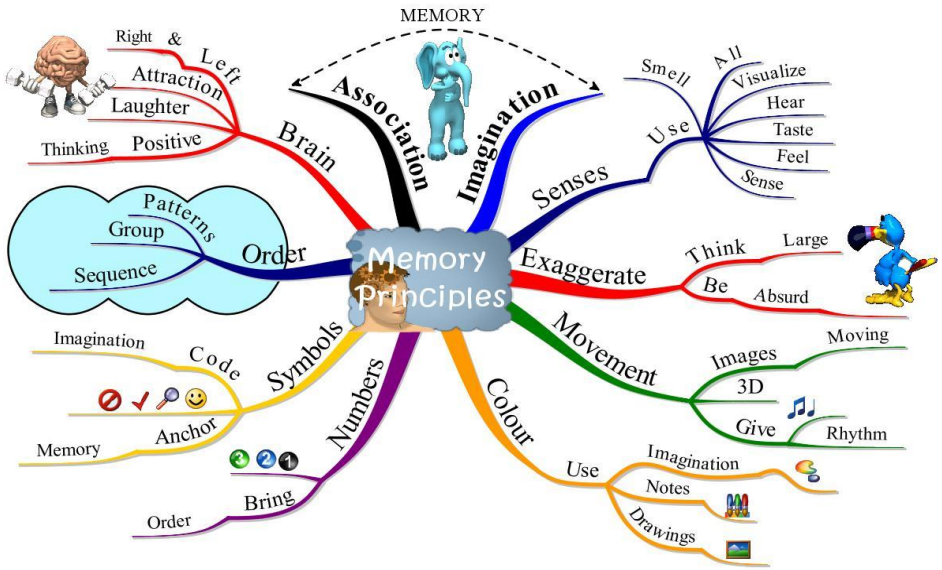
Cognitive mechanisms in visual associative learning & retrieval: Insights from synaesthesia and old age

Gaby Pfeifer



brighton and sussex medical school

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

- **Neural basis of Synaesthesia**

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

  - increased GM - volume
  - greater WM - connectivity

Synaesthesia and Memory

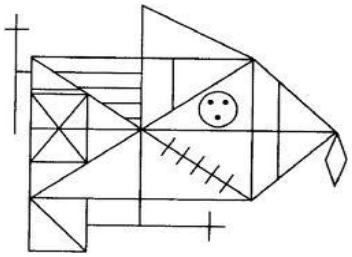
- Memory advantage for verbal stimuli *(e.g. Yaro & Ward, 2007; Radvansky et al., 2011)*

- Memory advantage for visual stimuli is less consistent:

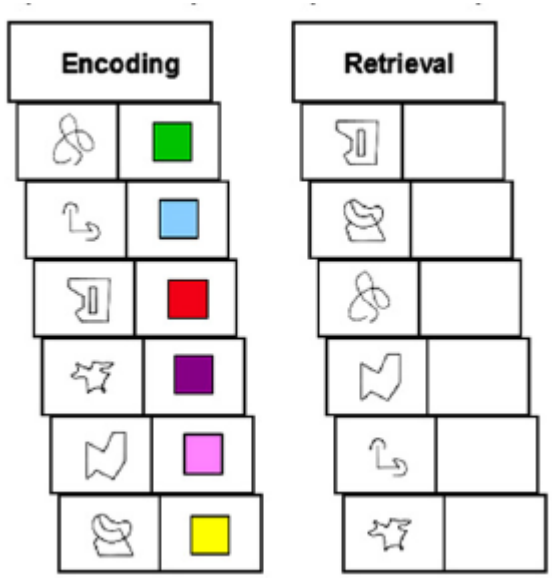
- Enhanced associative memory found for stimuli containing colour *(Pritchard et al., 2013; Rothen & Meier, 2010).*

- 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)

