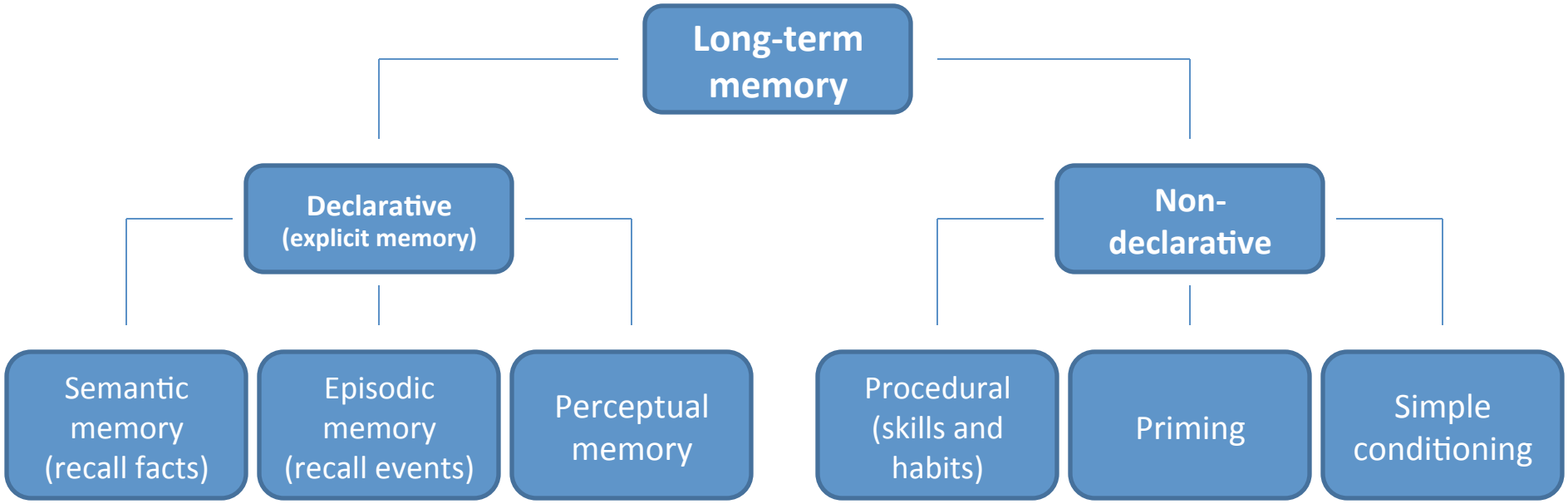
Insights into the ageing mind: a view from cognitive neuroscience

Trey Hedden and John D.E. Gabrieli

2004

Conceptualization of the long-term memory
(Squire & Zola, 1996)



→ **short-term memory:** information that is retained on the order of seconds or minutes

→ **Working memory:** refers to the short-term store and performs certain mental operations during retention

!Discussion!

What can be challenging in research investigating effects of ageing?

- separation of normal ageing from pathological processes
- no **experimental manipulation** of age → correlational effects
- mostly **cross-sectional** comparisons between age groups and no **longitudinal** designs
  - *cross-sectional studies:* confounded by cohort differences
    → overestimation of age-related differences
  - *longitudinal studies:* practice effects and selective attrition might lead to
    → underestimation of age-related changes
- **Causal relationships**: parallel occurence of brain and mental changes
- differences **in recruitment methods**: volunteering vs. Testing in their home

Findings from Behavioural Research

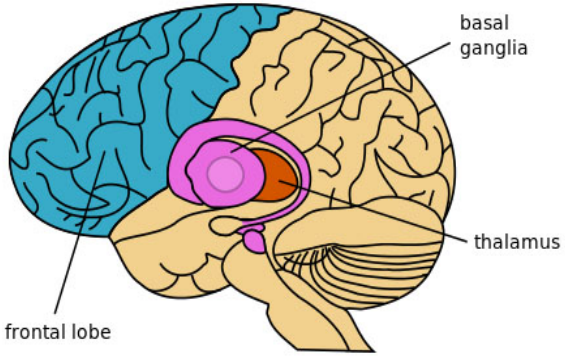
- three descriptive patterns of age-related changes in cognitive behavior
  - *life-long declines*
    - processing speed, working memory and encoding of information into episodic memory
    - different results in cross-sectional and longitudinal studies
  - late-life declines
    - well-practiced tasks or tasks involving knowledge
    - short-term memory (phonological storage): measures by digit span task
    - vocabulary and semantic knowledge
  - life-long stability
    - autobiographical memory, emotional processing and automatic memory processes
    - implicit memory

