Surprise Findings from Tower of Hanoi Research on Executive Cognitive Function in Older Adults: Assess? Intervene? Or Both?

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Purpose

☐ To determine feasibility, reliability, and item difficulty of the 22-task Tower of Hanoi (TOH) in older adults.

Background

- Tower of Hanoi (TOH): an executive cognitive function (ECF) puzzle game
  - 22-tasks, a 4-disk transfer game across 3 vertical pegs.
    - Minimal sequential moves/task (7-15 moves)
  - 22-task TOH never been administered to or scored on older adults.
  - TOH psychometrics have not been established in older adults.

Welsh, M. C. & Huizinga, M. (2001). The development and preliminary validation of the Tower of Hanoi-Revised. *Assessment, 8*, 167-176.
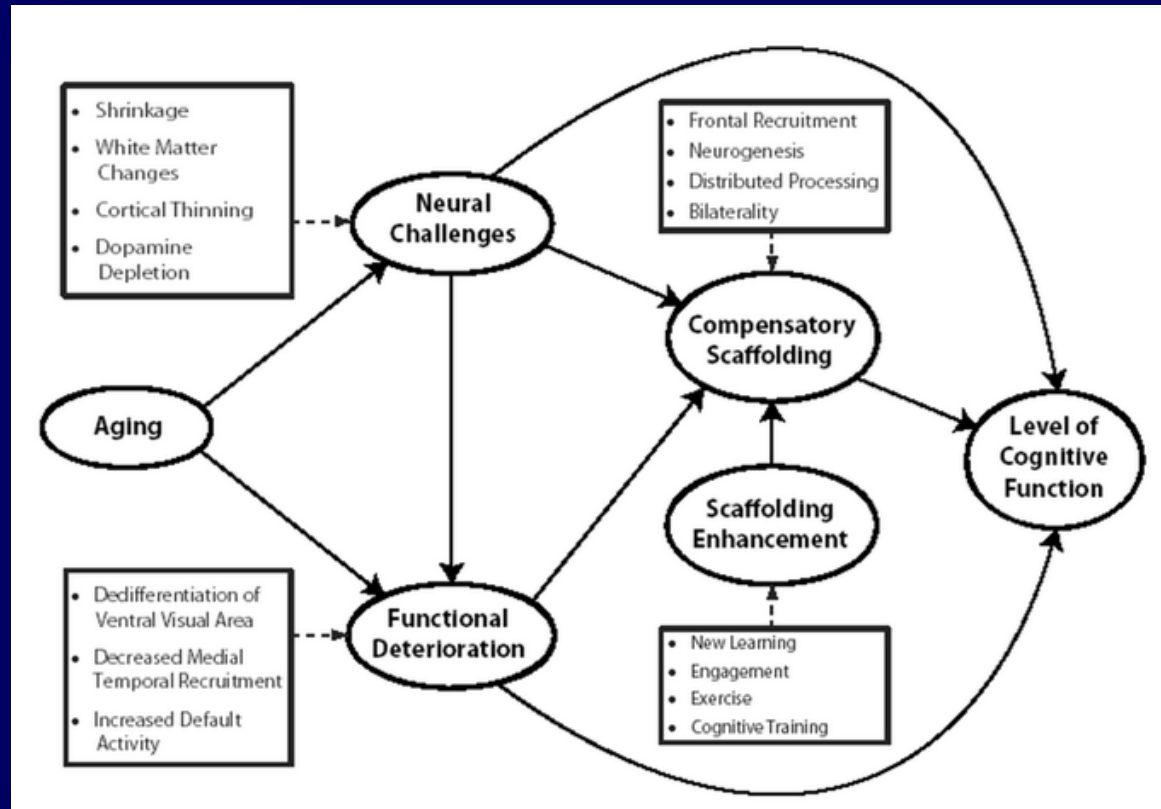
Background

□ Neuroimaging research has documented prefrontal cortex (PFC) changes in aging

■ Deficits in abstract thinking, problem solving, and loss of inhibitory control over irrelevant information.

Gray matter

White matter

CSF
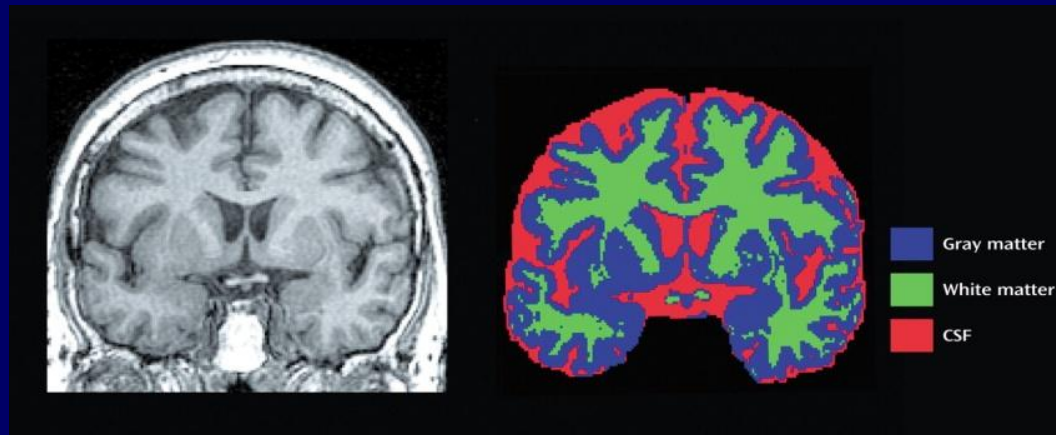
Brickman, A. M., Zimmerman, M. E., Paul, R. H., Grieve, S. M., Tate, D. F., Cohen, R. A. et al. (2006). Regional white matter and neuropsychological functioning across the adult lifespan. *Biological Psychiatry, 60*(5), 444-453.