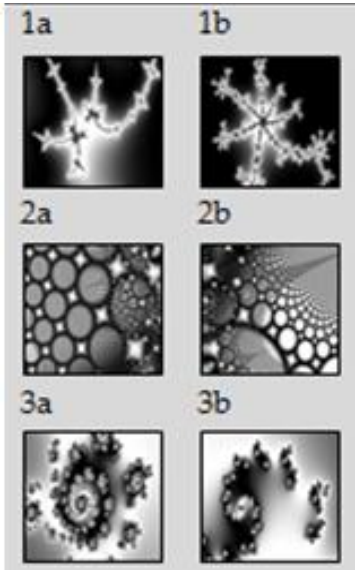
- 14 older adults, 62 – 83 years of age (M=68.79)

Methods

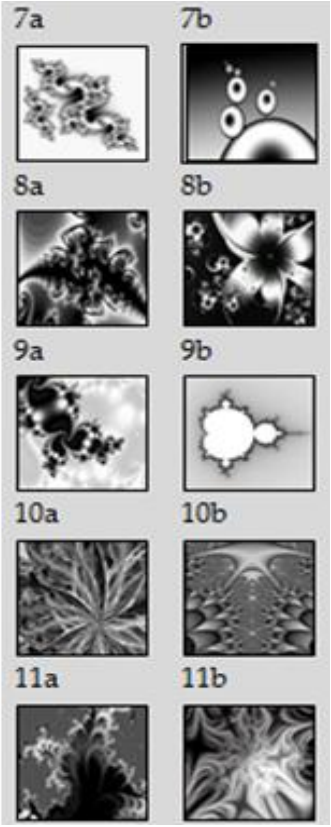
- ***Tasks:*** 1) self-paced learning paradigm with performance criterion
  2) associative retrieval, immediate & delayed

- ***Stimuli***: 8 pairs of achromatic fractals

similar pairs,
low memory load

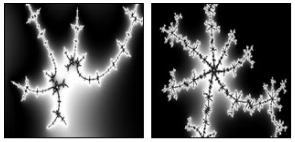


dissimilar pairs,
high memory load

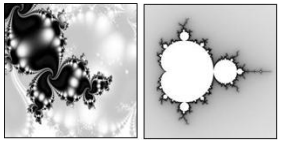


Hypotheses

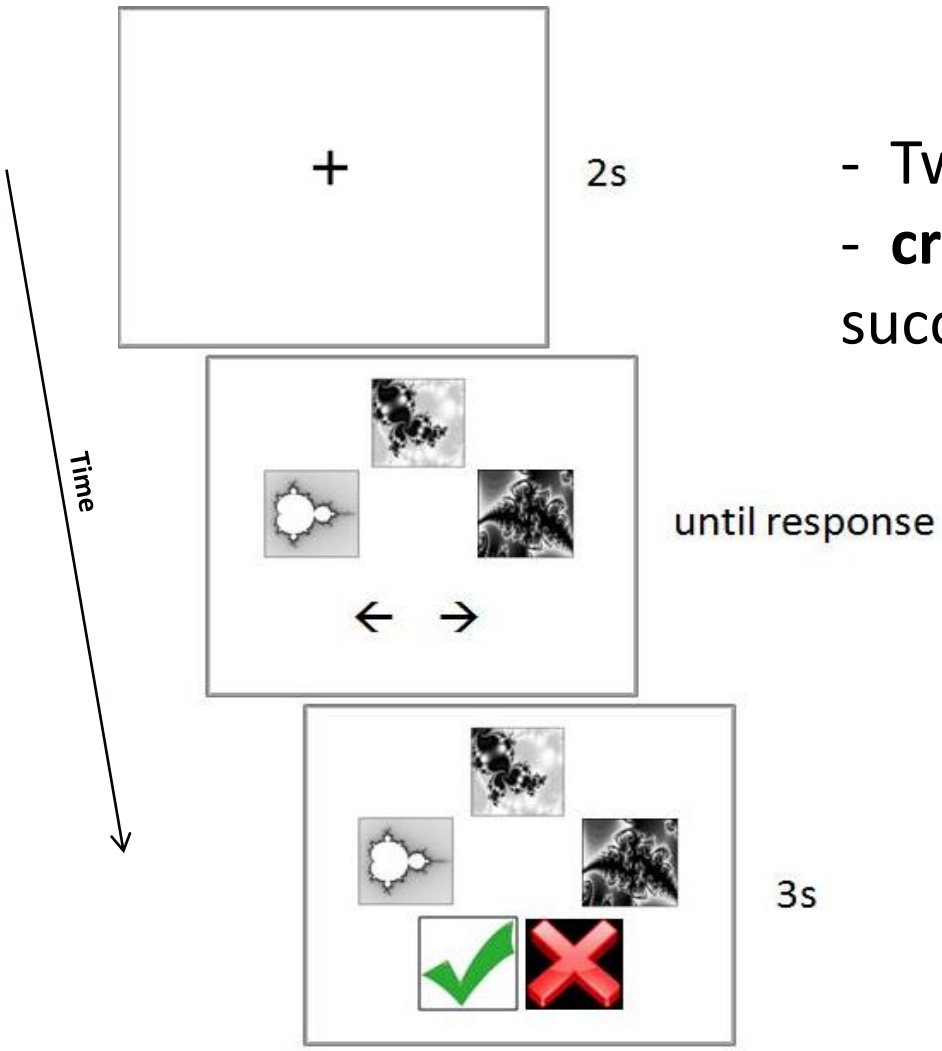
- Similar pair-associates should benefit *all* participant groups during learning & retrieval.



