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# Development of a test for spatial working memory in Parkinson's disease

## Sensitivity to medication induced periodic performance changes

Jerker Westin<sup>1\*</sup> and Georg Stenberg<sup>2</sup>

<sup>1</sup> Computer engineering, Dalarna University, <sup>2</sup> Psychology, Kristianstad University, Sweden, \* E-mail: jwe@du.se

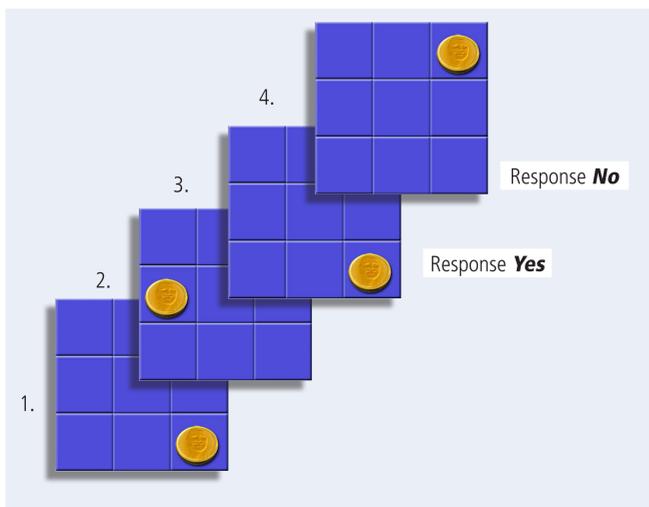
### Introduction

Working memory and visuospatial processing are known vulnerabilities in Parkinson's disease (PD), often found as early as in Hoehn & Yahr stages 1 and 2. These functions are more impaired off than on dopaminergic medication.

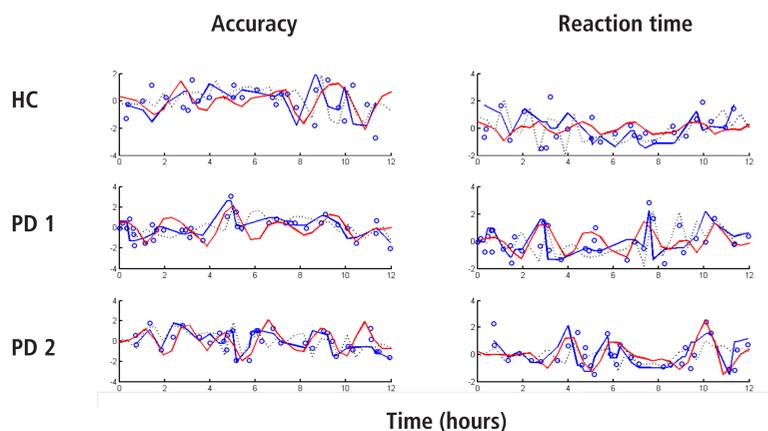
### Methods

The test consisted of six blocks of an n-back, yes/no task, with accuracy and latency of response automatically recorded. It was programmed using the Inquisit scripting language (Millisecond Software) and deployed as a web application. The test is described by Figure 1.

**Figure 1.** The 3-back task is about storing spatial positions into working memory on a continuous basis, in this case detecting whether position 3 is the same as position 1, nr 4 equals nr 2 etc. (Depending on preference, it could be called a 2-back task)



An initial feasibility study comprised extensive data from two persons, one PD patient and one healthy control (HC). The patient was on a regime of levodopa once every three hours, and the time of testing was recorded in relation to latest medicine intake. Data from the healthy control were similarly time-stamped. Altogether the patient performed tests on 70 occasions, spread out over several weeks. The healthy control took the test on 33 occasions over a period of three days. To equalise the sampling rates, the dataset from the patient was divided randomly into two halves. These served the secondary purpose of assessing the retest reliability. A frequency band containing period lengths from 1.7 to 3.5 hours was defined as the region of interest in regard to the medication cycle. The resulting time series were digitally filtered by a bandpass filter allowing the relevant frequencies to pass, and attenuating slower and faster frequencies. Reasoning that filtering would preserve essential information if the time series were periodic but eradicate it if they were not, we used as our primary outcome measure the correlations between filtered and unfiltered data. The three time series generated are illustrated by Figure 2.



