Language Technology and Early Signs of Cognitive Decline – Current Status of a Multimodal and Multidisciplinary Approach

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Summary
The number of people with cognitive impairments, e.g. various types of dementia, grows steadily on a global scale. To date, nearly all therapy interventions have failed to show significant benefits, perhaps because detection of the severity of the brain damage is made too late to be reversed with drug treatments. However, long before the clinical onset of symptoms, patients exhibit deficits in their oral and written communication, signs that can be objectively measured and serve as evidence to predict poor cognitive health in later life. We present a snapshot of our on-going experimental and analytical studies in this direction that could lead to significant complementary knowledge for early detection of dementia. We apply & explore automatic linguistic analysis to language samples produced by persons at various stages of cognitive decline in order to identify linguistic markers to be used as complementary, early diagnostic, knowledge. We conduct interdisciplinary research in Natural Language Processing (NLP) in collaboration with neuro-psychological expertise. The project’s results have the potential to prove its practicability in terms of new and improved scanning instruments for large scale population screening in the future.

Ethics and Demographics
All collected samples are produced by Swedish speakers, recruited from the ongoing Gothenburg MCI study, written consent approved by the local ethics committee (206-16, 2016 & T021-18, 2018).

<table>
<thead>
<tr>
<th></th>
<th>HC (n=36)</th>
<th>SCI (n=23)</th>
<th>MCI (n=31)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>67.9 (7.2)</td>
<td>66.3 (6.9)</td>
<td>70.1 (5.6)</td>
</tr>
<tr>
<td>Education (years)</td>
<td>13.2 (4.4)</td>
<td>16.1 (2.1)</td>
<td>14.1 (3.6)</td>
</tr>
<tr>
<td>Sex (F/M)</td>
<td>23/13</td>
<td>14/9</td>
<td>16/15</td>
</tr>
<tr>
<td>MMSE (30)</td>
<td>29.6 (0.61)</td>
<td>29.5 (0.90)</td>
<td>28.2 (1.43)</td>
</tr>
</tbody>
</table>

Demographic data for our cohort. HC: Healthy Controls; MCI: Mild Cognitive Impairment; SCI: Subjective Cognitive Impairment; MMSE (MiniMental State Exam): a test of general cognitive ability; max is 30; a score of ≤24 is been proposed for cognitive impairment; a score between 25–27 indicates possible cognitive impairment which should be further evaluated.

Recordings, Tools and Linguistic Annotation
Recordings made in two rounds with the same population: round 1 (2016) and 2 (2018). 3 new tasks were added in 2018.

- a picture description, the ‘Cookie theft’
  round 1&2
- a read silent task
  round 1&2
- a read aloud task
  round 1&2
- a complex planning task
  round 2
- a map task
  round 2
- a semantic verbal fluency, category ‘animals’
  round 2

The transcriptions during round 1 were made manually by professional transcribers; while for round 2, automatically, with a speech-to-text system, THEMIS-SV.

For the linguistic annotation we use SPARV, an infrastructure for Swedish processing (<https://spraakbanken.gu.se/sparv/>), that consists of basic NLP tools.

Experimental Studies...

Eye-tracking

Eye movements distinguish MCI from healthy aging with >86% accuracy: NB Silent reading: more informative – combination best results

Syntactic analysis of transcriptions

Syntax distinguish MCI from healthy aging with >63% accuracy: random forests

Recordings

- Acoustic properties, speech segments and prosody

- Multilinguality and Multimodality

- Multilingual word embeddings 72% accuracy; Combination of modalities: Neural networks [ongoing]

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