CoGames – Development of an adaptive, smartphone-based, and gamified monitoring tool for cognitive function

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Background & Objective

• Comprehensive monitoring of cognitive function using established psychometric tests is time consuming, costly, and often not well accepted.1
• Novel tools that are well accepted, convenient, and sensitive to change, are needed for long-term high-frequency assessments of cognitive performance.
• Adequately designed smartphone-games, might be useful in overcoming the issues of current established neuropsychological assessments.2,3
• As part of the development of a smartphone-based app for monitoring MS disease activity and progression (dreaMS, NCT05009160, BASEC-ID: 2021-D0040) we developed a set of cognitive games for assessing cognitive function.

The CoGames study aimed to obtain data about game functioning, reliability, acceptance, and training effects of this novel gamified assessment tool.

Study Outcomes

1. Correlation coefficients of test-retest conditions (Spearman’s rho)
2. Mean score of enjoyment rating (5-point Likert scale)
3. Observable performance change in the same difficulty level over time

Methods

• This study is a quality assurance project evaluating core aspects of 6 adaptive games, developed in cooperation with INDIVI, that aim to assess cognitive- and dexterity performance.4
• All but the dexterity game, which has 6 levels, comprise 8 difficulty levels.

Figure 1. Screenshot of Cognitive Games

From left to right: Match Maker, Think Fast, Numbers, Treasure Hunt, Mixer, Catch-a-Cloud

Study design:

• Between April and August 2023, we included 76 healthy volunteers. (Table 1)
• Participants played each game twice per day for 11 consecutive days. Every day the game difficulty increased.
• On multiple days, the easiest level (“Beginner”) was repeated to measure potential performance change over time (training effect).
• On 3 days, the participants were asked to rate the games on a 5-point Likert scale regarding enjoyment (1= not enjoyable, 5= very enjoyable).
• For each game predefined quantifiable measures, such as number of correct responses, time needed, and error rate, were assessed. (Table 2)

Analyses:

• For the reliability analysis we conducted a test-retest spearman’s correlation on the two daily repetitions.
• The average ratings on the 5-point Likert scale were used to describe perceived enjoyment. (Table 2)
• We visualized differences between the repetitions of level “Beginner” over the study duration in order to identify changes caused by training effects. (Figure 2)

Table 1. Characteristics of participants

<table>
<thead>
<tr>
<th>Domain</th>
<th>Game</th>
<th>Adherence (tests completed of total scheduled)</th>
<th>Mean ± std. Range</th>
<th>Healthy Volunteers (n=76)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive</td>
<td>Match Maker</td>
<td>97.33%</td>
<td>40 ± 13.9</td>
<td>53 (67%)</td>
</tr>
<tr>
<td>Domain</td>
<td>Think Fast</td>
<td>97.33%</td>
<td>35 ± 11.9</td>
<td>40 (52%)</td>
</tr>
<tr>
<td>Domain</td>
<td>Treasure Hunt</td>
<td>97.33%</td>
<td>35 ± 11.9</td>
<td>40 (52%)</td>
</tr>
<tr>
<td>Domain</td>
<td>Mixer</td>
<td>97.33%</td>
<td>40 ± 13.9</td>
<td>53 (67%)</td>
</tr>
<tr>
<td>Domain</td>
<td>Catch-a-Cloud</td>
<td>97.33%</td>
<td>35 ± 11.9</td>
<td>40 (52%)</td>
</tr>
<tr>
<td>Domain</td>
<td>Numbers</td>
<td>97.33%</td>
<td>40 ± 13.9</td>
<td>53 (67%)</td>
</tr>
<tr>
<td>Domain</td>
<td>Scores</td>
<td>97.33%</td>
<td>35 ± 11.9</td>
<td>40 (52%)</td>
</tr>
<tr>
<td>Domain</td>
<td>Total</td>
<td>97.33%</td>
<td>35 ± 11.9</td>
<td>40 (52%)</td>
</tr>
</tbody>
</table>

Table 2. Measures, Reliability, and Acceptance rating

<table>
<thead>
<tr>
<th>Cognitive Domain</th>
<th>Game</th>
<th>Predefined Measure</th>
<th>Reliability (Spearman’s rho)</th>
<th>Enjoyment rating (5-point Likert Scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working memory</td>
<td>Match Maker</td>
<td>Number of correct responses</td>
<td>.79 to .93</td>
<td>3.79</td>
</tr>
<tr>
<td>Processing speed</td>
<td>Think Fast</td>
<td>Number of correct responses</td>
<td>.74 to .92</td>
<td>4.23</td>
</tr>
<tr>
<td>Short-term memory</td>
<td>Treasure Hunt</td>
<td>Percentage of correct responses</td>
<td>.55 to .74</td>
<td>3.13</td>
</tr>
<tr>
<td>Mental flexibility</td>
<td>Mixer</td>
<td>Number of correct responses</td>
<td>.76 to .92</td>
<td>3.74</td>
</tr>
<tr>
<td>Dexterity</td>
<td>Catch-a-Cloud</td>
<td>Number of correct responses</td>
<td>.94 to .94</td>
<td>4.22</td>
</tr>
</tbody>
</table>

Figure 2. Average game performance of age groups over time**

** Repetitions of the same difficulty level (“Beginners”) on multiple days during the study

Conclusion

• CoGames have high reliability over all difficulty levels of all games and an acceptable to high rating of enjoyment. Both findings are important preconditions for accurate measurement and long-term adherence and motivation.
• All games show performance improvements, which are most prominent in Match Maker, Think Fast, and Mixer, and are most likely caused by training effects. In games with relatively low difficulty, improvement is less pronounced, which can be attributed to ceiling-effects.
• In summary, our results suggest that CoGames have the capability to reliably capture change in cognitive performance over time. However, training effects need to be considered in long-term monitoring.
• Currently, we aim to investigate the validity of the cognitive level in a two-year validation study with a large group of MS patients and healthy controls.

References: