# Cognivue® Evidence Summary

Objective, quantitative and reliable identification of changes in cognitive function that could be indicative of impairment

## Cognivue® Evidence at a Glance

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<th>Title</th>
<th>Key finding</th>
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<td>Cahn-Hidalgo D et al, 2020¹</td>
<td>Validity, reliability, and psychometric properties of a computerized, cognitive assessment test (Cognivue®)</td>
<td>Cognivue® demonstrates good agreement with and superior reliability vs the St. Louis University Mental Status (SLUMS, reference standard) test</td>
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<td>Bomprezzi R et al, 2020²</td>
<td>Cognitive Impairment in Patients with Multiple Sclerosis as Assessed by Objective Computerized Testing</td>
<td>Cognivue® proved helpful in detecting multi-domain cognitive impairment in patients with multiple sclerosis</td>
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<td>Andrefsky J et al, 2020³</td>
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<td>Cognivue® demonstrated superior reliability vs SLUMS over 18 months</td>
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<td>Ma F et al, 2021⁴</td>
<td>Clinical validation of Cognivue®—a computerized alternative to the Montreal Cognitive Assessment</td>
<td>Cognivue® is as effective as MoCA while demonstrating better test-retest reliability. Cognivue® also improves opportunities for timely, objective assessment of cognitive function and eliminates the biases</td>
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<td>Godbole MM et al, 2019⁵</td>
<td>Objective measurement of cognitive impairment in breast cancer survivors who received chemotherapy with the use of novel computerized testing</td>
<td>Cognivue® testing is beneficial in its ability to detect cognitive impairment in breast cancer patients</td>
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<td>Ma F et al, 2021⁶</td>
<td>COVID-19-Related Stressors and the Role of Cognitive Assessment</td>
<td>Prevalence of stressors known to affect cognitive functioning has increased during the pandemic, underscoring the importance of cognitive testing</td>
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# Cognivue® Evidence: Cahn-Hidalgo D, 2020

## Validity, reliability, and psychometric properties of a computerized, cognitive assessment test (Cognivue®)


### Key Findings

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<tr>
<th>Objective</th>
<th>Cognivue® demonstrates good agreement with and superior reliability vs the St. Louis University Mental Status (SLUMS, reference standard) test. Results of this study were used by FDA for Cognivue® device clearance.</th>
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<tr>
<td>Population</td>
<td>To determine cut-off scores for classification of cognitive impairment and assess Cognivue® safety and efficacy in a large validation study. Adults 55 to 95 years of age from assisted and independent-living communities who were at risk for age-related cognitive decline or dementia.</td>
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</table>
| Methods   | Cut-off score determination study:  
- 92 subjects were administered the SLUMS and Cognivue® tests at 1 of 5 sites  
- Optimization analyses by positive percent agreement (PPA) and negative percent agreement (NPA), and by accuracy and error bias were conducted. Validation study:  
- 401 subjects completed ≥1 testing session, and 358 completed 2 sessions 1 to 2 weeks apart  
- Regression, rank linear regression, and factor analyses were conducted. |
| Results   | Cut-off score determination study:  
- Cognivue® scores of 54.5 (NPA = 0.92; PPA = 0.64; impairment) and 78.5 (NPA = 0.5; PPA = 0.79; no impairment) correspond to SLUMS cut-off scores of < 21 and > 26, respectively. Validation study:  
- Cognivue® classification scores were validated, demonstrating good agreement with SLUMS scores (weighted K = 0.57; 95%CI: 0.50-0.63).  
- Reliability analyses showed similar scores across repeated testing for Cognivue® (R2 = 0.81; r = 0.90) and SLUMS (R2 = 0.67; r = 0.82). |
| Conclusion| Cut-off score determination study:  
- Cognivue® scores established to avoid misclassification of impairment. Validation study:  
- Good agreement between Cognivue® and SLUMS  
- Superior reliability vs SLUMS  
- Good psychometric validity. |
Cognitive Impairment in Patients with Multiple Sclerosis as Assessed by Objective Computerized Testing


