Neural differentiation at encoding predicts memory performance in young and older adults.

Sabina Srokova

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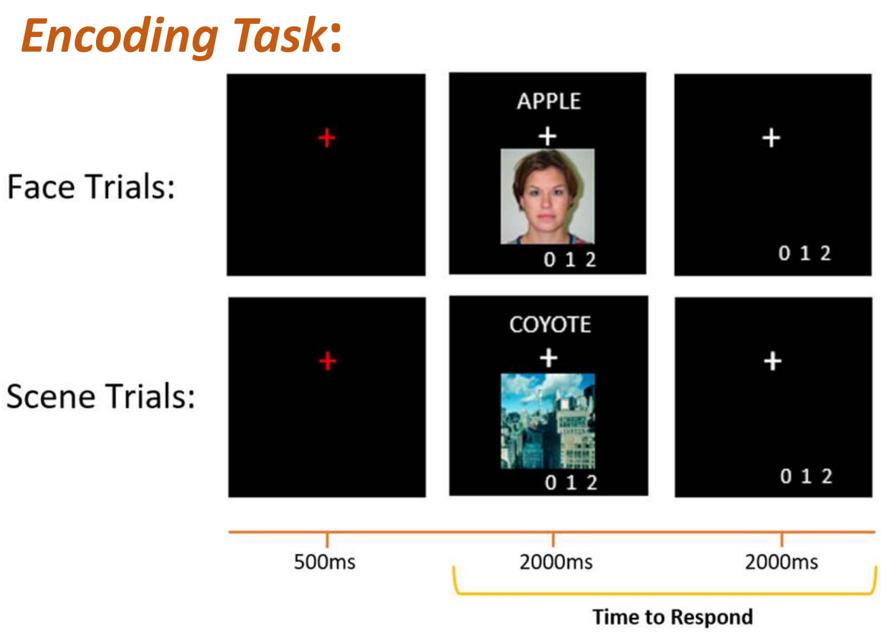
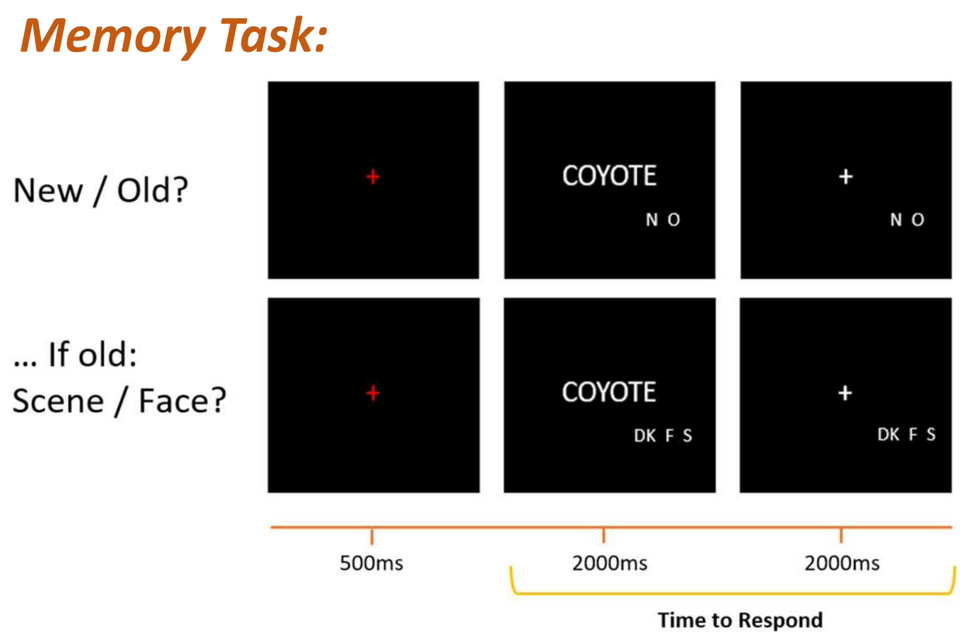
functional Neuroimaging of Memory

Background

- Neural dedifferentiation in older age – reduced distinctiveness of perceptual representations. (Park et al., 2004, 2012)
- Neural dedifferentiation as a factor driving age-related cognitive decline. (Berron et al., 2018; Park et al., 2010)
- Crucially, the relationship between neural differentiation and cognitive performance appear to not be moderated by age – i.e. it is age-invariant (Koen et al., 2019)
- The phenomenon is not ubiquitous to all stimuli. (Voss et al., 2008)





Active Encoding Task:

Faces: Imagine the person interacting with the object denoted by the word.

Scenes: Imagine the object denoted by the word interacting with the scene.

Rate the vividness of the imagined scenario.

Behavioral Performance

	Younger Adults	Older adults	p-value
Item Memory – Faces	0.69 (0.18)	0.56 (0.14)	.008
Item Memory – Scenes	0.67 (0.17)	0.52 (0.13)	.002
Source Memory	0.68 (0.18)	0.51 (0.16)	.001

Item memory computed as the difference between hit and false alarm rates:

$$Item\ pR = \frac{Item\ Hit}{Old\ Trials} - \frac{False\ Alarms}{New\ Trials}$$

Source memory computed using a single high-threshold model (Snodgrass and Corwin, 1988):

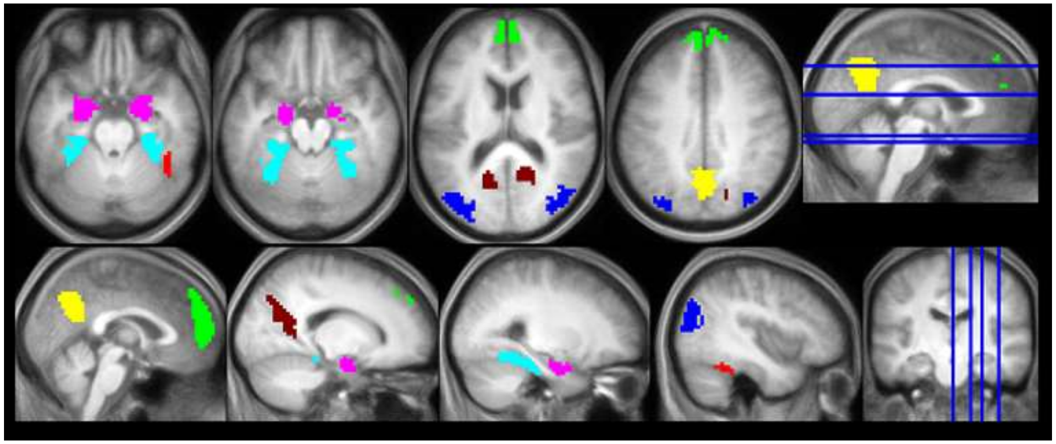
$$pSR = \frac{pSource\ Hit - 0.5 * (1 - pSource\ Don't\ Know)}{1 - 0.5 * (1 - pSource\ Don't\ know)}$$

Measuring Neural Differentiation
Differentiation Index

$$Differentiation\ Index = \frac{\mu_{pref} - \mu_{non\ pref}}{\sqrt{\frac{\sigma^2_{pref} + \sigma^2_{non\ pref}}{2}}}$$

Voss et al., 2008

Differentiation Index computed for 7 Regions of Interest:



Face-selective ROIs:

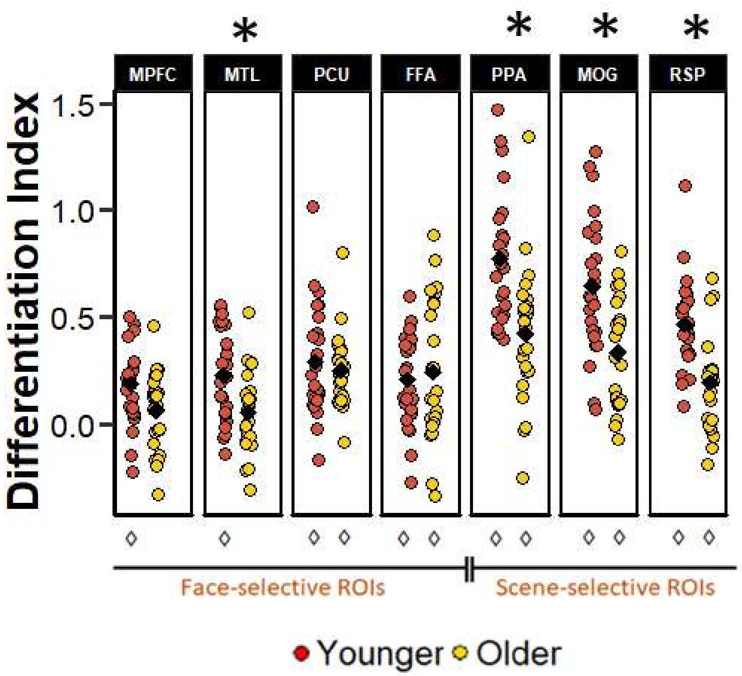
- Medial Prefrontal Cortex (**MPFC**)
- Medial Temporal Lobe (**MTL**)
- Precuneus (**PCU**)
- Fusiform Face Area (**FFA**)