Brickman, A. M., Habeck, C., Zarahn, E., Flynn, J., & Stern. Y. (2007). Structural MRI covariance patterns associated with normal aging and neuropsychological functioning. *Neurobiology of Aging, 28*, 284-295.

Theoretical Framework

Scaffolding Theory of Aging and Cognition

Park, D. C., & Reuter-Lorenz, P. A. (2009). The adaptive brain: aging and neurocognitive scaffolding. *Annual Review of Psychology, 60*, 173-96.

Sample

- Convenience sample
  - Diverse geographical regions
- 50 cognitively-intact independent-living older adults ($\geq$ 65 years)
  - Completed 22 TOH tasks
  - 22 different start and end configurations
- Eligibility
  - Pre-screening score of $\geq$26 score on the Montreal Cognitive Assessment (MoCA)

Nasreddine, Z. (2010). Montreal Cognitive Assessment (MoCA) administration and scoring instructions. Retrieved from http://www.mocatest.org/.

Methods

- Quantitative descriptive design for psychometric analysis
- Rasch analysis was completed
  - Based on Item Response Theory (IRT)
  - Scoring based on construct of ECF
  - Participant ability categories analyzed
- TOH scoring:
  - Total correct number of tasks, number of moves beyond minimal moves, and gender differences.
- Cronbach's alpha (α) obtained for reliability on 22-task TOH.

Yu, C. H. (2010). *A simple guide to the Item Response Theory (IRT) and Rasch Modeling.* Retrieved from http://www.creative-wisdom.com.

Results- Demographics

- Age range: 65-89 years old, mean: 75.6 (6.6) years
- Race
  - White/Caucasian: 98% (n= 49)
  - Asian: 2% (n=1)
- Gender
  - Male: 42% (n= 21)
  - Female: 58% (n=29)
- Education Level
  - Less than high school: 10% (n=5)
  - High school diploma/GED: 16% (n=8)
  - Some college: 32% (n=16)
  - College degrees (all levels): 42% (n = 21)

Results- Demographics

- Marital status
  - Never been married: 2% (n=1)
  - Married: 72% (n=36)
  - Divorced: 10% (n=5)
  - Widow/widower: 16% (n=8)
- Score on MoCA ($\geq$26)
  - Mean score: 27.9 (1.3); range 26-30
  - No gender differences in MoCA scores (*p = 0.82)*
- Participant Ability Levels categorized/task
  - 3: met minimal moves/task
  - 2: 1-15 extra moves/task
  - 1: 16-50 extra moves/task
  - 0: over 51 extra moves/task

Results- Gender Differences

☐ Total Number of Correct Tasks:

- One-Way ANOVA
- No gender differences [$F_{(1,48)}$ = 2.6; p= 0.11]
  - ☐ 3.7 (2.6) for males vs. 5.1 (3.2) for females

☐ Total number of extra moves

- One-Way ANOVA
- <u>Significant gender differences</u> [$F_{(1,37)}$ =7.3; p = 0.01]
- Males: 223.8 (88.4) ranging from 64-450
- Females: 157.7 (61.3) ranging from 65-88

Rasch Analysis Results

□ Normal distribution of abilities with item difficulties.

□ Reduction from 22 to 15 tasks

   ■ Fit of items: "infit" and "outfit" items (2 items)

   ■ Fit of participants: 79% fit Rasch Model

   ■ Item Difficulty to Person Measures

      □ Range of ability less than range of item coverage

   ■ Differential item function (3 items)

   ■ Duplicative (same item difficulty; 3 items)

Results

□ TOH reliability: α= 0.69.

□ Factor analysis

    ■ Rasch Assumption: unidimensionality

    ■ 2 factors present in TOH-22 tasks

        □ Factor #1(12 items): 18.3% of total variance

        □ Factor #2 (10 items): 9.7% of total variance

           ■ TOH may measure different dimensions of ECF

           ■ ECF: multiple cognitive domains

           ■ Separate factors may emerge as learning progresses

Surprise Findings

☐ Despite TOH's range of difficulty, participants reported:

- All participants completed 22 tasks
- Increased self-confidence.
- Improved perception of cognitive abilities.
- Greater motivation to further practice on TOH.

Conclusion

☐ Introduces TOH as a potential cognitive assessment tool AND intervention in older adults.

☐ Future research includes:

  ■ Development of concurrent and predictive validity of 15-task TOH

  ■ Addition of motion sensors with computerized data collection