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<th>Key Finding</th>
<th>Cognivue® proved helpful in detecting multi-domain cognitive impairment, providing an opportunity for early intervention and potentially improving outcomes</th>
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<td>Objective</td>
<td>To determine the utility of Cognivue® relative to the Expanded Disability Status Scale (EDSS), Symbol Digit Modality Test (SDMT), Nine-Hole Peg Test (NHPT), and a Timed 25-foot Walk (T25W)</td>
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<tr>
<td>Population</td>
<td>Adults with multiple sclerosis enrolled at the University of Massachusetts Medical School</td>
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| Methods    | • 36 subjects completed 5 tests during the study visit: EDSS, SDMT, NHPT, T25W, and Cognivue®  
            • Statistical analyses using a one-way ANOVA model were conducted with Pearson correlation coefficients being calculated |
| Results    | • Statistically significant negative correlations were demonstrated between the Cognivue® total score and EDSS (-0.54) and T25W (-0.56)  
            • Statistically significant positive correlation was demonstrated between the Cognivue® total score and SDMT (0.67)  
            • Highest positive correlation was between overall scores on the Cognivue® perception sub-battery and SDMT scores (0.72)  
            • 7 of the 10 Cognivue® sub-tests were significantly correlated with EDSS (P<0.05) |
| Conclusion | • Cognivue® proved helpful in detecting multi-domain cognitive impairment, providing an opportunity for early intervention and potentially improving outcomes |
Superior test-retest reliability of cognitive assessment with Cognivue® vs SLUMS during an 18-month longitudinal study³


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<td>Cognivue® demonstrated superior reliability vs SLUMS over 18 months</td>
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**Objective**
To compare the test-retest reliability of Cognivue® with that of the SLUMS test over the course of 18 months

**Population**
Subjects from the FDA pivotal clinical trial, who were adults (55-95 y) from independent-living communities at risk for age-related cognitive decline or dementia

**Methods**
- 238 subjects from the FDA-regulated clinical study for device clearance were included in the longitudinal study
- Subjects underwent the Cognivue® test and SLUMS at 3 sessions over the course of 18 months (6, 12, 18 months post-FDA study)
- Test-retest reliability was determined through analysis of the correlation (r) and linear regression ($r^2$) between variables
- In a separate sub-analysis, the medical records of those subjects were analyzed to determine the correlation, if any, between comorbidities or medication usage and Cognivue® score

**Results**
- Cognivue® demonstrated similar linear regression scores across comparisons:
  - Test session 1&2: regression fit: $R^2 = 0.76; r = 0.87$
  - Test session 1&3: regression fit: $R^2 = 0.72; r = 0.85$
  - Test session 1&4: regression fit: $R^2 = 0.73; r = 0.86$
- The SLUMS test demonstrated greater variability in regression scores across test sessions
  - Test session 1&2: regression fit: $R^2 = 0.63; r = 0.79$
  - Test session 1&3: regression fit: $R^2 = 0.43 r = 0.65$
  - Test session 1&4: regression fit: $R^2 = 0.64; r = 0.80$
- In the subanalysis, an increased co-morbidity count significantly decreased subjects’ Cognivue® scores (correlation -0.21; P=0.01)
  - Cardiopulmonary comorbidities had a significant impact on a patient’s Cognivue® score (P<0.001)

**Conclusion**
- Cognivue® demonstrated maintained superior test re-test reliability compared to SLUMS over up to 5 test sessions in a period of 18 months
- An increased comorbidity count and cardiopulmonary comorbidities significantly decreased a subject’s Cognivue score
Clinical validation of Cognivue®—a computerized alternative to the Montreal Cognitive Assessment