Normal vs. Pathological Ageing

- A two-component model -

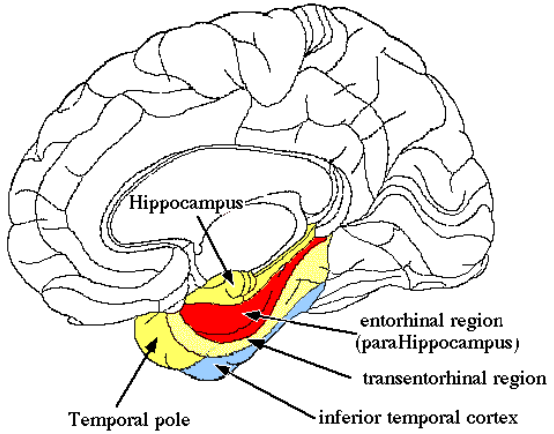
Normal Aging – Changes in the frontostriatal system

- Involves the frontal lobes and the basal ganglia
- Decreases in dopamine, noradrenaline and serotonin
- Declines in the volume and function of the PFC



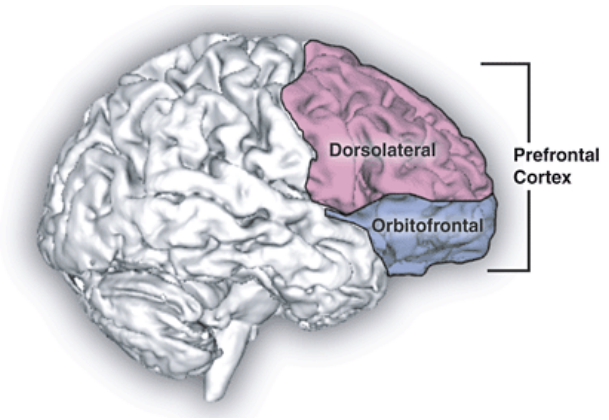
Pathological Aging

1.) loss of volume in the entorhinal cortex
2.) advanced state: impairment of the hippocampus



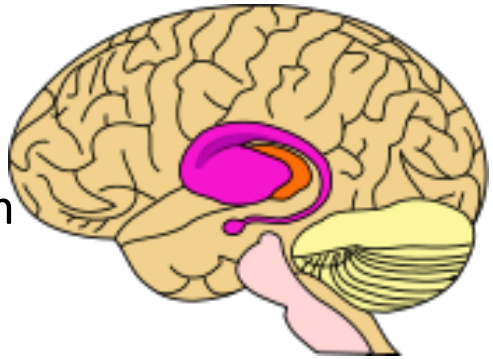
Prefrontal cortex and Striatal circuits

- PFC: largest age-related volumetric changes (5%)
  → decreased synaptic density



- Declines in the striatum (3%)

- Declines of neurotransmitters in the PFC and striatum
  - Dopamine concentration
  - Transporter availability
  - Dopamine D2 receptor density



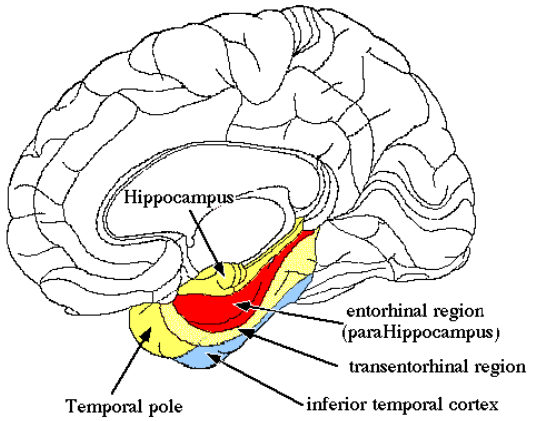
Prefrontal cortex and Striatal circuits

- Impact on the cognitive performance

  - fMRI and PET studies show that subregions of the PFC subserve executive processes
    - investigated tasks: increased working memory demands, control inference, task-switching, etc.

  - Older adults experience greater difficulty than younger adults in performing executive processes
    - Less activity in PFC
    - Additional activations in PFC regions contralateral to those activated in younger adults → aids processing

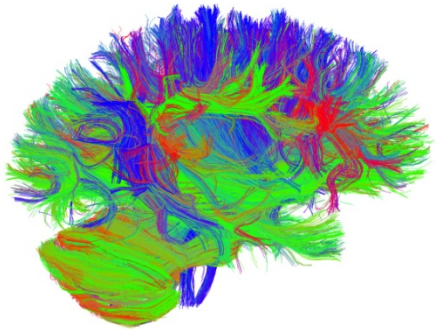
Medial temporal lobe and Hippocampus



- Only slight age-related changes
- After the age of 60 hippocampal volume tends to predict explicit memory performance
  - Activity in the left hippocampus is decreased relative to younger controls during tasks that require the maintenance of pictures or encoding of subsequently remembered words
  - Simultaneous changes in prefrontal activation
    → hippocampal activity is part of a circuit that involves the PFC

