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Considering sulcal width rather than cortical thickness to assess brain atrophy in ageing: a large multi-sample study

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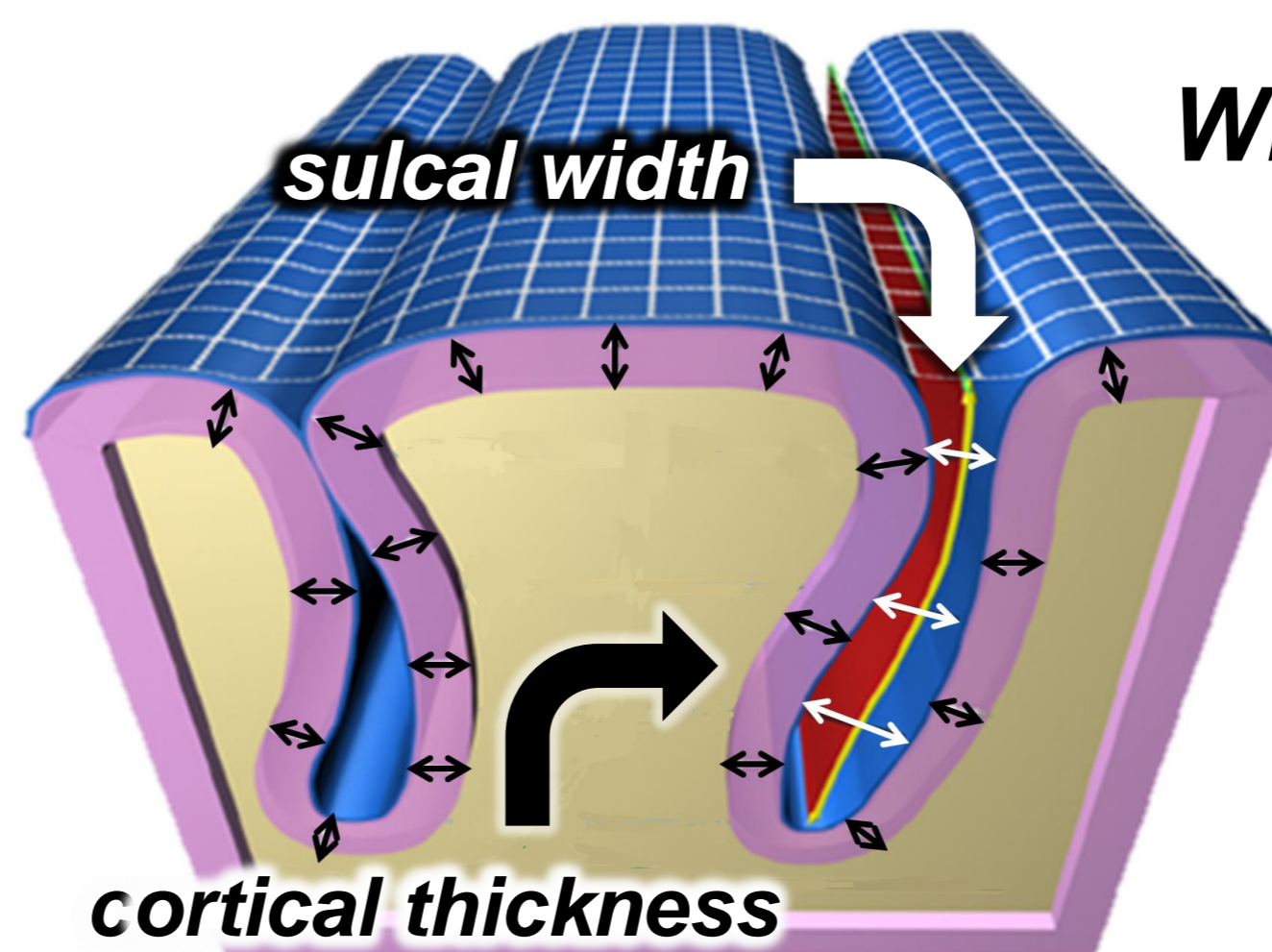
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Context

As life expectancy is increasing, **maintaining brain health** is a prevailing societal challenge and calls for a better understanding of the aging brain.

