

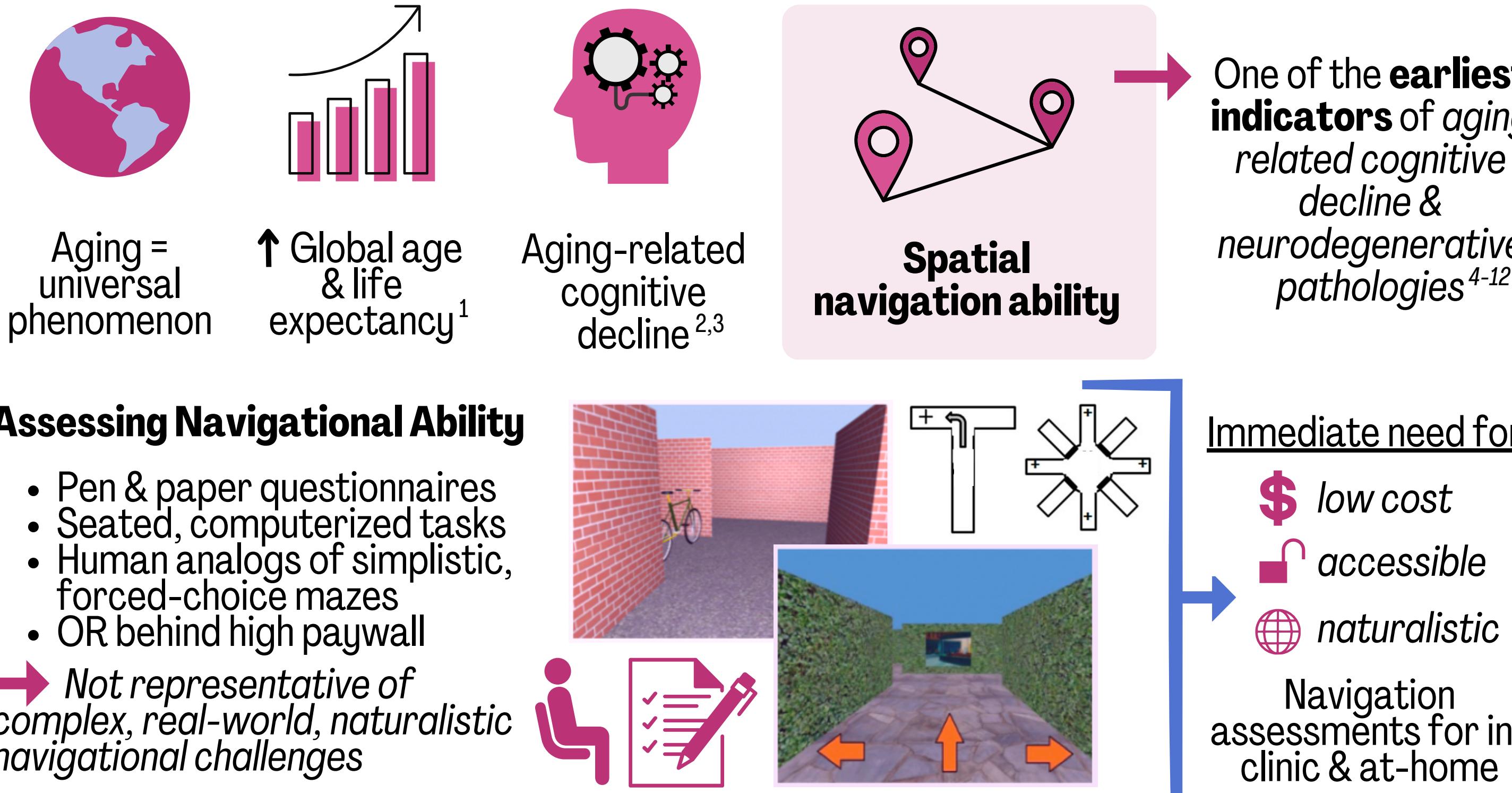
A novel, open-source, city-like virtual reality maze to index naturalistic spatial navigation ability

