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.

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.


Theoretical Framework

Scaffolding Theory of Aging and Cognition

Sample

- Convenience sample
  - Diverse geographical regions
- 50 cognitively-intact independent-living older adults (≥ 65 years)
  - Completed 22 TOH tasks
  - 22 different start and end configurations

Eligibility
- Pre-screening score of ≥26 score on the Montreal Cognitive Assessment (MoCA)

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.

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 (>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
  - **Significant gender differences** \([F (1,37) = 7.3; p = 0.01]\)
    - 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: $\alpha = 0.69$.

- 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

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