Recent developments in neuroimaging have popularized the use of **cortical thickness** as a morphological biomarker to assess **local cerebral atrophy** [1]. Based on several considerations, it is suggested that exploring **sulcal width** as an alternative fold-related feature could provide novel insights, as studies on the slow opening of the cortical folds due to continuous tissue loss are rare [2-3]. To date, there exists no single, well-powered, multi-sample study **comparing the performances of cortical thickness and sulcal opening** through the examination of age-dependent trajectories and cognition in the aging brain.

- Two cohorts studied:
 - **UK Biobank** ($n_1=20,541$) – no inclusion requirements
 - **MEMENTO** ($n_2=2,323$) – isolated SCCs or MCI while not demented
- **T1-weighted MRIs**
- Cortical thickness and sulcal width extracted for each ROI using two atlases: **BrainVISA** and **Desikan-Killiany**



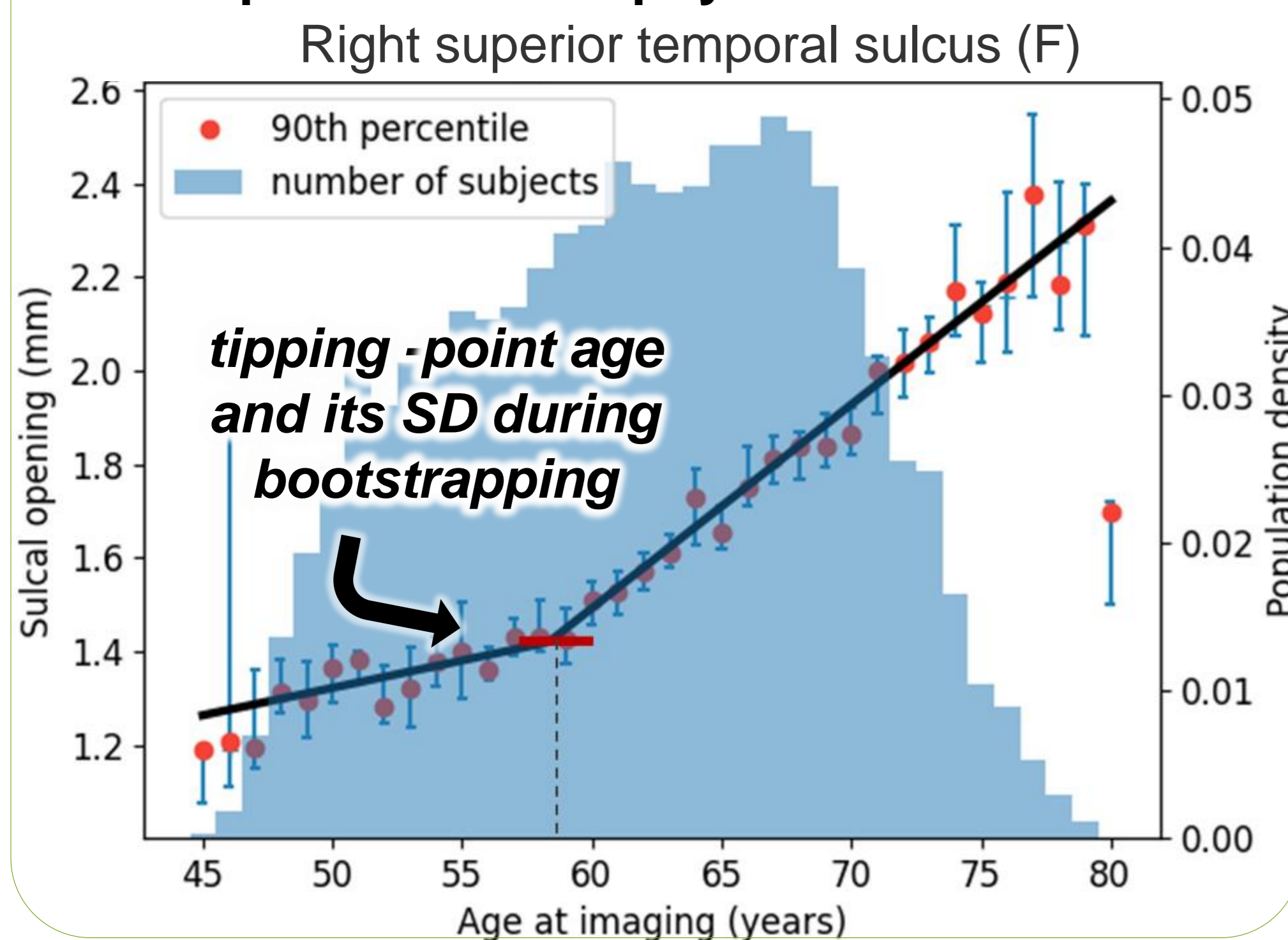
Why consider sulcal width rather than cortical thickness ?