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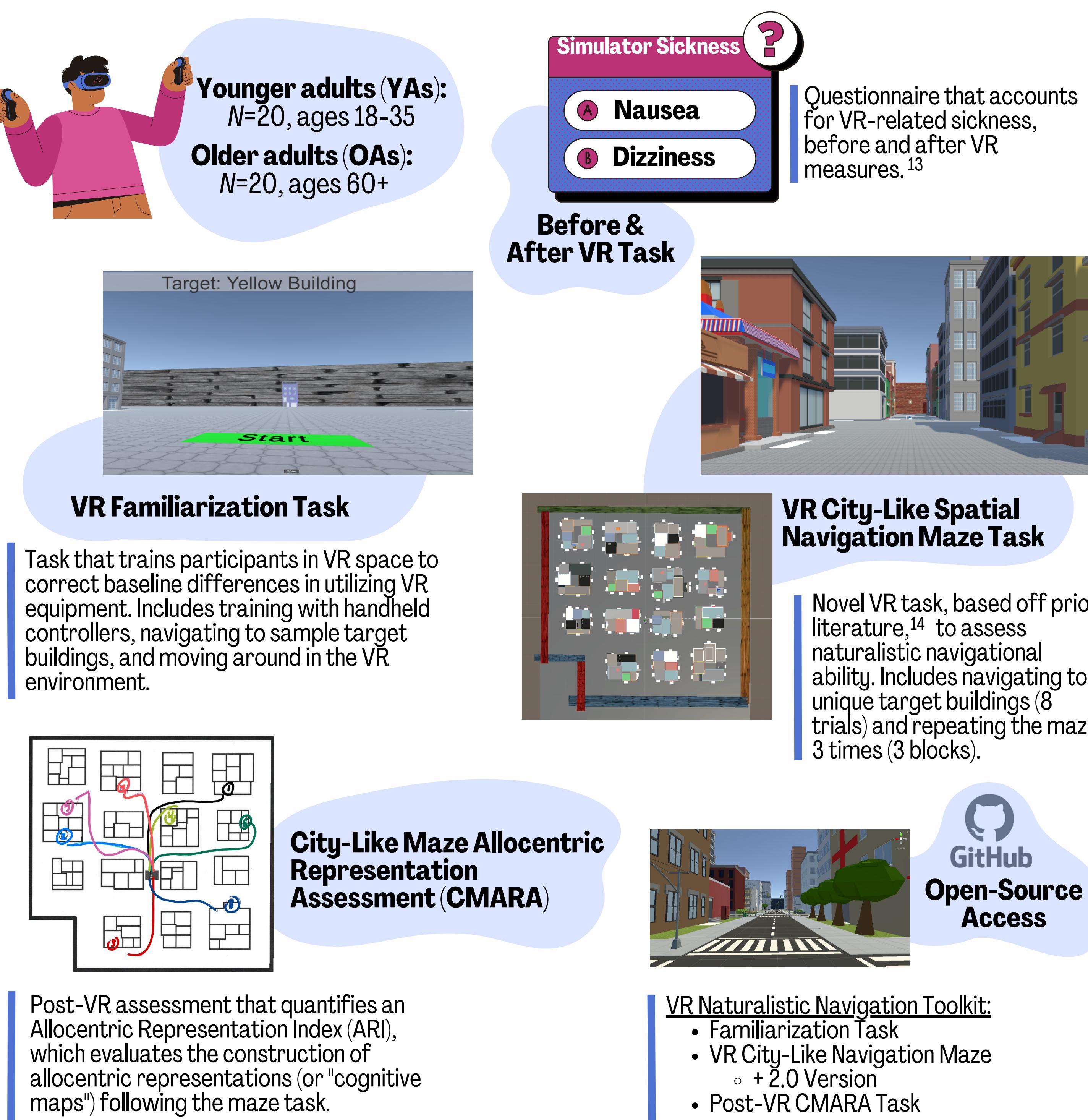
Introduction



Study Objectives:

- Develop a novel, open-source, real-world-like spatial navigation maze task to measure individual naturalistic navigation ability in lab environments using VR.
- Characterize aging effects on navigational performance on maze + accompanying tasks.
- Test neural circuit mechanisms of aging-related navigational deficits, utilizing task-based concurrent TMS-fMRI.