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<th>Key Findings</th>
<th>Cognivue® is as effective as MoCA while demonstrating better test-retest reliability. Cognivue® also improves opportunities for timely, objective assessment of cognitive function and eliminates the biases</th>
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<tr>
<td>Objective</td>
<td>Determine the utility of Cognivue® compared to MoCA (Montreal Cognitive Assessment) for reliably assessing cognitive impairment</td>
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<tr>
<td>Population</td>
<td>Adults ≥55 years</td>
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</tbody>
</table>
| Methods      | • Participants completed two testing sessions 1 to 2 weeks apart during which both Cognivue® and MoCA were conducted  
• Correlation analyses were performed for overall scores on each neuropsychological test and retest reliability was assessed via regression analyses  
• 100 participants completed testing sessions |
| Results      | • Statistically significant positive correlation between overall scores on Cognivue® and MoCA (r = 0.38; p<0.001)  
• Test-retest reliability was greater for Cognivue® than MoCA for participants initially classified as having no cognitive impairment (87.3% vs. 73.1%)  
• Regression analyses of test-retest reliability revealed a tighter and more linear pattern for Cognivue® than MoCA  
  — Statistically significant regression fit for both was demonstrated (Cognivue®: R² = 0.439, r = 0.663; MoCA: R² = 0.378, r = 0.615) |
| Conclusion   | • Cognivue® provides better test-retest reliability vs MoCA  
• Cognivue® provides an efficient, easy-to-use alternative for assessing cognitive impairment and eliminates biases |
Objective measurement of cognitive impairment in breast cancer survivors who received chemotherapy with the use of novel computerized testing


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<th>Key Finding</th>
<th>Cognivue® testing is beneficial in its ability to detect cognitive impairment in breast cancer patients</th>
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<tr>
<td>Objective</td>
<td>Assess utility of Cognivue® and standard paper-and-pencil neuropsychological assessment tools in breast cancer patients who report cognitive impairment after chemotherapy</td>
</tr>
<tr>
<td>Population</td>
<td>Subjects who had undergone chemotherapy that self-reported cognitive impairment</td>
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<tr>
<td>Methods</td>
<td>• 23 subjects underwent testing with the Mini-Mental State Exam (MMSE), St. Louis University Mental Status examination (SLUMS), and Cognivue®</td>
</tr>
</tbody>
</table>
| Results     | • Cognivue® provides higher sensitivity to evaluate CI than MMSE overall and SLUMS in the intermediate scores  
• There was a statistically significant correlation between Cognivue® scores and duration of chemotherapy |
| Conclusion  | • Cognivue® testing is beneficial in detecting cognitive impairment when compared to MMSE or SLUMS in breast cancer patients  
• Use of cognitive testing to detect cognitive impairment could help predict daily life activity issues for patients post-chemotherapy |
## COVID-19-Related Stressors and the Role of Cognitive Assessment


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<th>Key Findings</th>
<th>Prevalence of stressors known to affect cognitive functioning has increased during the pandemic, underscoring the importance of cognitive testing</th>
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### Objective
Determine the prevalence of various stress-related factors among a sample of the US adult population in order to ascertain the potential impact upon cognitive functioning during the COVID-19 pandemic.

### Population
US-census, age-balanced sample of adults

### Methods
- Participants recruited through an online survey platform in June 2020, in which they completed a 20-question survey regarding activity participation as well as experiences and perceptions prior to and since the onset of the pandemic.
- 693 respondents were included, of which 23% (n=159/693) were ≥60 years of age.

### Results
- 93.2% of participants reported experiencing one or more stressors.
- Prevalence of lifestyle stressors was high:
  - 47.2% reported poor diet
  - 63.1% reported poor sleep
  - Substantially greater proportion indicated a worsening of diet, sleep, and financial stress since the pandemic began.
- Overall prevalence of health-related stressors was also high:
  - 63.5% reported anxious symptoms, of which 26.6% were new onset.
  - 51.7% reported depressive symptoms, of which 21.1% were new onset.
- Overall, 20.8% described a worsening of their cognitive health since the pandemic began, with a greater likelihood of such among those who also experienced worsening of a health-related issue.