- ✓ **Better contrast**, as GM/CSF contrast $>$ GM/WM contrast
- ✓ **Better SNR**, as sulcal width incorporates the atrophy of two cortical ribbons
- ✓ **Sensitivity to WM changes**

Method Local brain atrophy modelling on a general population (UK Biobank)

Piecewise modeling of age-dependency on all the neuroanatomical features

Idea: capture local atrophy acceleration.



Brainvisa cortical thickness VS Brainvisa sulcal width

How many ROIs effectively display accelerated atrophy during ageing ?

Sulcal opening (BrainVISA)

- 58 ROI on women
- 14 ROI on men

Cortical thickness (BrainVISA)

- 4 ROI on women
- 4 ROI on men

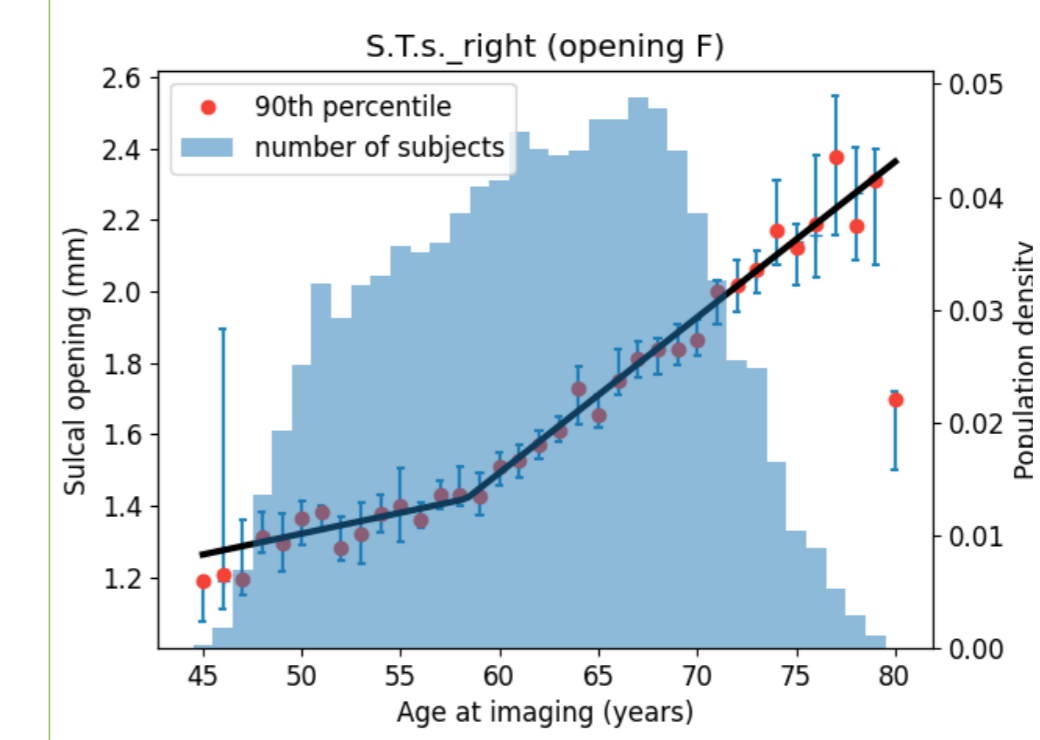
⚡ **A well-marked acceleration in trajectory would result in a small SD for the tipping-point age during bootstrapping.** Here, we chose a 3-year arbitrary threshold to distinguish the ROIs effectively displaying accelerated atrophy.