**Figure 2.** Data from healthy control, upper row, and the PD patient whose data were randomly divided into two approximately equal-sized parts, the lower two rows. Left column contains accuracy data, right column contains reaction times. All data sets have been z-transformed for comparability. Dots are original data, in each data set 27-36 measurements spread out over a 12h period. Interpolation yielded a series consisting of 32 equally spaced samples (blue line). This series was passed through a filter, designed to pass frequencies with period lengths of 1.7-3.5 hrs. The filtered series is shown as a red line.

### Aim

To initialize development of a test capable of separating spatial working memory function levels of PD patients from that of healthy controls and to capture the variation within a patient's daily functioning.

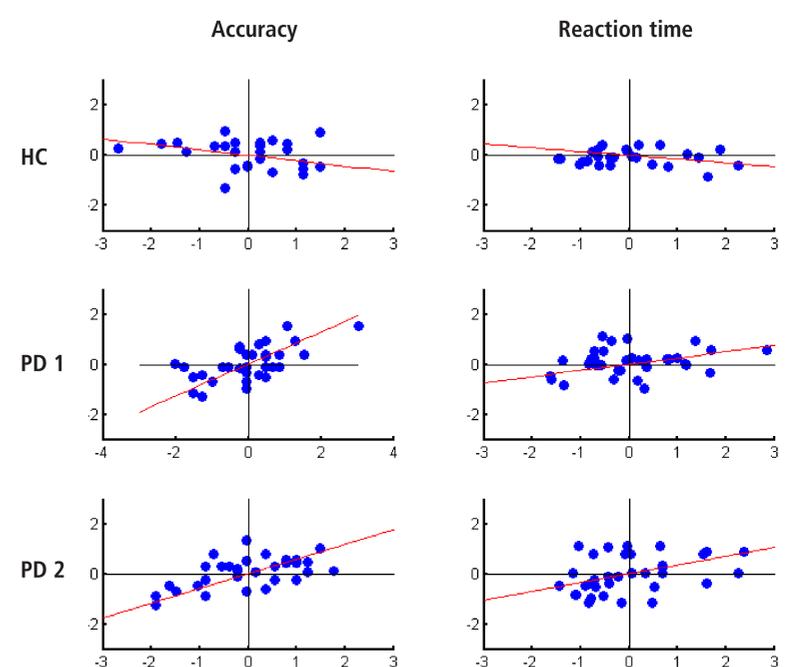
### Results

The comparison between the two test persons, although confounded with a large age difference, showed the expected superiority for the HC in both reaction time and accuracy of target detection.

Correlations between the pass-band relating to the levodopa intake schedule and the full data were positive and significantly larger for the patient than for the HC. These differences applied to both latency and accuracy (Table 1) but were larger for accuracy. The correlations are illustrated by Figure 3.

**Table 1.** Correlations between original data and bandpass filtered data.

Participant	Accuracy		Reaction time	
	Correlation	P(Correlation > HC)	Correlation	P(Correlation > HC)
Healthy control	-0.214		-0.148	
Parkinson patient 1	0.636	< 0.001	0.250	0.056
Parkinson patient 2	0.591	< 0.001	0.356	0.022



**Figure 3.** Correlations from healthy control, upper row, and the PD patient whose data were randomly divided into two approximately equal-sized parts, the lower two rows. Left column contains accuracy data, right column contains reaction times. On the x-axis, original data, on the y-axis, band pass filtered data.

### Conclusions

The patient data contained a greater abundance of frequencies related to the medication schedule than the control data, which support the hypothesis that this test is able to detect levodopa-dependent variations in spatial working memory.