- 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.

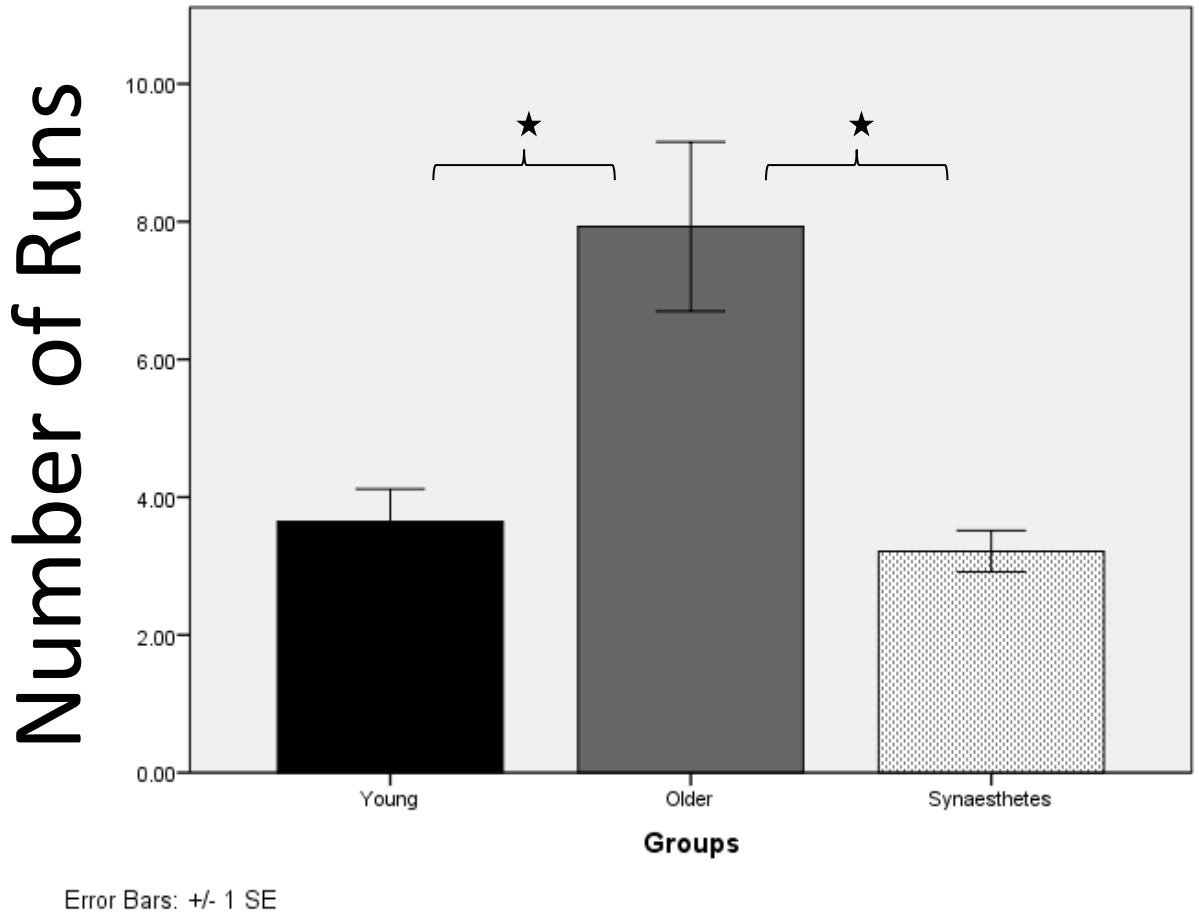


Pair-associative learning

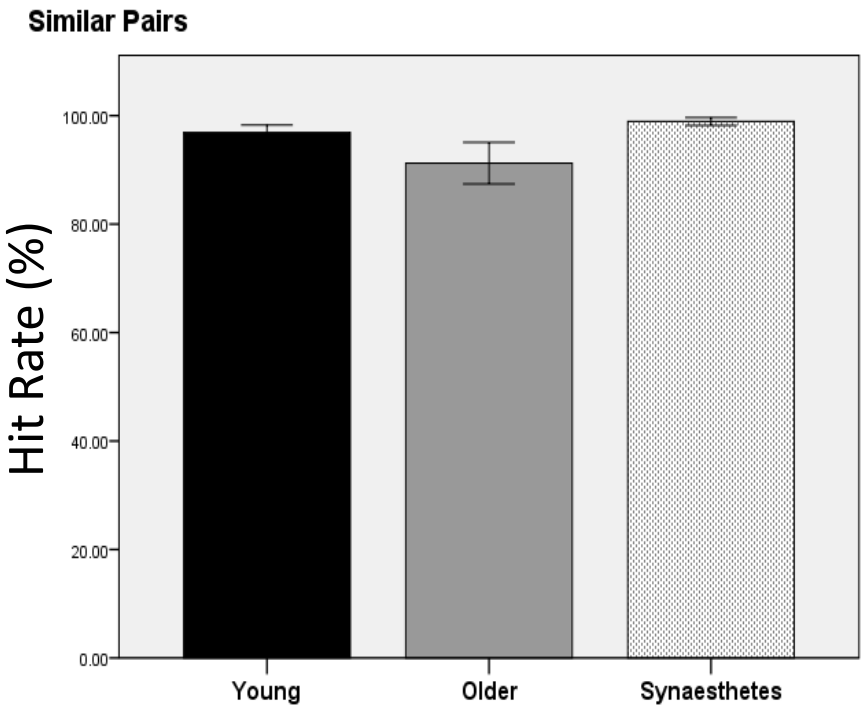


