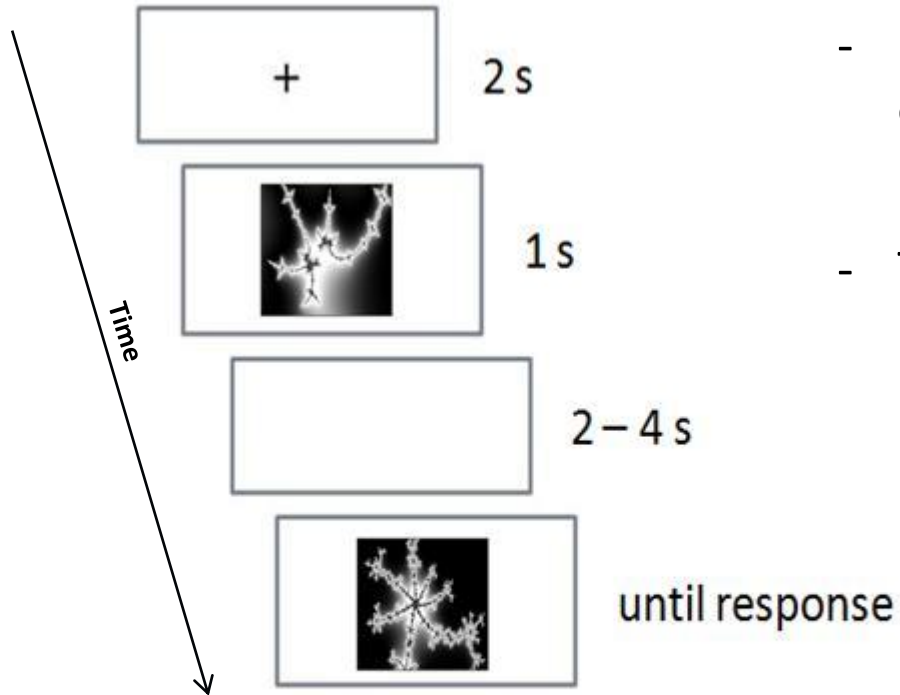
Syns > Older, $p < .001$

Interim Summary I

- **Pair-associative learning paradigm**

- There was an effect of age in learning the **dissimilar pair-associates**.
- However, the synaesthetes' enhanced perceptual mechanisms did not facilitate associative learning *over and above* the effects of age.

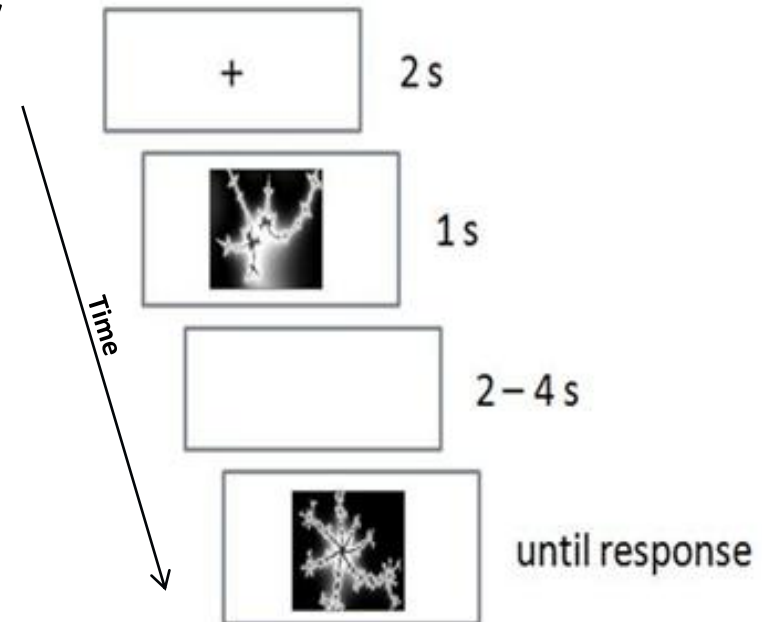
Pair-associative retrieval



- Immediate and delayed retrieval, with completion of visuo-perceptual tasks in between
- Tested on 2 Runs

