Visuospatial abilities throughout the lifespan: a dorsal visual stream decline?

Anne-Sophie Laurin[1], Jane Abdo[1], Linda Gabriela Dunoyer[1], Denise Y. Henriques[2], Bernard Marius 'T Hart[2] & Aarlenne Khan[3]

[1]Department of Psychology, Université de Montréal, QC, Canada, [2]School of Kinesiology & Health Science, York University, ON, Canada, [3]School of Optometry, Université de Montréal, QC, Canada

École d'optométrie
Université de Montréal
YORK UNIVERSITÉ UNIVERSITY
CIHR IRSC Canadian Institutes of Health Research / Instituts de recherche en santé du Canada
CIRCA

Introduction

Visuospatial abilities enable perception of details and globality, identification of objects' locations, visualization, mental operations on visual stimuli, etc[1].

Spatial:
- Localization in space, movement
- Associated with the dorsal visual stream

Discrimination:
- Perceiving features, details
- Associated with the ventral visual stream

In aging, it has been suggested that change in visuospatial abilities may be due to a specific impairment of the dorsal visual stream[2].

How do different visuospatial abilities evolve over the lifespan?

How do visuospatial abilities involving the dorsal stream compare to abilities involving the ventral stream?

Methods

52 participants (*M* = 58 years, *SD* = 13 years, range = 40-85 years) completed 12 different online spatial and non-spatial tasks from their personal computer.

Spatial tasks

1. Visual search task
2. Spatial N-back task
3. Reach correction task
4. Mirrored reaching task
5. Mental rotation task
6. Spatial working memory task*
7. Paired associates learning task*

Non-spatial tasks

1. Visual oddity task
2. Task switching/ flexibility task
3. Rapid visual processing task*
4. Stockings of Cambridge: planning task*
5. Delayed matching to sample task*

*These tasks were taken from the Cambridge Neuropsychological Test automated Battery (CANTAB). For more details:

We used linear regressions for statistical analysis, including age and education level (university degree or not) as predictors for performance on the tasks.

References

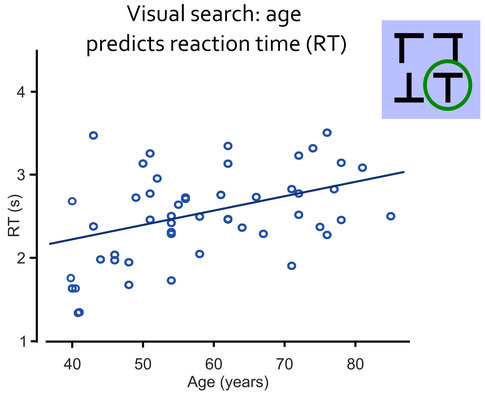
1. Salimi, S., Irish, M., Foxe, D., Hodges, J. R., Piguet, O., & Burrell, J. R. (2017). Can visuospatial measures improve the diagnosis of Alzheimer's disease? *Alzheimer's & dementia, 10*, 66–74. https://doi.org/10.1016/j.dadm.2017.10.004
2. Sciberras-Lim, E. T., Lambert, A. J. (2017). Attentional Orienting and Dorsal Visual Stream Decline: Review of Behavioral and EEG Studies. *Frontiers in Aging Neuroscience, 9*. DOI=10.3389/fnagi.2017.00246
3. Vidyasagar, T. R. (1999). A neuronal model of attentional spotlight: parietal guiding the temporal. *Brain Research Review*, 30, 66-76, 10.1016/S0165-0173(99)00005-3

Results

1 We observed a general slowing across all spatial and most non-spatial tasks over the lifespan.

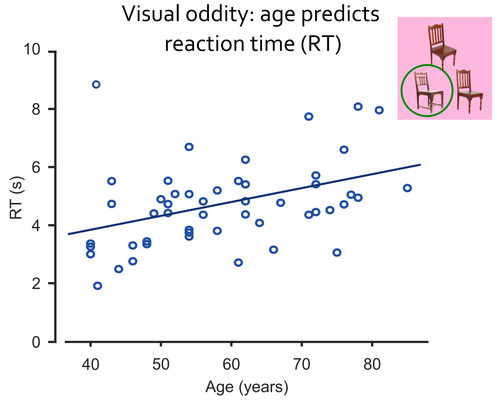
2 There was evidence towards a dorsal stream decline in some spatial tasks.