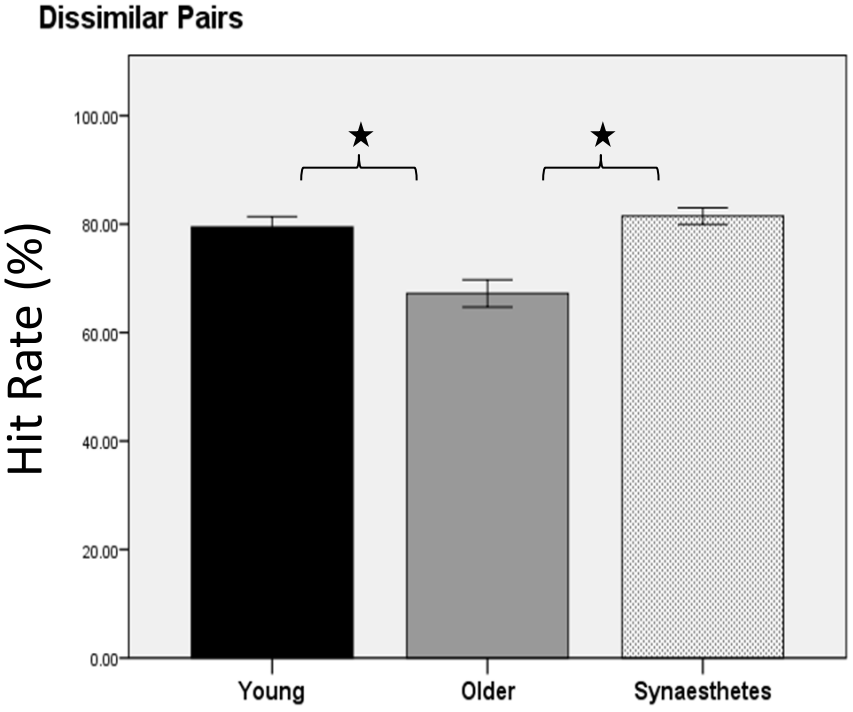
- Two alternative forced choice
- **criterion**: 7 out of 8 Hits in two successive Runs

