Cortical Signatures of Cognitive Resilience in Aging

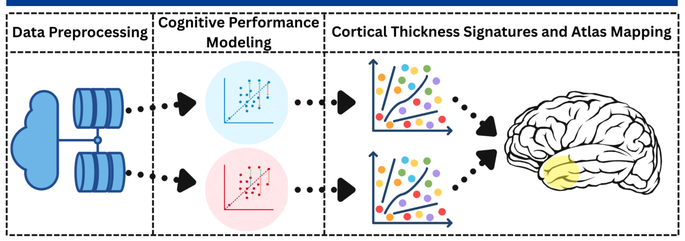
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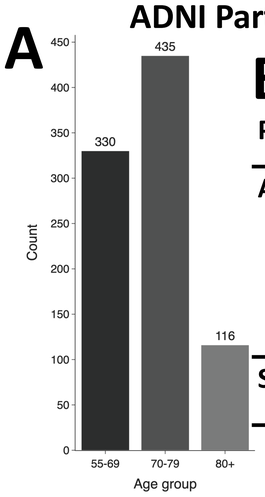
Introduction

While previous research has focused on mapping cortical thinning in aging and Alzheimer's disease, our project examines **how cortical thickness is related to optimal cognitive performance in a cognitively healthy sample aged 55+.** We focus on two cognitive domains: **episodic memory** (Rey Auditory Verbal Learning Test-immediate learning; RAVLT-IR) and **executive function** (Trail Making Test B; TMT-B). By deriving residualized performance scores, we explored the brain structure features that may support superior cognitive performance at later years.

Method



ADNI Participant Demographics



B

Participants (N=881)

Age	Mean ± SD: **72.21 ± 6.66** Range: **55.10-90.30** Below 65 years: **79** 65+ years: **802**
Sex	Female Count: **501**

- Demographic data (**age, sex, education**), cognitive scores (RAVLT-IR, TMT-B), and cortical thickness values were obtained from the ADNI database.
- Healthy participants were selected and grouped into three age cohorts (**55-69, 70-79, 80+**). Within each cohort, cognitive scores were regressed against age and sex.
- Global analyses assessed relationships between cognitive performance and mean cortical thickness by regressing residuals against cortical thickness, adjusted for age, sex, and education. Regional analyses **estimated β-coefficients and BH-adjusted p-values for each ROI**.
- The results were visualized on the **Desikan-Killiany atlas**, creating brain maps that highlight structural differences between superior and poorer cognitive performance.

Main Results

Creation of Age-adjusted cognitive performance scores

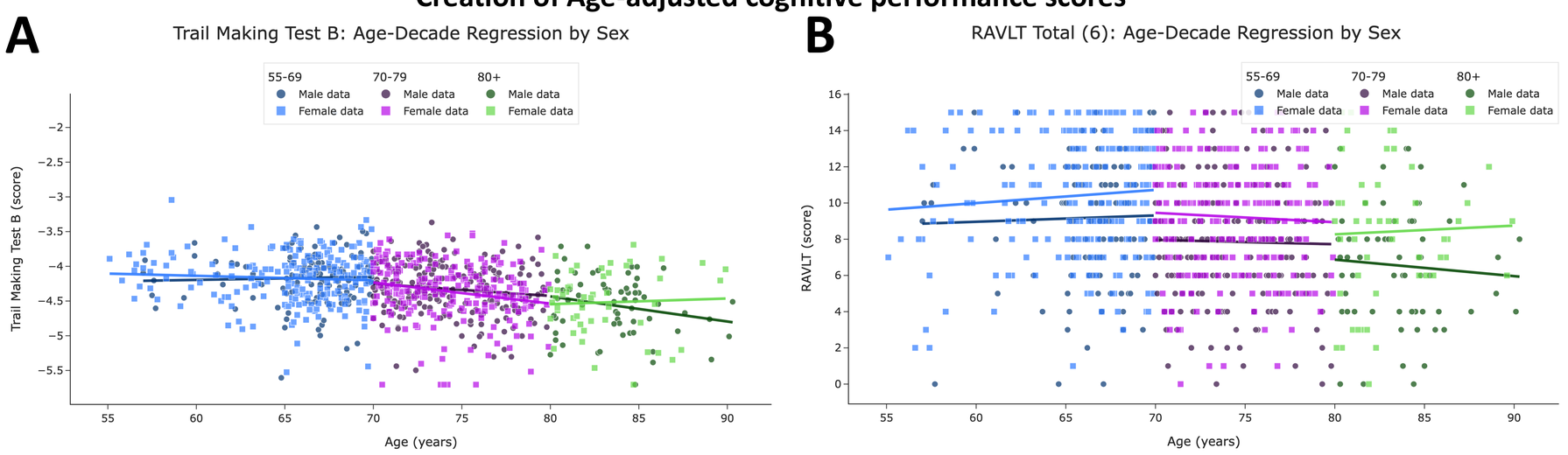


Figure 1. (A) Age effects on executive function were modest, with **Trail Making Test B** (plotted as –log scores, higher = better) **declining significantly** with age only in the 70–79 group (β = –0.0245, $p < 0.001$), and **no reliable sex differences** across decades. **(B)** For verbal memory (RAVLT), age was not significant in any group, but males performed consistently worse than females (β ≈ –1.3 to –1.9, $p \leq 0.01$)

Cortical Thickness Associations With Age-Adjusted Cognitive Performance Across Age Groups