Desikan cortical thickness VS Brainvisa sulcal width

How late do these ROIs display accelerated atrophy during ageing ?

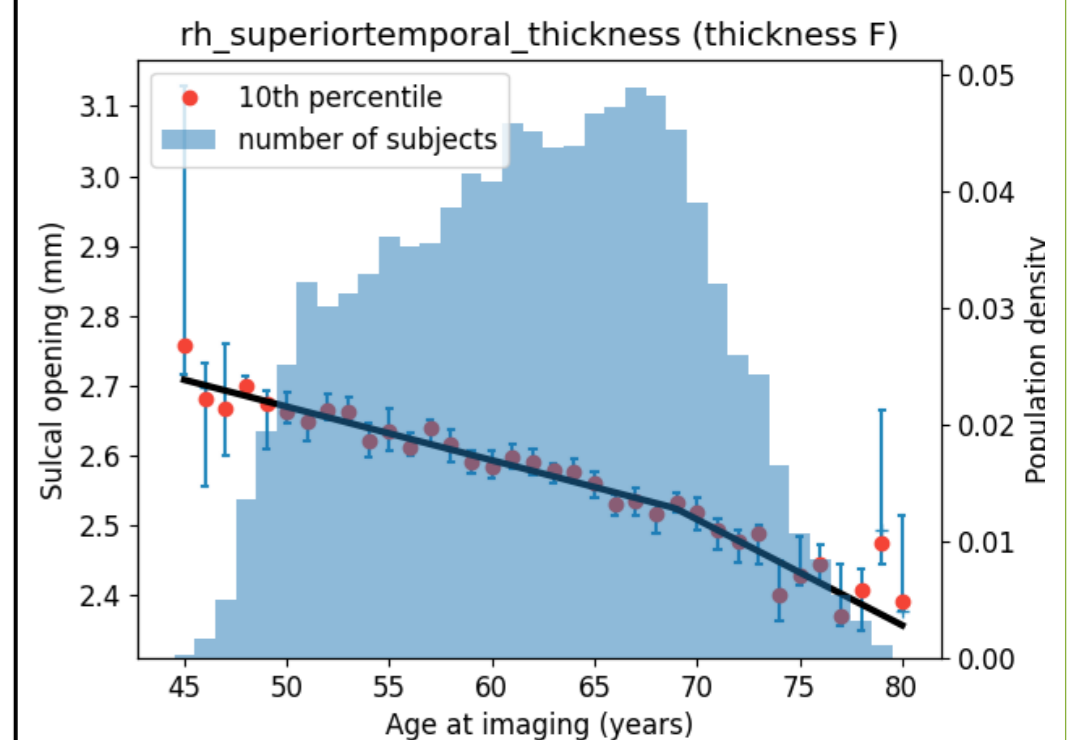
Sulcal opening (BrainVISA)

- Mean : 57.1 yrs on women



Cortical thickness (Desikan-Killiany)