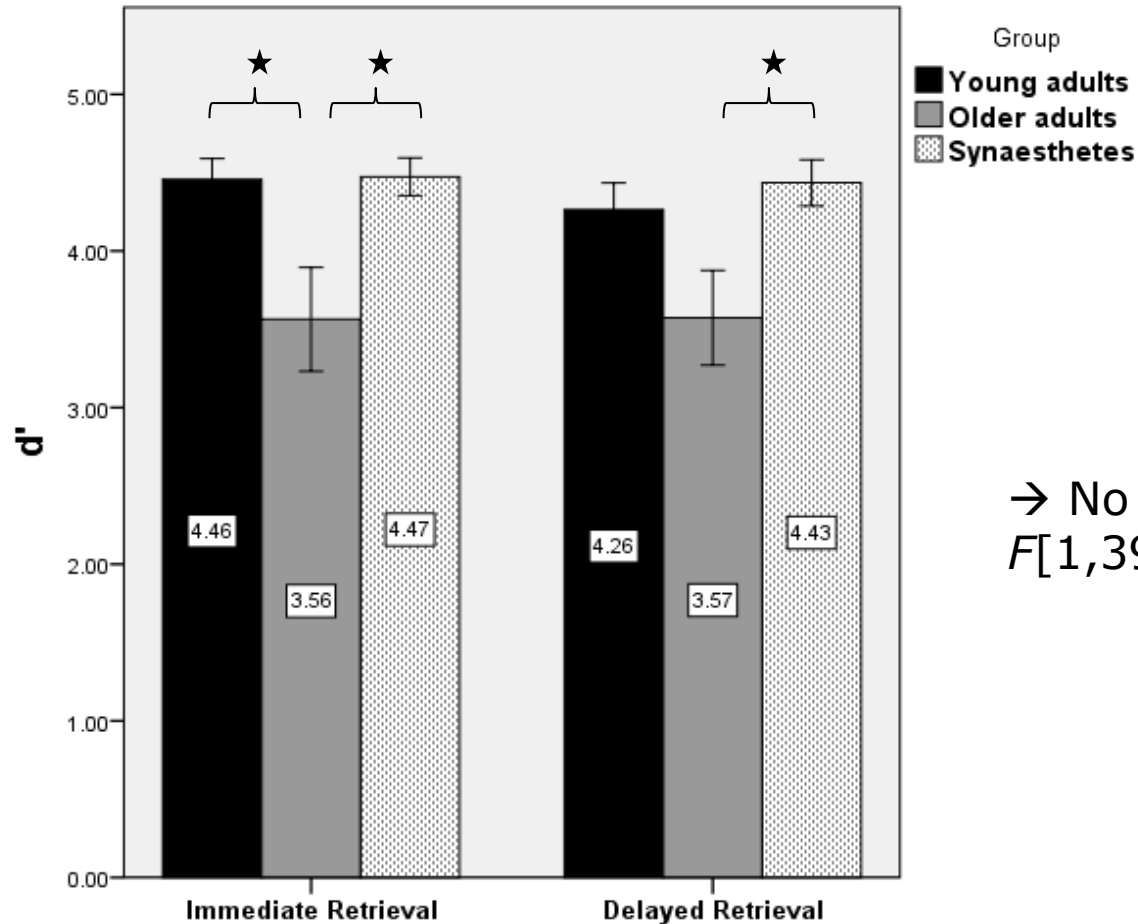
Signal detection analyses

- **d'-prime estimates**
- Represent sensitivity in discriminating between signal trials and noise trials
- $d' = z(\text{proportion Hits}) - z(\text{proportion False Alarms})$
- **Higher d'-prime scores = greater sensitivity**