Scene-selective ROIs:

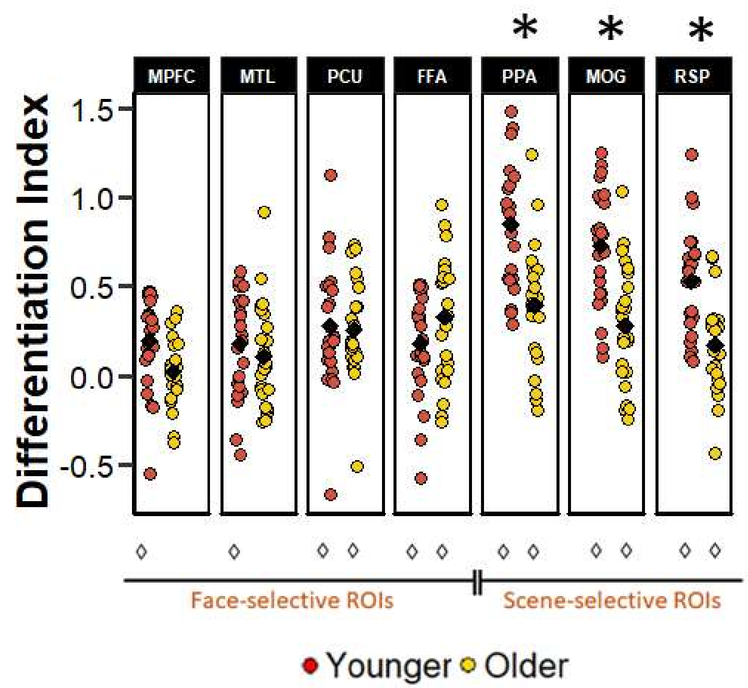
- Parahippocampal Place Area (**PPA**)
- Middle Occipital Gyrus (**MOG**)
- Retrosplenial Cortex (**RSP**)

Differentiation Index

Differentiation indices in each ROI across all trials.



Differentiation indices for source correct trials only.



** Sig. age difference after correcting for multiple comparisons*
◊ Index sig. different from zero

Measuring Neural Differentiation

Pattern Similarity Analysis

Similarity Index = Within-class Similarity – Between-class Similarity

Within-class similarity

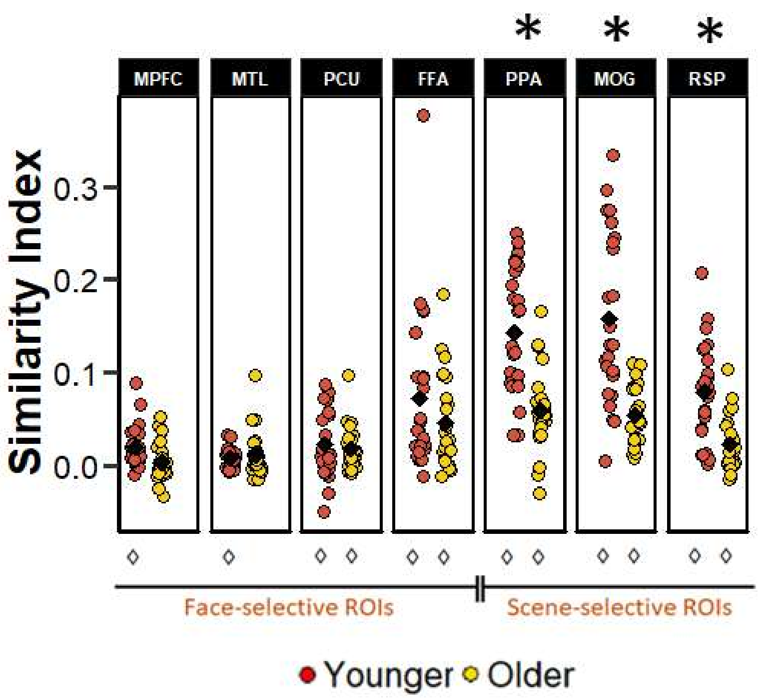
*Average correlation between a given trial and all trials of the **same** image category.*