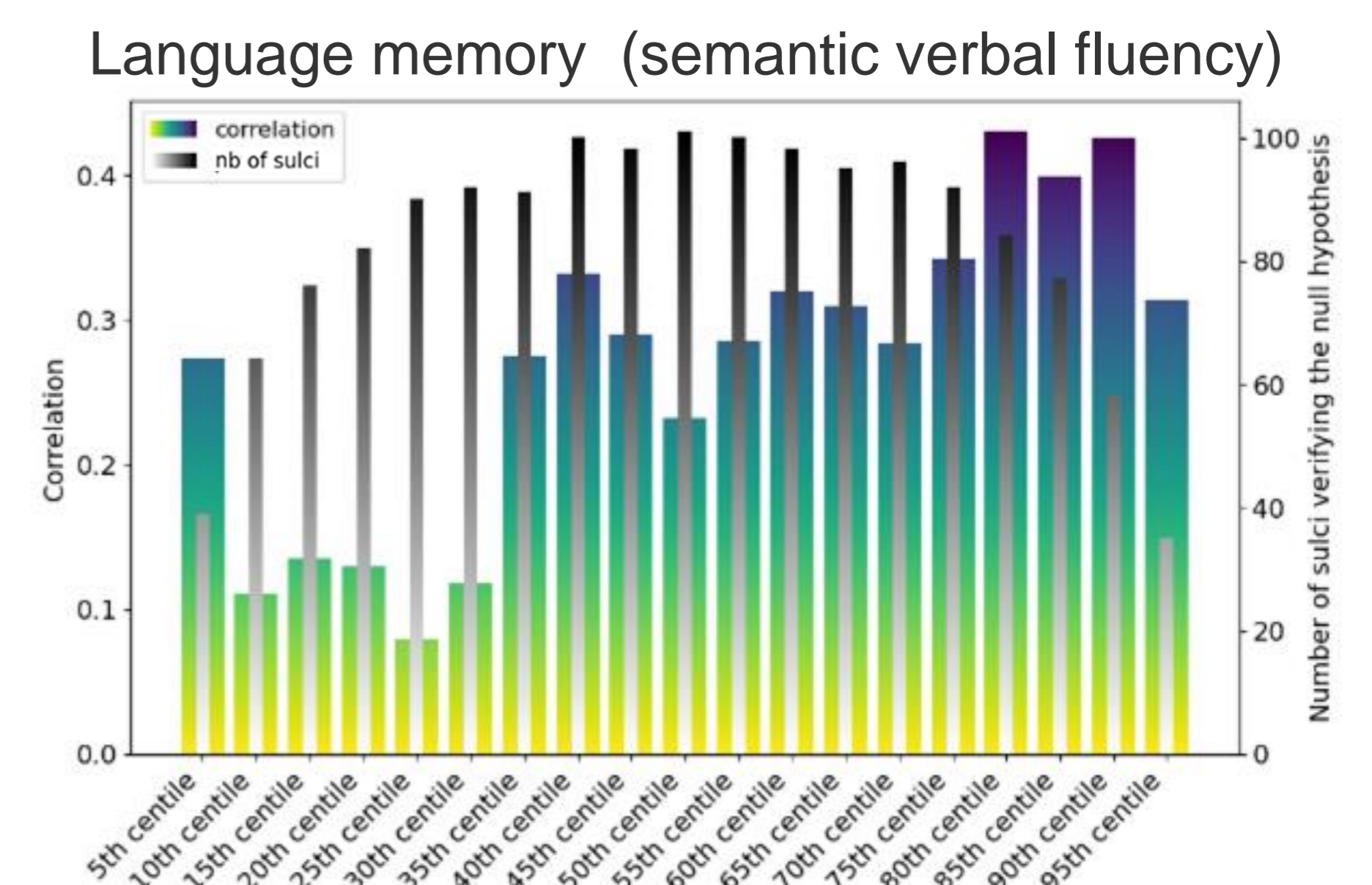
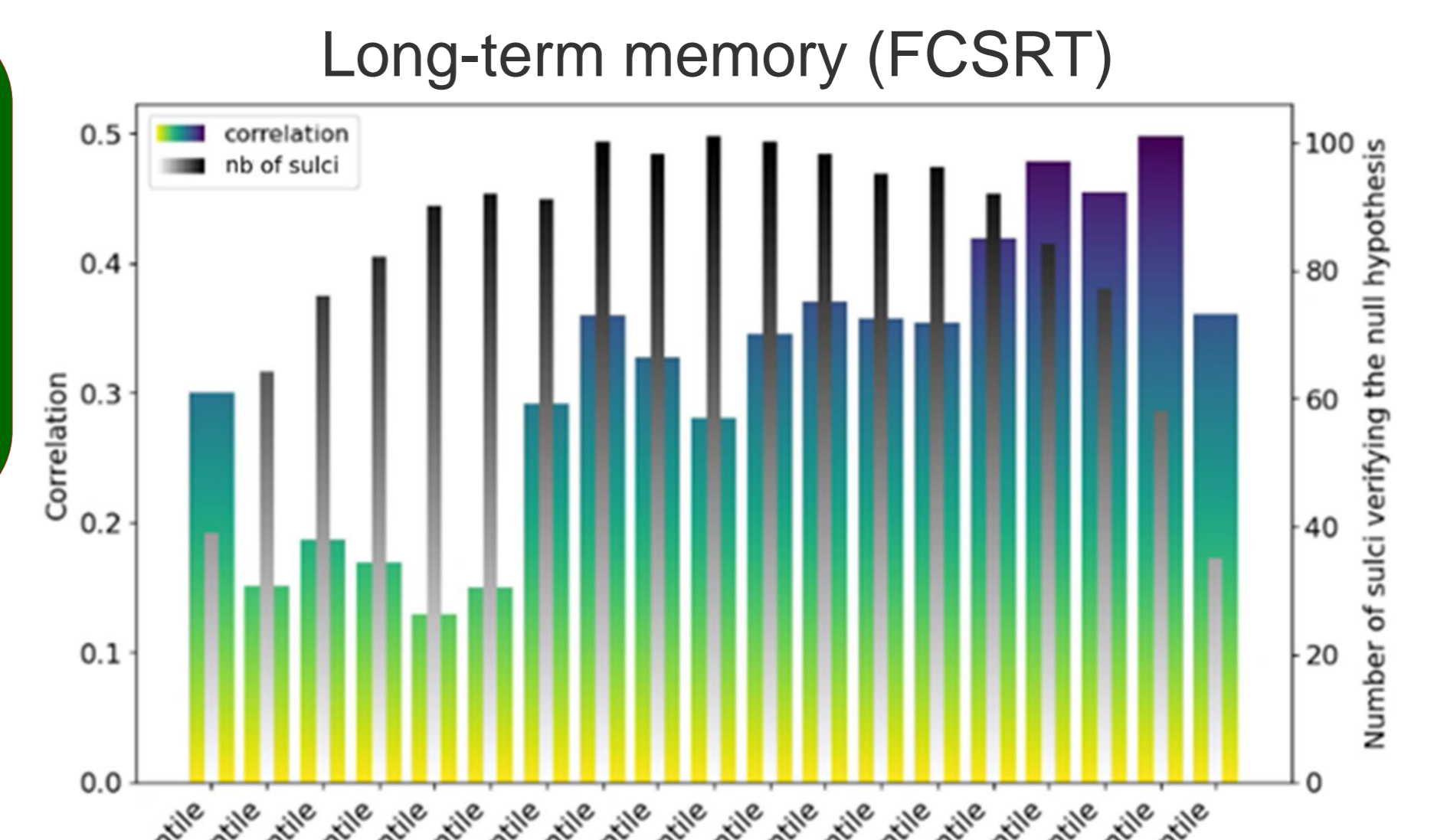
