Remote computerized detection of pre-clinical cognitive disorders – Bridging the gap between cognitive training and cognitive assessment

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Mild Cognitive Impairment (MCI)

- MCI is characterized by impairment of cognitive functions beyond that expected based on the age and education of the individual*
  - MCI patients are able to live autonomously
- MCI patients have a high conversion rate to dementia compared to healthy older adults
- Early detection of MCI and suitable interventions can stabilize or improve the patient’s condition

Virtual reality (VR)

- VR technology allows the user to enter a virtual environment and interact with it*

- Immersion
  - Immersion into virtual reality is a perception of being physically present in a non-physical world
  - Varying degrees of immersion

• VR technology for cognitive training/rehabilitation
  ◦ High ecological validity
  ◦ Can be adjusted for various clinical/research applications
VR and cognitive assessment

• Recently there has been much interest in the use of VR for cognitive assessment

• Widespread use of virtual super market environments
  ◦ Visuospatial ability
  ◦ Orientation
  ◦ Executive function
  ◦ Mathematical ability
The Virtual Super Market (VSM) application

- Designed as part of the “Ev-ΝΟΗΣΗΣ” project
  - A collaboration of Aristotle University of Thessaloniki (AUTH), Information Technologies Institute (ITI) and the Greek Association of Alzheimer Disease and Relative Disorders (GAADRD)
  - Designed as a cognitive training exercise and also validated as a screening test
- Tablet, web-based and Windows versions available
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ΕΙΚΟΝΙΚΟ ΣΟΥΠΕΡΜΑΡΚΕΤ
Σκοπός του παιχνιδιού
Αγοράστε τα προϊόντα της λίστας με τα ψώνια στις σωστές ποσότητες.

Χειρισμός:
Πλήρωση: Κάνε κλικ στα πράσινα βήματα για να μετακινηθείς προς την κατεύθυνση που δείχνουν. Σύρε το ποντίκι πάνω τα το δεξί κουμπί για να δεις το χώρο γύρω σου.
Επιλογή προϊόντος: Όταν βρίσκεσαι δίπλα σε ράφι, κάνε κλικ στο προϊόν για να το βάλεις στο καλάθι.
Αφαίρεση προϊόντος: Κάνε κλικ σε ένα αντικείμενο της λίστας με τα προϊόντα του καλαθιού για να το επαναφέρεις στο ράφι του.
Πληρωμή: Κάνε κλικ στο ταμείο για να πας εκεί. Κάνε κλικ στα νομίσματα για να συγκεντρώσεις το ποσό της πληρωμής. Κάνε κλικ στο κουμπί "ΠΛΗΡΩΜΗ" για να τελειώσει η αγορά των προϊόντων.

Αριστερό κλικ: πάτημα κουμπιού
Δεξιό κλικ: ηγεμονική περιγραφή κειμένου

Α. Δυσκολία: 2
Γ. Εκκενώθηκε
VSM as a screening test

• The first VR application that achieved reliable MCI detection on its own
• First study used one administration by an examiner.
  ◦ 55 subjects
  ◦ Familiarization session before administration
  ◦ Conducted on the tablet version of VSM on a medium difficulty level (Level 2)
Results of first VSM study*

- Correct classification rate (CCR): 87.30%
  - Sensitivity 82.35%
  - Specificity 95.24%

Shortcomings of first VSM study

- One administration only
  - Random variation in performance can affect results
  - Need for a strict administration protocol
    - Time-consuming
    - Can induce fatigue
- Need for an examiner
The rationale for the 2nd VSM study - VSM Remote Assessment Routine (VSM-RAR)

- Moving toward remote assessment while minimizing costs
- Integration of cognitive screening and cognitive training
  - Older adults can manage more aspects of their cognitive health on their own
Hardware and software

- Commercially available Android tablet
  - Uses touch screen which is more intuitive than a keyboard
  - 10 inch display for better visibility

- Software:
  - Custom software that loads VSM on startup
  - Android version of VSM
    - Configured by the researcher
Study participants

- 12 participants (9 female / 3 male)
  - Also participated in the first VSM study
  - Age: $\mu = 63.75$ (sd = 5.1)
    - Min = 56 / max = 72
  - Years of formal education: $\mu = 11.08$
    - (sd = 3.965)
    - Min = 6 / Max = 16
6 healthy (5 female/ 1 male)

- Age: $\mu = 63$ (sd = 5,4)
  - Min = 56
  - Max = 70
- Years of formal education: $\mu = 11,33$ (sd = 4,367)
  - Min = 6
  - Max = 16
6 MCI (4 female/ 2 male)

- Age: $\mu = 64.5$ (sd = 5.1)
  - Min = 57
  - Max = 72

- Years of formal education: $\mu = 10.38$ (sd = 3.920)
  - Min = 6
  - Max = 15
Administration protocol

- Demonstration of the VSM program by the researcher
  - 1 trial administration in the first meeting with the researcher
- Autonomous use of VSM for 1 month
  - No examiner (self-administered)
  - Contact after 2 weeks to enquire for possible issues
  - Researcher available for help
- 4 familiarization administrations
- 20 administrations used for screening
  - Level 1: 5 administrations
  - Level 2: 5 administrations
  - Level 3: 5 administrations
  - Level 4: 5 administrations
Usability

- The VSM application was user friendly
  - All users were able to operate the VSM software on their own
- The few instances of incorrect use were excluded from the analysis as outliers
Performance of healthy Vs MCI

- Small differences in mistakes made during the exercise
- Significant differences in the mean completion time
  - Healthy: $\mu = 247.41$ sec ($sd=89.006$)
  - MCI: $\mu = 454.52$ sec ($sd=177.604$)
- Mean completion time is the most effective metric for MCI detection
  - Less mistakes (even in MCI patients) due to familiarization
VSM-RAR diagnostic utility

- Correct classification rate (CCR): 91.6%*
  - Sensitivity 94%
  - Specificity 89%

The mean time to complete the exercise correlates with the performance of the same individual in the previous study.
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<th>All Levels</th>
<th>1st Study</th>
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<td>Correlation Coefficient</td>
<td>1.000</td>
<td>0.822**</td>
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**. Correlation is significant at the 0.01 level (2-tailed)
Correlations with established tests

- Mean completion time correlates with
  - TEA4 (visual elevator) raw score
    - Cognitive flexibility/shifting attention
    - Correlation also present in previous study
  - ROCFT (pattern copying)
    - Visual-spatial abilities
    - Correlation also present in previous study
### Correlations (Kendall’s Tau B)

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<tr>
<td>TEA₄r</td>
<td>-1.617*</td>
<td>.040</td>
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<tr>
<td>ROCFT₁</td>
<td>-1.547*</td>
<td>.039</td>
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**. Correlation is significant at the 0.01 level (2-tailed)**
Limitations

- Does not replace traditional neuropsychological testing
  - Acts as a method of detecting persons in need of specialized neuropsychological testing
- Not applicable to older adults who exhibit no interest in training their memory/ preventing cognitive decline
- Cost of equipment
Future directions

• Automation of instructions – training routine
  ◦ 5 tasks of increasing difficulty
  ◦ Scored in order to assess differences in learning ability between groups

• Calculation of minimum number of administrations for MCI detection without an examiner
  ◦ Pilot study in GAADRD day centers

• Usability study
  ◦ USE questionnaire (in digital format) integrated in the VSM software
We wish to thank all participants in both VSM studies for their valuable contribution to our research!
References