Between-class similarity

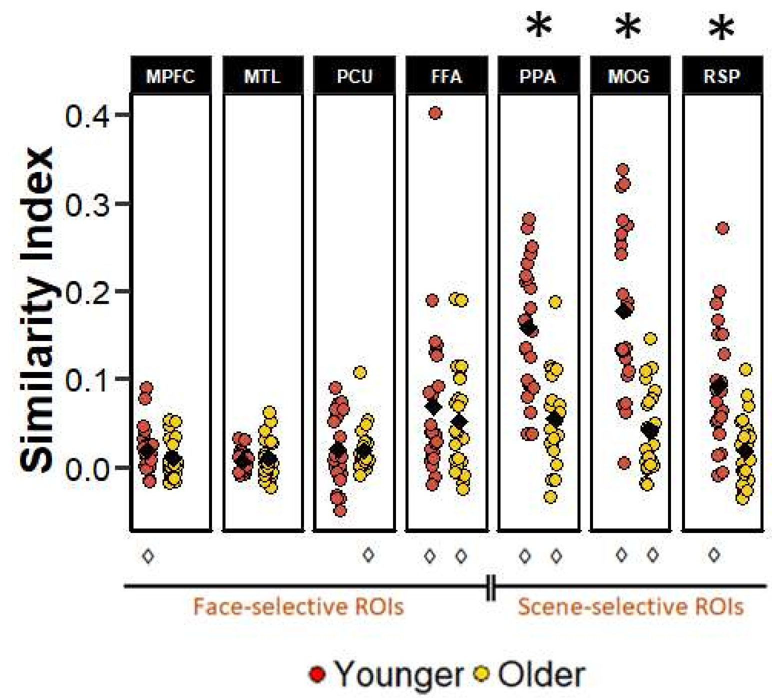
*Average correlation between a given trial and all trials of the **other** image category.*

Pattern Similarity Analysis

Similarity indices in each ROI across all trials.



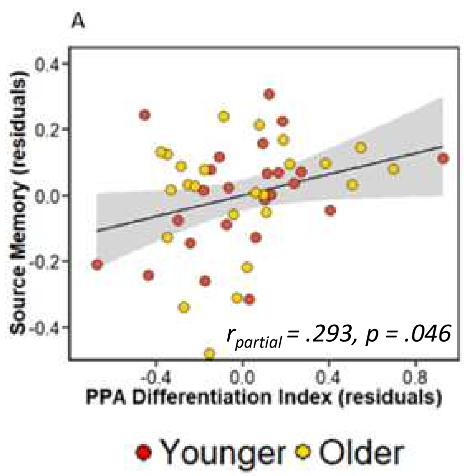
Similarity indices for source correct trials only.



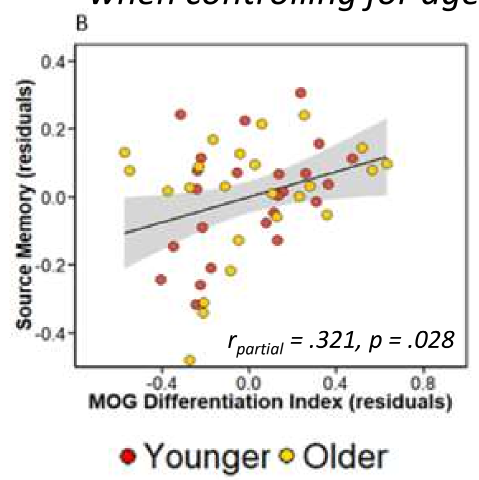
* *Sig. age difference after correcting for multiple comparisons*
◊ *Index sig. different from zero*