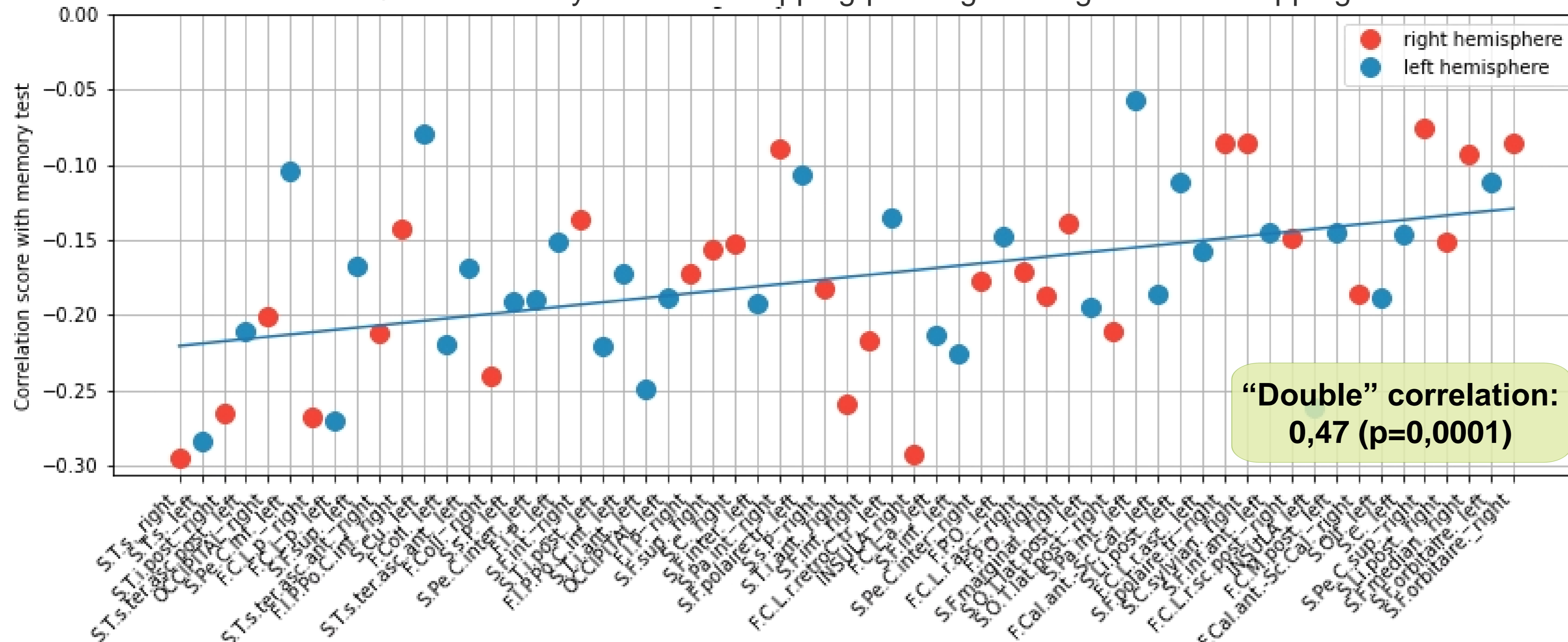
- Mean : 70.7 yrs on women