Results


Number of Runs
10.00
8.00
6.00
4.00
2.00
0.00
★
★
Young
Older
Synaesthetes
Groups
Error Bars: +/- 1 SE

Similar & Dissimilar pairs





No sign. difference

Syns - Young, p = .815
Young- Older, p = .231
Syns - Older, p = .071

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

Syns - Young, p = .762
Young > Older, $p < .001$
Syns > Older, $p < .001$

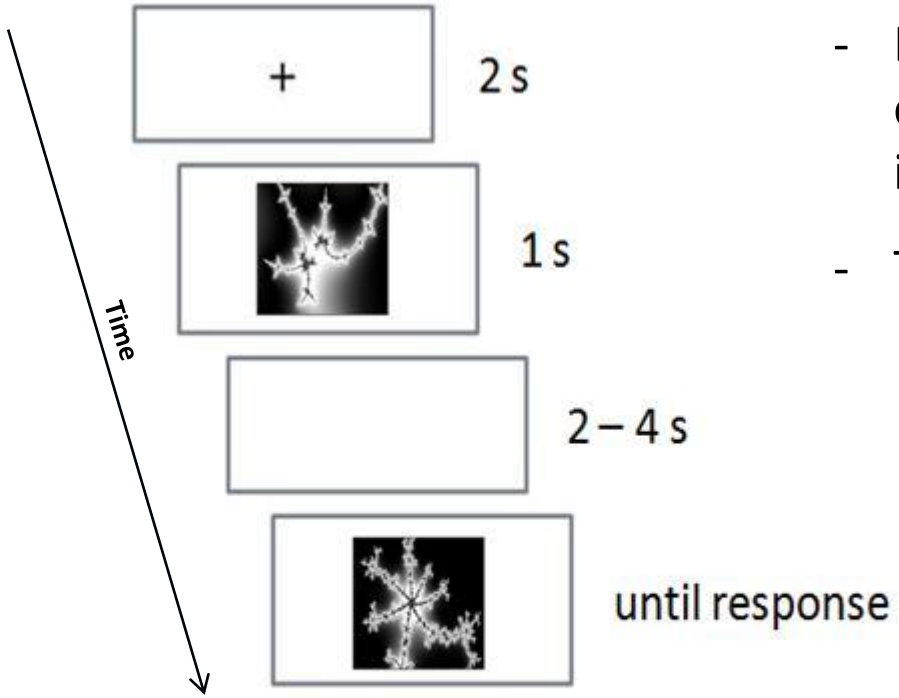
Interim Summary I

- **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

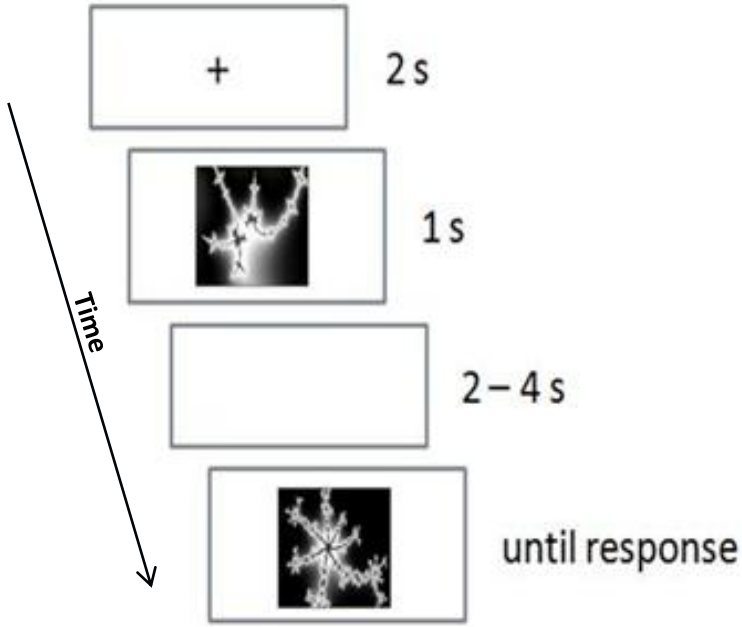


- Immediate and delayed retrieval, with completion of visuo-perceptual tasks in between
- Tested on 2 Runs