Methods & Tools



Results

1. OAs exhibit lower naturalistic navigational ability, compared to YAs.

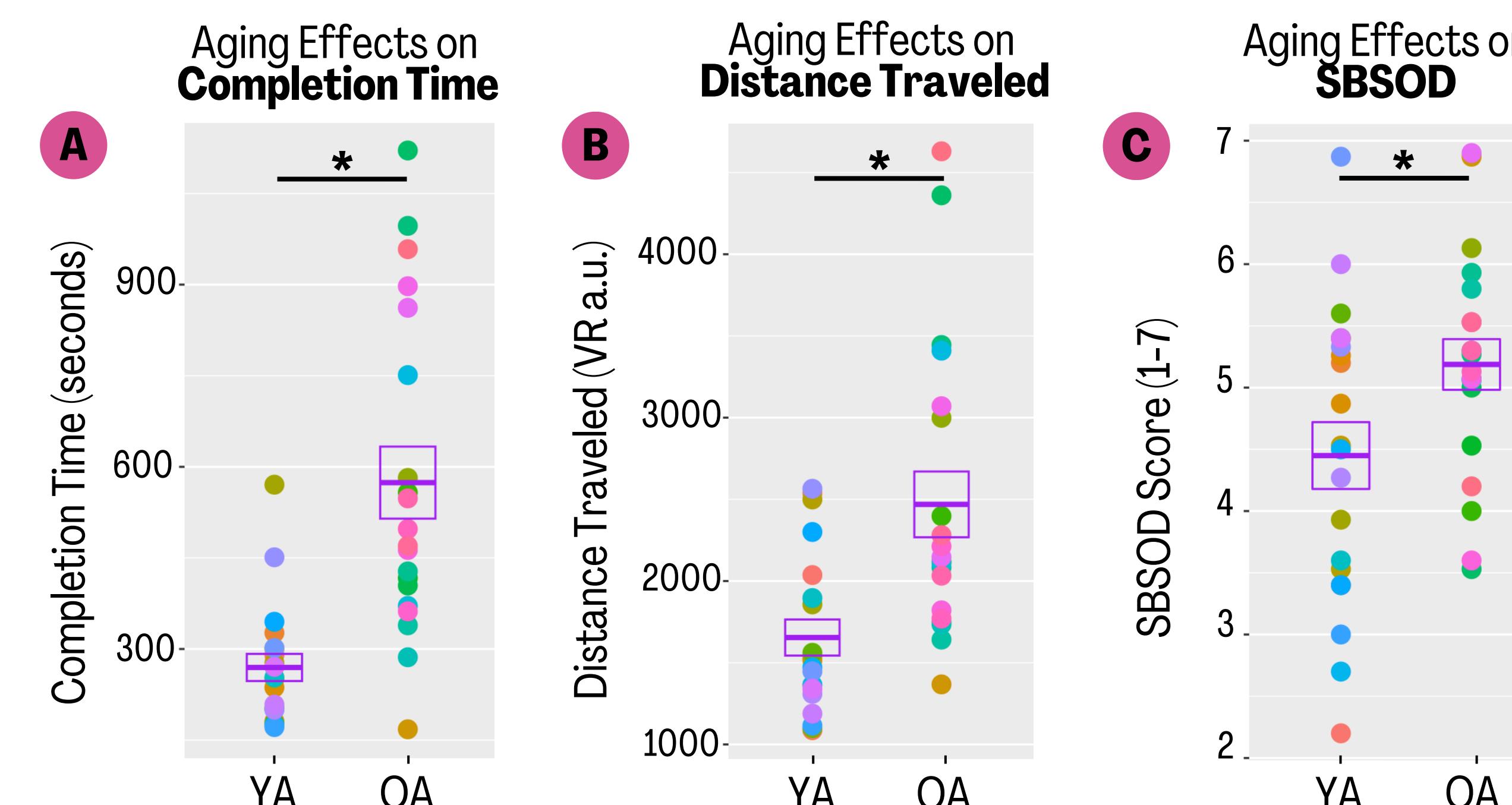


Figure 1. Mean (A) completion time (CT) and (B) distance traveled (DT) on 3 blocks of VR City-Like Maze for YAs and OAs. (C) Individual self-report of navigational ability from the Santa Barbara Sense of Direction questionnaire. Results indicate that YAs have decreased completion times ($p = 6.71e-05$) and distances traveled ($p = 0.0013$) than OAs, indicating better navigation ability in YAs. Interestingly, OAs rated themselves as better navigators than YAs ($p = 0.0366$).