Results Focus on sulcal openings: transposition to an at-risk population (MEMENTO)

- **LEFT** – Sulci with most stable modelling during bootstrap have higher correlation scores with memory scores on the 90th quantile → **sulci most associated with the memory test score are those which exhibit pronounced acceleration in sulcal atrophy**
- **RIGHT** – For each quantile, we computed this “double correlation” between the bootstrapping SD of tipping-point age and cognitive score. It reaches its **maximum for the highest percentiles consistently across all cognitive tests** → **phenomenon matching impairment across multiple cognitive systems**

Sulci ranked by most stable tipping-point age throughout bootstrapping



Conclusion

- ❖ Sulcal width **captures accelerated brain atrophy** better and earlier than cortical thickness
- ❖ Sulcal width shows promise as a feature able to **detect deviations from the norm** in neuroanatomical patterns

Sulcal width seems a better feature than cortical thickness to visualize and model brain atrophy during ageing

References [1] Fjell, A. M. (2014). "What is normal in normal aging? Effects of aging, amyloid and Alzheimer's disease on the cerebral cortex and the hippocampus"
[2] Bertoux, M. (2019). "Sulcal morphology in Alzheimer's disease: an effective marker of diagnosis and cognition"
[3] Tang, H. (2021). "A slower rate of sulcal widening in the brains of the nondemented oldest old"

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