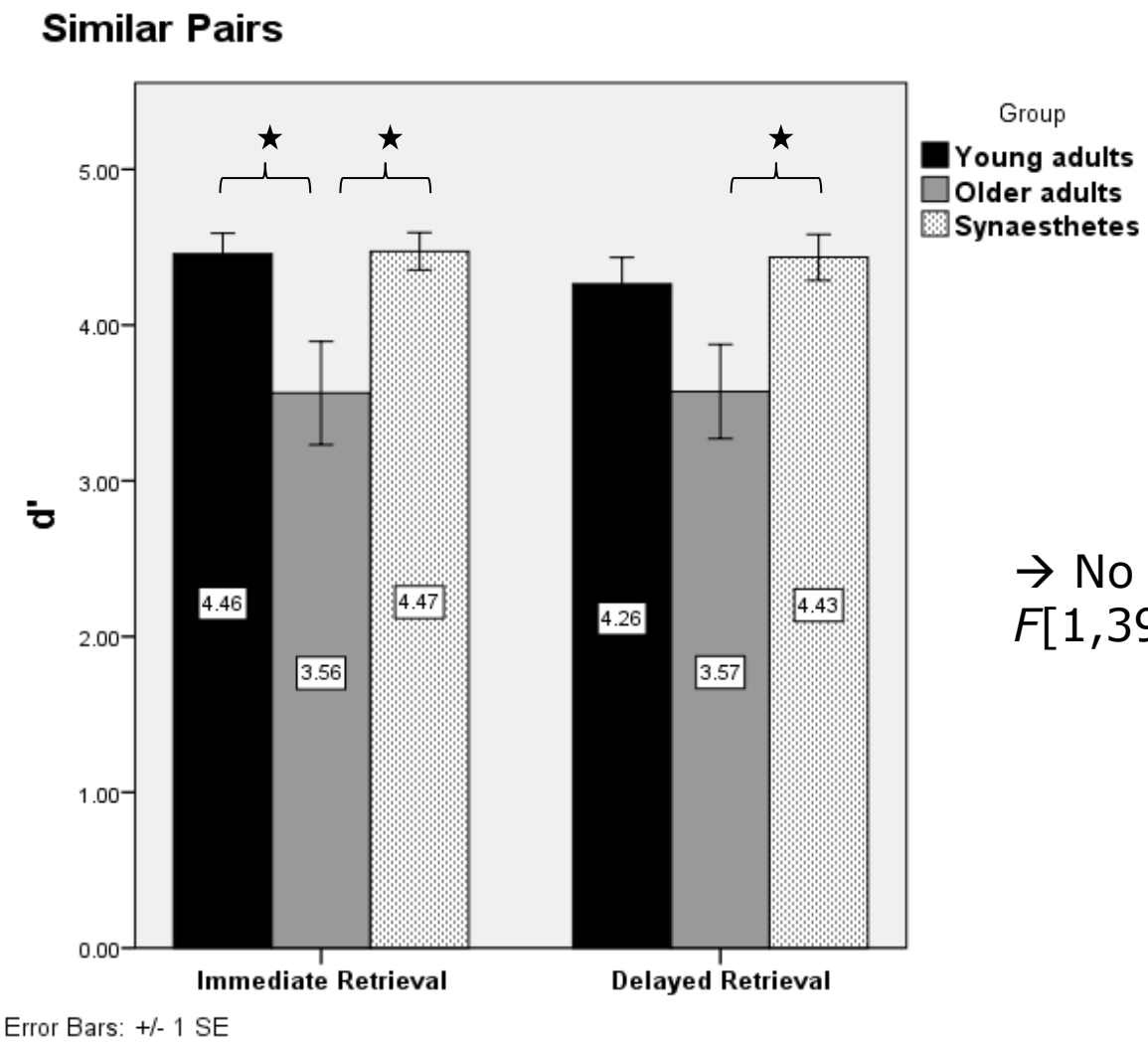
Signal detection analyses

- **d'-prime estimates**
- Represent sensitivity in discriminating between signal trials and noise trials
- d' = *z* (proportion Hits) – *z* (proportion False Alarms)