d'-prime, Similar pairs

Similar Pairs

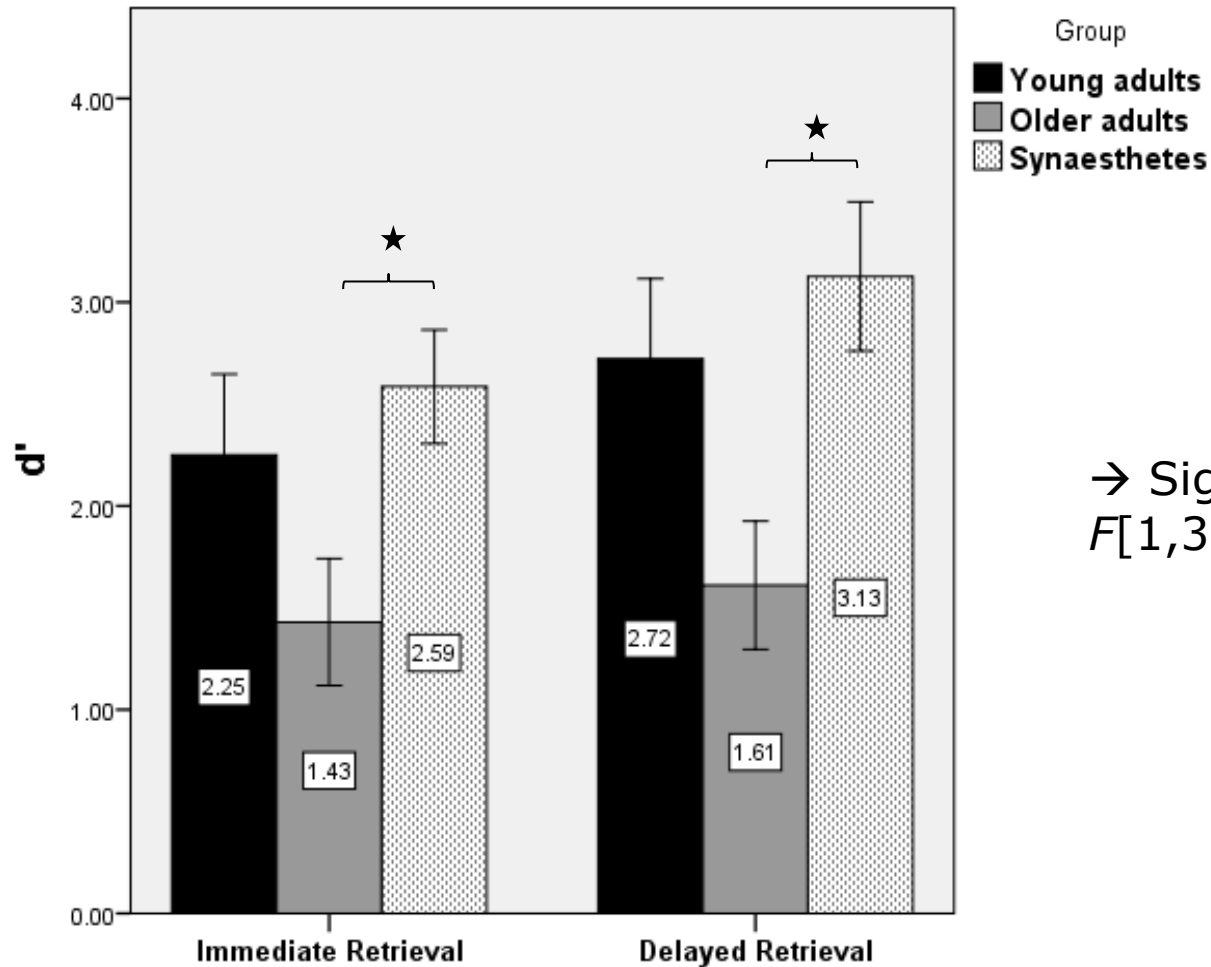


Error Bars: +/- 1 SE

→ No effect of time
 $F[1,39] = .269, p = .607$

d'-prime, Dissimilar pairs

Dissimilar Pairs



Error Bars: +/- 1 SE

→ Sign. effect of time
 $F[1,39] = 4.09, p = .050$

Interim Summary II

- **Pair-associative retrieval task**

- Significantly higher d' -prime scores were *only* found between synaesthetes and older adults
 - similar pair condition at delayed retrieval
 - dissimilar pair condition at both retrieval stages
- This suggests that the synaesthetes' enhanced perceptual mechanisms lead to enhanced sensitivity in discriminating between matching and non-matching pair-associates, resulting in a higher effective memory score.

Conclusions

- 1. Associative memory advantages are obtained even from achromatic, non-synaesthesia-inducing stimuli.**
 - But the advantages are *subtle* and can only be detected in comparison to older adults.**
- 2. Enhanced perceptual mechanisms (as found in synaesthesia) feed into an associative memory advantage.**

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