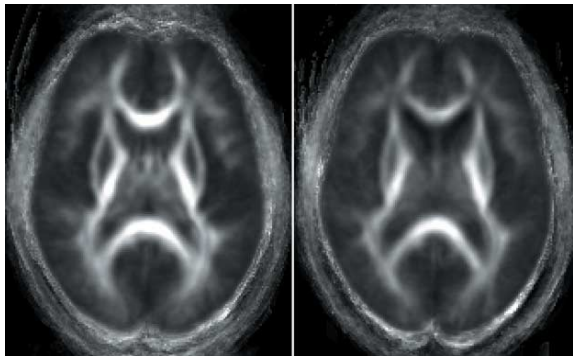
Decreases in hippocampal activity can be explained due to changes of the PFC as older adults tend to process task information by **alternative routes**

White vs. Grey matter



- Grey matter:
  - post-mortem and in vivo studies show a reduction in older adults as a result of **lower synaptic densities**

- White matter:
  - *Diffusion tensor imaging (DTI):* is a MRI-based neuroimaging technique which makes it possible to visualize the location, orientation and direction of the brain's white matter tracts
  - Greatest normal age-related changes in white matter occur in the **PFC** and **anterior corpus callosum**
  - Correlation between decreases in frontal white matter coherence and decreases in **processing speed** and **reasoning ability**



Age-related changes in the grey and white matter of the frontal cortex mediate behavioural patterns of cognitive ageing

Individual Variability

- General age-related **decreases in function** tend to be accompanied by **increases in variability**
  - Individual differences: life experiences, genetic influences, preferred strategies, susceptibility to neuropathology
  - Variability within individuals across tasks
  - Variability within individuals across time: remarkable stability before the age of 60
- **behavioural performance** seems to be similar, **functional activation** often differs among individuals
  - Age-related declines might affect the neural correlates of processing efficiency
  - Higher activation levels might be necessary to maintain same level of performance as younger adults

Individual Variability

How can there be older adults who tend to perform as well as younger ones?

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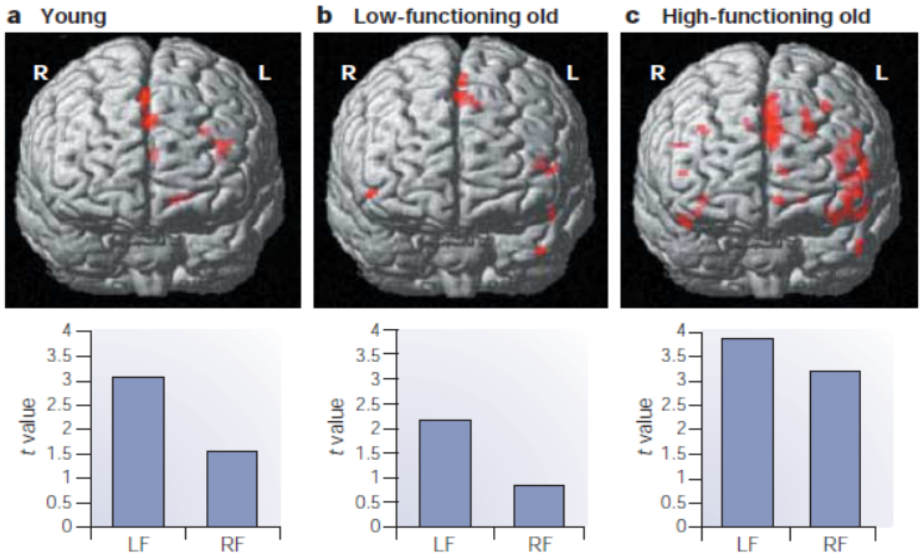
- **High-performance vs. low performance:**
  - Frontal function in strategic memory tasks or source memory



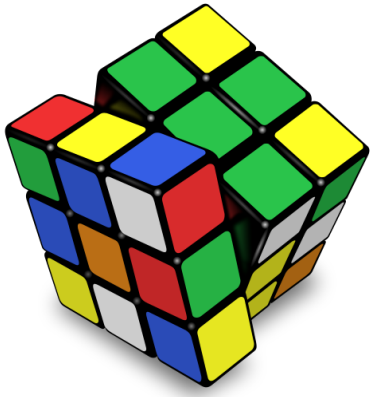
  - High-performing older adults show greater functional activation of brain regions that are less active in younger adults

How can there be older adults who tend to perform as well as younger ones?

- breakdown in inhibitory connections: high-functioning older adults often show neural compensation by a recruitment of irrelevant or competing brain regions

Individual differences in older populations are due to variability in the severity of deficits in the two-component model

How can we care about our ageing brain?



Stay intellectually engaged

Maintain cardiovascular physical activity

Minimize chronic stressors

Maintain a brain-healthy diet

Literature

- Trey Hedden & John D.E. Gabrieli (2004). Insights into the ageing mind: a view from cognitive neuroscience perspective. Nature reviews neuroscience 5, 87-96.

- Brickman, A. M. & Stern, Y. (2009). Aging and Memory in Humans. Encyclopedia of Neuroscience, Vol. 1, 175-180.

- Squire, L. R. & Zola, S. M. (1996). Structure and function of declarative and non-declarative memory systems. Proceedings National Academy of Science 93, 13515-13522.