Relationship with Memory performance

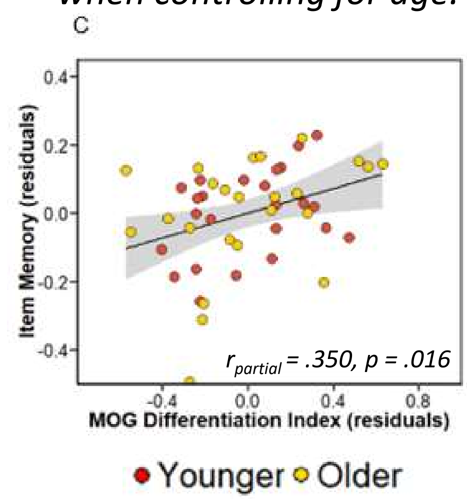
PPA Differentiation index and Source Memory when controlling for age.



MOG Differentiation index and Source Memory when controlling for age.



MOG Differentiation index and Item Memory when controlling for age.



Conclusions

- The relationship between neural differentiation and memory performance is *age-invariant*.
- Age-related neural dedifferentiation is not ubiquitous for all types of stimuli. Why?
  - Lifetime experience?
  - Inefficient perceptual processing of highly complex stimuli?
  - Inconsistent reports for face stimuli? Passive vs Active encoding tasks? Differing ways of operationalizing neural differentiation?

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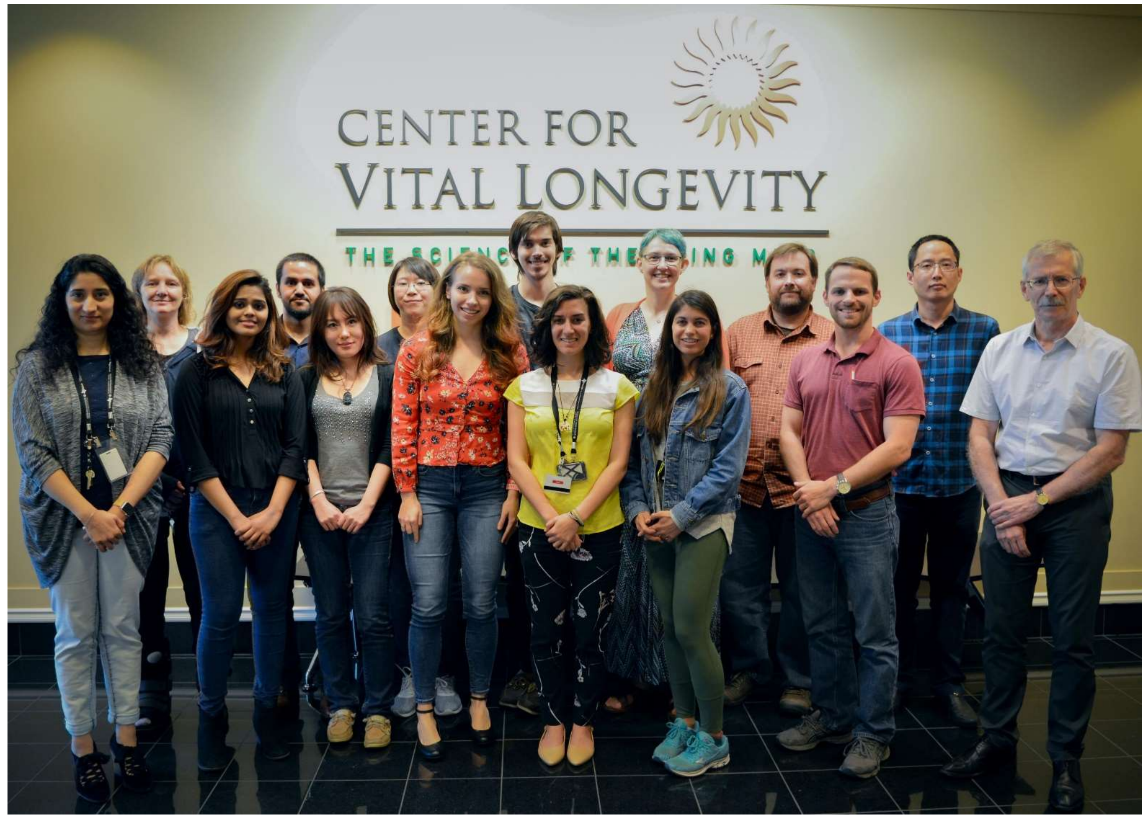

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