- **Higher d'-prime scores = greater sensitivity**

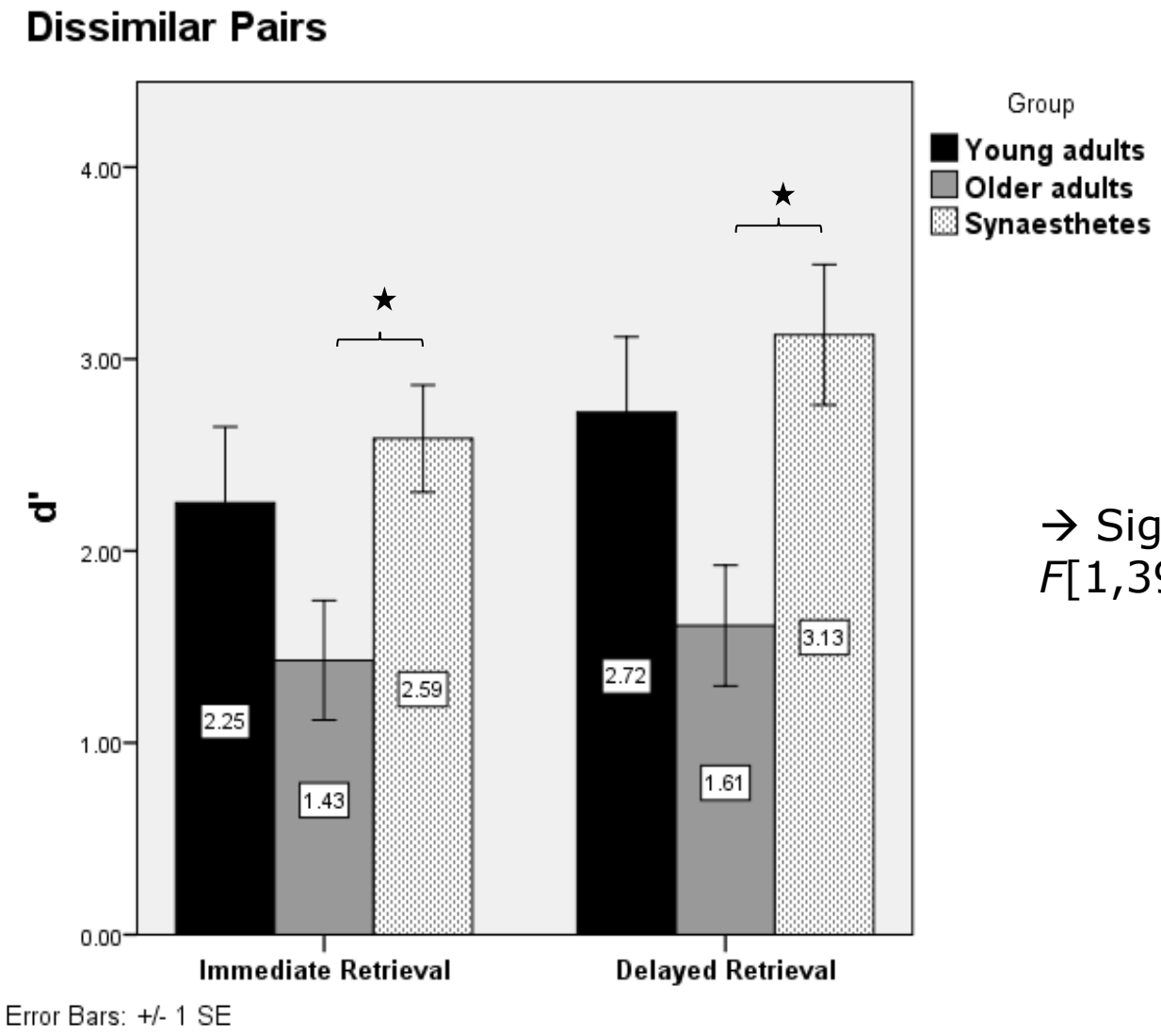


d’-prime, Similar pairs



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

d'-prime, Dissimilar pairs



→ 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 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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References

·Gross, V. C., Neargarder, S., Caldwell-Harris, C. L., & Cronin-Golomb, A. (2011). Superior encoding enhances recall in color-graphemic synesthesia. *Perception, 40*, 196 - 208.

·Lockhart, S.N., Mayda, A.B.V., Roach, A.E., Fletcher, E., Carmichael, O., Maillard, P., Schwarz, C.G., Yonelinas, A.P., Ranganath, & C., DeCarli, C. (2012). Episodic memory function is associated with multiple measures of white matter integrity in cognitive aging. *Frontiers in Human Neuroscience, 6 (56).*

· Pritchard, J., Rothen, N., Coolbear, D., Ward, J. (2013). Enhanced associative memory for colour (but not shape or location) in synaesthesia. Cognition, 127, 230 – 234.

·Gutchess, A.H., Welsh, R.C., Hedden, T., Bangert, A., Minear, M., Liu, L.L., & Park, D.C. (2005). Aging and the Neural Correlates of Successful Picture Encoding: Frontal Activations Compensate for Decreased Medial-Temporal Activity. *Journal of Cognitive Neuroscience 17 (1),* 84–96.

