A web-based system for visualizing upper limb motor performance of Parkinson’s disease patients

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OBJECTIVE
To design, develop and set up a web-based system for enabling graphical visualization of upper limb motor performance (ULMP) of Parkinson’s disease (PD) patients to clinicians.

BACKGROUND
Sixty-five patients diagnosed with advanced PD have used a test battery implemented in a touch-screen handheld computer, in their home environment settings over the course of a 3-year clinical study [1]. The test items consisted of objective measures of ULMP through a set of upper limb motor tests (finger to tapping and spiral drawings), see Fig. 1. For the tapping tests, patients were asked to perform alternate tapping of two buttons as fast and accurate as possible, first using the right hand and then the left hand. The test duration was 30 seconds. For the spiral drawing test, patients traced a pre-drawn Archimedes spiral using the dominant hand, and the test was repeated 3 times per test occasion [2]. In total, the study database consisted of symptom assessments during 10,079 test occasions.

Figure 1. Performance of upper limb motor tests using the handheld computer; a) spiral tracing, and b) alternate tapping of two buttons.

METHODS

VISUALIZATION OF ULMP
The web-based system is used by two neurologists for assessing the performance of PD patients during motor tests collected over the course of the said study. The system employs animations, scatter plots and time series graphs to visualize the ULMP of patients to the neurologists. The performance during spiral tests is depicted by animating the three spiral drawings, allowing the neurologists to observe real-time accelerations or hesitations and sharp changes during the actual drawing process (Fig 2a). The tapping performance is visualized by displaying different types of graphs (Fig 2b). Information presented included distribution of taps over the two buttons, horizontal tap distance vs. time, vertical tap distance vs. time, and tapping reaction time over the test length.

RESULTS

The present study used a web-based system that allows two neurologists to rate the performance of PD patients during motor tests collected over the course of the said study. The system employs animations, scatter plots and time series graphs to visualize ULMP of patients to the neurologists. The performance during spiral tests is depicted by animating three spiral drawings, allowing the neurologists to observe real-time accelerations or hesitations and sharp changes during the actual drawing process (Fig 2a). The tapping performance is visualized by displaying different types of graphs (Fig 2b). Information presented included distribution of taps over the two buttons, horizontal tap distance vs. time, vertical tap distance vs. time, and tapping reaction time over the test length.

ASSESSMENTS
Different scales are utilized by the neurologists to assess the observed impairments. For the spiral drawing performance, the neurologists rated firstly the ‘impairment’ using a 0 (no impairment) – 10 (extremely severe) scale, secondly three kinematic properties: ‘drawing speed’, ‘irregularity’ and ‘hesitation’ using a 0 (no impairment) – 4 (extremely severe) scale, and thirdly the probable ‘cause’ for the said impairment using 3 choices including Tremor, Bradykinesia/Rigidity and Dyskinesia. For the tapping performance, a 0 (normal) – 4 (extremely severe) scale is used for first rating four tapping properties: ‘tapping speed’, ‘accuracy’, ‘fatigue’, ‘‘arthrythmia’, and then the ‘global tapping severity’ (GTS). To achieve a common basis for assessment, initially one neurologist (DN) performed preliminary ratings by browsing through the database to collect and rate at least 20 samples of each GTS level and at least 33 samples of each ‘cause’ category. These preliminary ratings were then observed by the two neurologists (DN and PG) to be used as templates for rating of tests afterwards. In another track, the two neurologists (DN and PG) then performed preliminary ratings by browsing through the database to collect and rate at least 20 samples of each GTS level and at least 33 samples of each ‘cause’ category. These preliminary ratings were then observed by the two neurologists (DN and PG) to be used as templates for rating of tests afterwards. In another track, the two neurologists (DN and PG) then performed preliminary ratings by browsing through the database to collect and rate at least 20 samples of each GTS level and at least 33 samples of each ‘cause’ category.

Table 1. Agreements between the two neurologists’ ratings of the visualized tapping tests; a) GTS, and b) ‘tapping speed’. Zero means normal and 4 means extremely severe.

<table>
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<th>Neurologist</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<td>a) GTS</td>
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<td>0.68</td>
<td>0.76</td>
<td>0.68</td>
<td>0.72</td>
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<td>b) Tapping</td>
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<td>0.76</td>
<td>0.66</td>
<td>0.76</td>
<td>0.66</td>
<td>0.72</td>
</tr>
</tbody>
</table>

CONCLUSIONS
In contrast from current approaches used in clinical setting for the assessment of PD symptoms, this system enables clinicians to animate easily and realistically the ULMP of patients who at the same time are at their homes. Dynamic access of visualized motor tests may also be useful when observing and evaluating therapy-related complications such as under- and over-medication. In future, we foresee to utilize these manual ratings for developing and validating computer methods for automating the process of assessing ULMP of PD patients.

REFERENCES