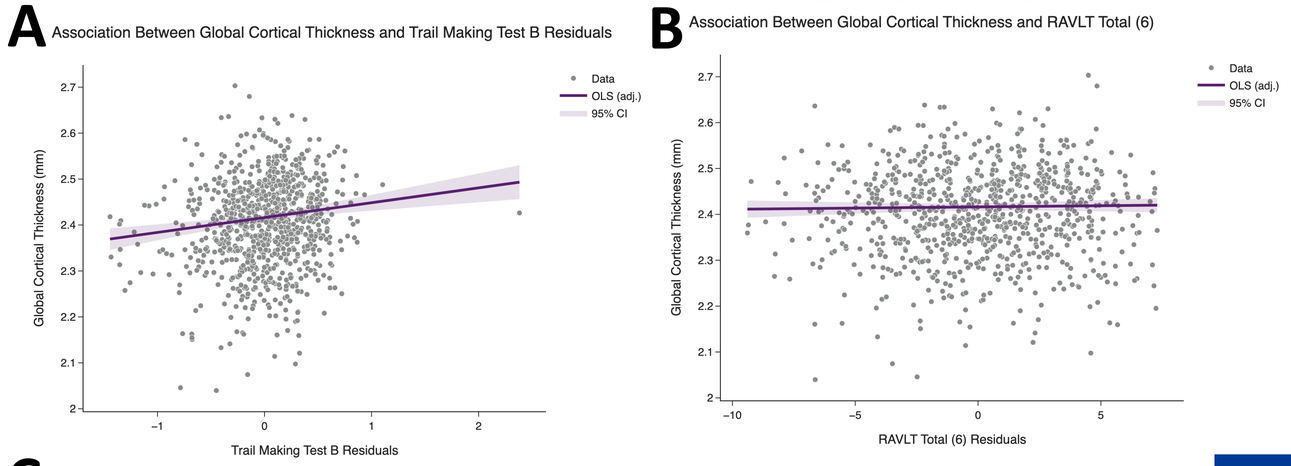


Figure 2. Global relationships: (A) Higher executive function (**TMT-B**) was significantly associated with **thicker global cortex**, whereas **(B)** auditory memory (**RAVLT**) showed **no significant association** at the global level.

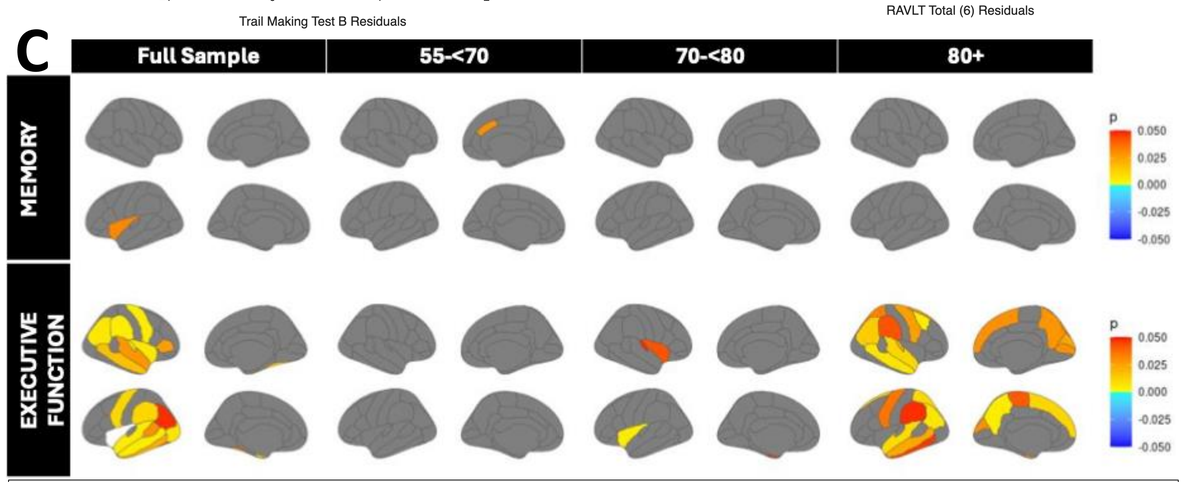


Figure 2. (C) ROI Relationships: Associations are shown for memory (RAVLT) and executive function (TMT-B), with significance defined as FDR-adjusted $p < 0.05$ at the ROI level.

- **Memory showed sparse associations**, limited to small regions in the full sample and in the 55–69 group.
- **Executive function showed widespread associations** in lateral temporal and parietal regions, that were **strongest in the 80+ group**, with weaker findings in the 70–79 group.

Conclusion

Cortical thickness signatures of cognition varied by domain and age. Episodic memory (RAVLT) effects were minimal after correction. In contrast, executive function (TMT-B) showed widespread and robust associations, including bilateral temporal and parietal regions as well as global thickness, indicating that executive function may depends on more distributed cortical integrity as measured by thickness.

References

Salat DH, Buckner RL, Snyder AZ, Greve DN, Desikan RS, Busa E, Morris JC, Dale AM, Fischl B. Thinning of the cerebral cortex in aging. Cereb Cortex. 2004 Jul;14(7):721-30. doi: 10.1093/cercor/bhh032. Epub 2004 Mar 28. PMID: 15054051.

McGinnis, S. M., Brickhouse, M., Pascual, B., & Dickerson, B. C. (2011). Age-related changes in the thickness of cortical zones in humans. *Brain topography*, *24*(3-4), 279–291. https://doi.org/10.1007/s10548-011-0198-6