2. Task performance improvement is similar between OAs and YAs.

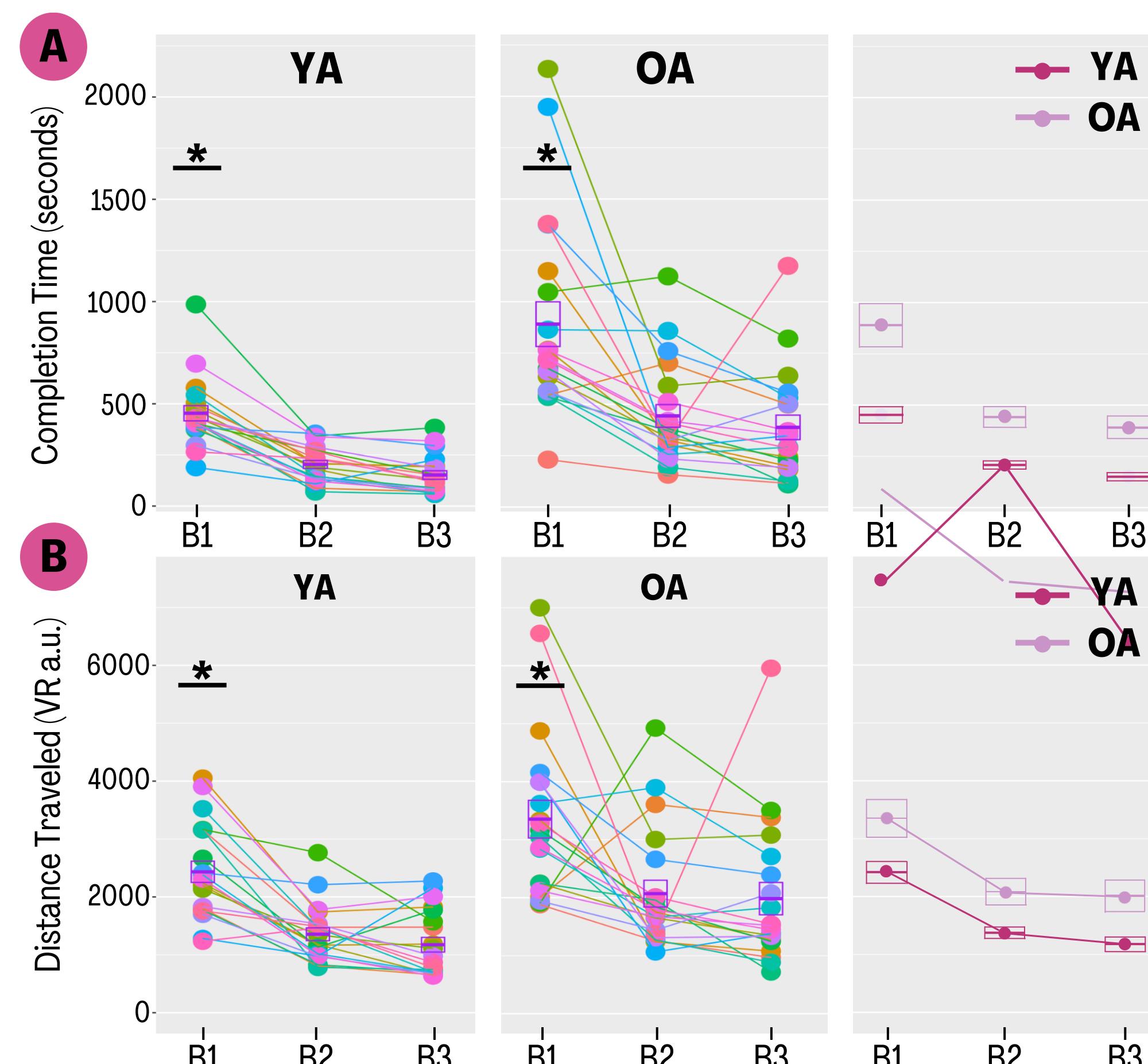


Figure 2. (A) Completion times and (B) distances traveled per block of the VR City-Like Maze for YAs and OAs. In YAs, both outcome measures were significantly decreased between B1-B2 and B1-B3 (all $p < 0.0005$), but not B2-B3 (CT $p = 0.0784$, DT $p = 0.289$). The same phenomenon was observed in OAs, with significantly decreased outcome measures between B1-B2 and B1-B3 (all $p < 0.003$), but not B2-B3 (CT $p = 0.4971$, DT $p = 0.8132$). Therefore, outcome measures between blocks revealed significant reductions between Block 1 and Blocks 2 & 3, with similar rates of improvement between age groups.