### Conclusion
- The prevalence of stressors known to affect cognitive functioning has increased during the pandemic, underscoring the necessity of proactively establishing routine neurocognitive assessment in clinical practice in order to better mitigate the impending mental health crisis.
Hearing loss is the #1 modifiable risk factor for dementia

Research has shown that people with hearing loss have a 24% increase in their risk for cognitive impairment, a risk that rises with the severity of hearing problems. Though hearing loss is associated with negative effects on neurophysiology, quality of life, and health outcomes, when audiologists intervene to preserve a patient’s hearing in mid-life, they have the opportunity to reduce the prevalence of dementia by as much as 8%. That’s because preserving hearing increases the cognitive brain reserve, a core dementia-prevention strategy.

Dementia prevention, intervention, and care: 2020 report of the Lancet Commission

Livingston G et al. The Lancet. 2020;396(10248):413-446.

- Hearing loss is the largest potentially modifiable risk factor for dementia
- Eliminating this risk factor may lower dementia prevalence rates by 8%
- Treating hearing impairment may help enhance or maintain cognitive reserve, thereby reducing risk for dementia
  - Use of hearing aids may be protective

A review of new insights on the association between hearing loss and cognitive decline in ageing


- Hearing loss in the elderly is independently associated with development of cognitive decline and dementia
- Long-term hearing deprivation of auditory inputs can impact cognitive performance by decreasing the quality of communication, which may contribute to social isolation and depression, thus facilitating dementia
- Limited cognitive skills may in turn reduce the cognitive resources available for auditory perception, increasing the effects of hearing loss
- Effective interventions with hearing aids or cochlear implant may improve social and emotional function, communication, cognitive function and positively impact quality of life
Social and public health implications of the links between age-related declines in hearing and cognition


- When sensory inputs are diminished, there can be short-term consequences to brain functioning, and long-term deprivation can affect brain neuroplasticity
- Prevention and mitigation of hearing loss may play a significant role in reducing the risk of cognitive decline
- Even if dementias cannot be entirely prevented by addressing hearing issues, simply delaying the onset of disease would result in significant benefits to individuals and society

Key Findings

Hearing loss and cognitive decline in older adults


- Hearing loss is independently associated with accelerated cognitive decline and incident cognitive impairment in community-dwelling older adults
- Individuals with hearing loss have a 30% to 40% accelerated rate of cognitive decline vs those with no hearing loss
- People with hearing loss have a 24% increase in their risk for cognitive impairment vs those without hearing loss, a risk that rises with the severity of hearing problems

Key Findings

Longitudinal relationship between hearing aid use and cognitive function in older Americans


- National representative survey spanning 18 years found that decrease in episodic memory performance was less steep after beginning to use hearing aids
  - Results support the cascade hypothesis, which postulates that hearing aids may allow better audio input and delay cognitive decline by preventing the adverse effects of auditory deprivation to protect cognitive function
- Public health efforts to increase access to quality hearing health care might delay the onset of cognitive impairment and prove a successful preventive intervention to reduce the impending dementia epidemic

Key Findings
The clinically validated test for cognitive function

Cognivue® technology has been compared with traditional cognitive tests in hundreds of patients

- Good agreement with and superior reliability vs SLUMS¹
- Superior reliability vs SLUMS over 18 months³
- Cognivue® is as effective as MoCA while demonstrating better test-retest reliability⁴
  – Cognivue® also improves opportunities for timely, objective assessment of cognitive function and eliminates the biases⁴
- Proven helpful in detecting multi-domain cognitive impairment in patients with multiple sclerosis²

A growing body of evidence has connected cognitive outcomes with maintaining healthy hearing⁷

- Hearing loss is the largest potentially modifiable risk factor for dementia⁷
- Eliminating this risk factor may lower dementia prevalence rates by 8%⁷