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

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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)
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**

1a | 1b
---|---
2a | 2b
3a | 3b

**dissimilar pairs, high memory load**

7a | 7b
---|---
8a | 8b
9a | 9b
10a | 10b
11a | 11b
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

Groups

Error Bars: +/- 1 SE
Similar & Dissimilar pairs

**Similar Pairs**

- **Hit Rate (%)**
- **Error Bars: +/- 1 SE**

**Dissimilar Pairs**

- **Hit Rate (%)**
- **Error Bars: +/- 1 SE**

**No sign. difference**
- Syns - Young, $p = .815$
- Young - Older, $p = .231$
- Syns - Older, $p = .071$

$\Rightarrow$ **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 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