3. OAs exhibit decreased formation of allocentric representations (or "cognitive maps"), compared to YAs.

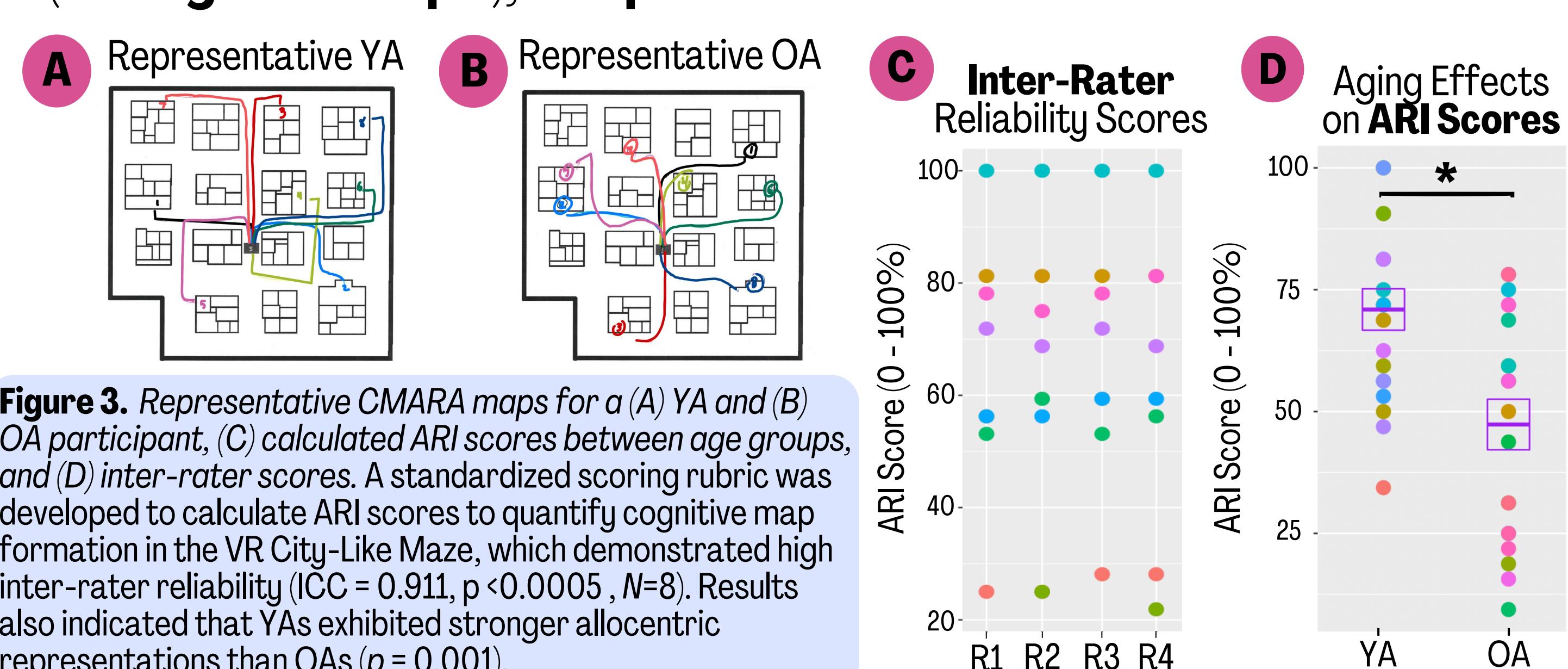


Figure 3. Representative CMARA maps for (A) YA and (B) OA participant, (C) calculated ARI scores between age groups, and (D) inter-rater scores. A standardized scoring rubric was developed to calculate ARI scores to quantify cognitive map formation in the VR City-Like Maze, which demonstrated high inter-rater reliability ($ICC = 0.911$, $p < 0.0005$, $N=8$). Results also indicated that YAs exhibited stronger allocentric representations than OAs ($p = 0.001$).

Results (cont.)