Visual search: age predicts reaction time (RT)



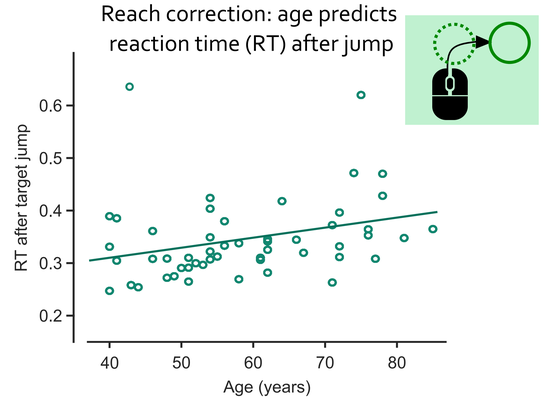
In visual search, age and education accounted for ~33.5% of the variance in RT (R^2=0.34, R=0.58, F=11.84, p<.001, target present trials). The coefficients were 0.02 for age (t=3.82, p<.001) and -0.46 for education (t=-3.52, p<.001).

Visual oddity: age predicts reaction time (RT)



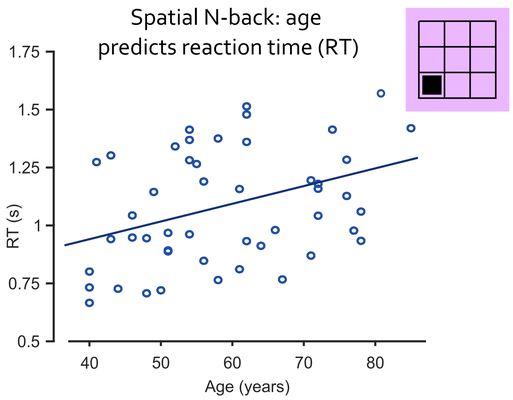
In the visual oddity task, age accounted for ~16.9% of the variance in RT (R^2=0.17, R=0.41, F=9.55, p=.003, familiar objects trials). The coefficient was 0.047 (t=3.09, p=.003).

Reach correction: age predicts reaction time (RT) after jump



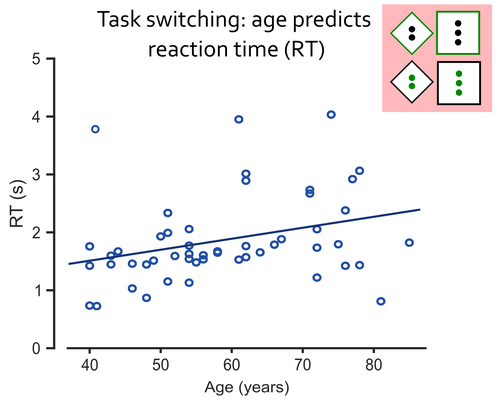
In reach correction, age predicted ~18% of the variance in RT to adjust movement after a target jump (R^2=0.18, R=0.42, F=10.51, p=.002). Initial RT was not predicted by age. The coefficient was 0.002 (t=3.24, p=.002).

Spatial N-back: age predicts reaction time (RT)



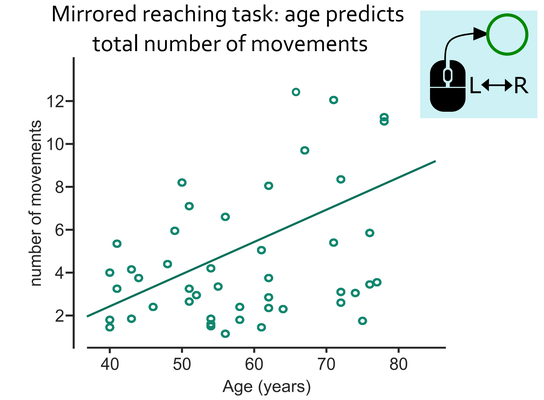
In the spatial N-back task, age accounted for ~12.9% of the variance in RT (R^2=0.13, R=0.36, F=6.80, p=.012, 2-back trials). The coefficient was 0.007 (t=2.61, p=.012)..

Task switching: age predicts reaction time (RT)



In task switching, age accounted for ~8.7% of the variance in RT (R^2=0.09, R=0.30, F=4.67, p=.036, switch trials). The coefficient was 0.018 (t=2.16, p=.036).

Mirrored reaching task: age predicts total number of movements



In the mirrored reaching task, age predicted ~8.8% of the variance in the total number of movements made to reach target (R^2=0.09, R=0.30, F=4.43, p=.041). The coefficient was 0.088 (t=2.10, p=.041).

Discussion

- In healthy aging, while reaction times were slower across most tasks, error rates remained similar across all ages, indicating preserved ability to perform various visuospatial tasks.
- Slower initiation and execution time can be attributed to a decline in the dorsal stream, which serves as an early filter for object identification and localization, preceding detailed feature analysis by the ventral stream[3].
- Age related declines occured within the reach correction and mirror reversal tasks, tasks involving primarily the dorsal stream, which is responsible for spatial localization and movement. These findings support the interpretation of a specific impairment in this network with aging.