·Rothen, N. & Meier, B. Grapheme–colour synaesthesia yields an ordinary rather than extraordinary memory advantage: Evidence from a group study. *Memory,* 18, 258-264 (2010).

·Rouw, R., Scholte, H. S., & Colizoli, O. (2011). Brain areas involved in Synaesthesia: A review. *Journal of Neuropsychology, 5*, 214 – 242.

·Yaro, C. & Ward, J. (2007). Searching for Shereshevskii: What is superior about the memory of synaesthetes? *The Quarterly Journal of Experimental Psychology, 60 (5),* 681 – 695.

·Ward, J. (2013). Synesthesia. *Annual Review of Psychology, 64 (1)*, 49 - 75.

·Rothen, N., Meier, B., & Ward, J. (2012). Enhanced memory ability: Insights from synaesthesia. *Neuroscience and Biobehavioral Reviews, 36*, 1952-1963.

·Fjell, A.M., & Walhovd, K.B. (2004). Lifespan changes in P3a. *Psychophysiology, 41*, 575–583.

·Naveh-Benjamin, M. (2000). Adult Age Differences in Memory Performance: Tests of an Associative Deficit Hypothesis. *Journal of Experimental Psychology: Learning, Memory and Cognition, 26 (5),* 1170 – 1187.

·Simner, J., Mulvenna, C., Sagiv, N., Tsakanikos, E., Witherby, S. A., Fraser, C., Scott, K., & Ward, J. (2006). Synaesthesia: The prevalence of atypical cross-modal experiences. *Perception, 35*, 1024-1033.

·Oh, H., Madison, C., Villeneuve, S., Markley, C., & Jagust, W.J. (*in press*). Association of Gray Amyloid, and Cognition in Aging. Cerebral Cortex.