4. Strong correlations are observed between ARI scores and navigational outcome measures, in both YAs and OAs.

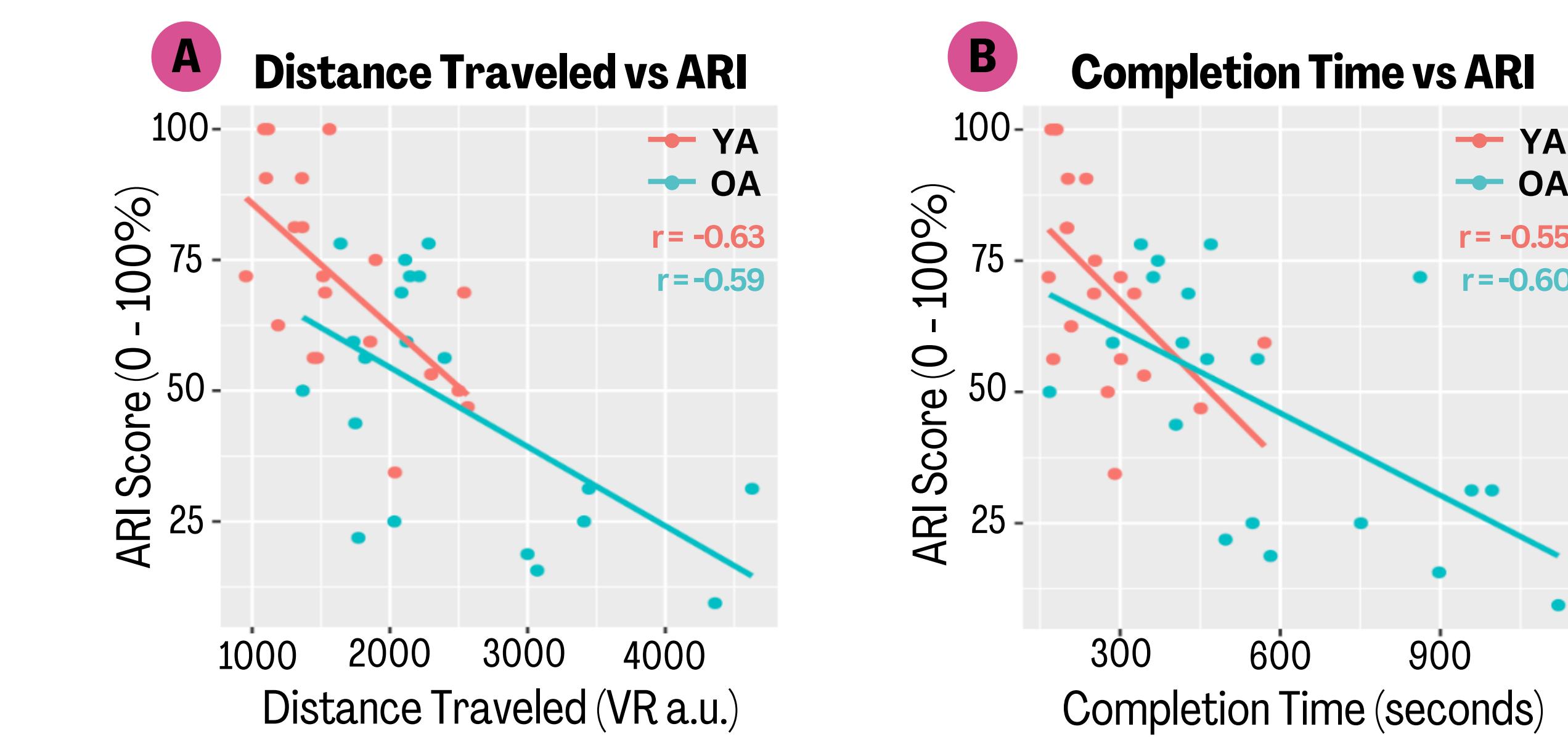


Figure 4. Pearson's correlations between ARI scores and (A) mean distance traveled and (B) mean completion time on the VR City-Like Maze. Strong, significant correlations were observed both for distance traveled and completion time (both $p < 0.0005$). Spread of the data indicates greater variability in OAs than YAs. Results indicate that higher ARI scores are correlated with lower distances traveled and completion times, indicative of better navigational performance.

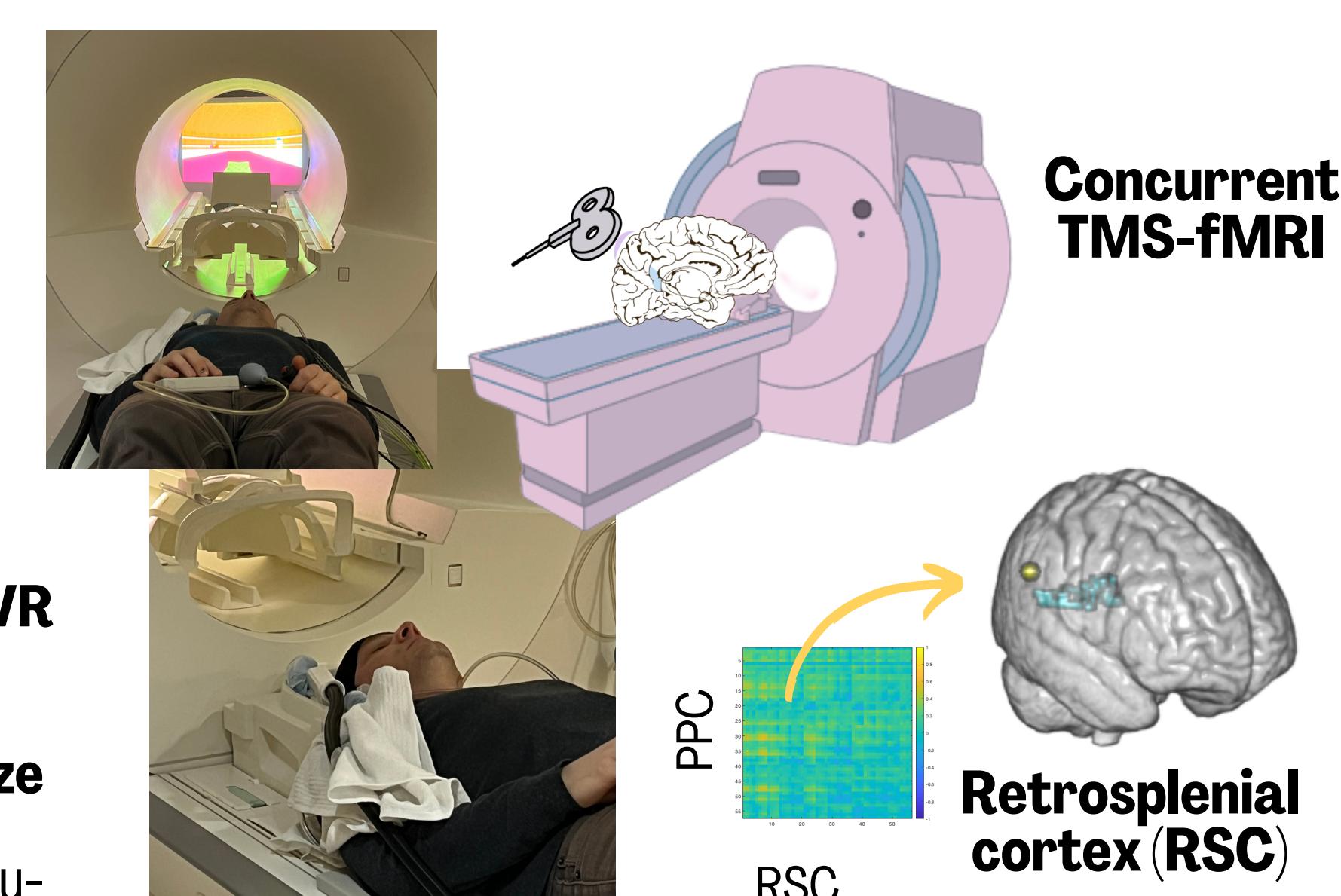
Discussion & Future Directions

Main Takeaways:

- VR City-Like Maze task → open-source, real-world-like VR navigational task + validation by participant cohorts who completed the task.
- Aging → decreased VR-based naturalistic navigational ability. OAs and YAs improved performance at similar rates, showing training effects across groups.
- CMARA task → captures aging differences in cognitive map formation, effectively capturing retention of allocentric spatial information.

Future Directions:

- Web-based versions of navigation tasks
 - Piloting for clinic & home settings
- Quantitative measures for VR Familiarization Task
 - VR Familiarization Score
- Testing 2.0 VR City-Like Maze
 - More realistic setting (included streets, signs, city-like infrastructure)



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