Can analysis of reach and grasp using evolutionary algorithms diagnose cognitive problems in Parkinson's?

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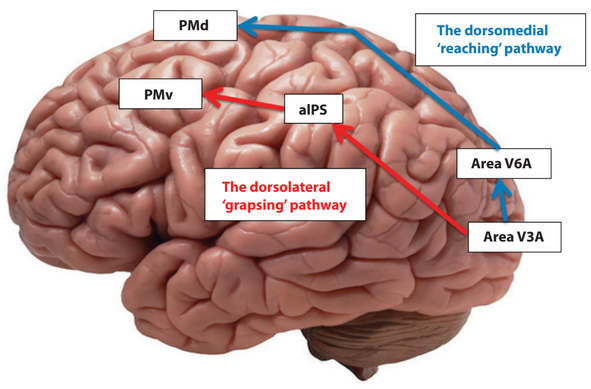
Hypothesis

Subtle differences in reaching and grasping movements will differentiate people with Parkinson's dementia (PDD), people with Parkinson's with mild cognitive impairment (PD-MCI), people with Parkinson's with normal cognition (PD-NC) and healthy controls (HC). The changes in the PDD group are likely to be driven by deficits in visuospatial function caused by parietal lobe pathology whilst the changes in reach and grasp in the PD-MCI group may correlate with milder deficits in visuospatial function or deficits in executive function.

Background

1) The cortical pathways controlling reach and grasp:



aIPS - anterior intraparietal sulcus, PMv - ventral premotor cortex, PMd - dorsal premotor cortex

Figure 1: The reach and grasp pathways

Two distinct but temporally integrated neural networks control reach and grasp movements. Both pathways originate in the occipital lobe and pass to the premotor cortex via the parietal lobe. The network controlling reaching movements lies medial to the network controlling grasping movements; see figure 1.

The dorsomedial circuit, controlling reach, originates in visual area V3A of the occipital lobe. It then passes through area V6A in the superior parieto-occiptal cortex, then the dorsal premotor cortex before terminating in the primary motor cortex.

The grasp pathway is the dorsolateral circuit. It also begins in visual area V3A but then passes through the anterior intraparietal sulcus to the ventral premotor cortex before terminating in the primary motor cortex.

2) The pathology and neuropsychology of cognitive impairment in Parkinson's

A number of pathologies are associated with cognitive decline in Parkinson's. Alpha-synuclein aggregation in the form of Lewy bodies is thought to be the major contributor. Other pathologies include those related to Alzheimer's disease (AD) and vascular disease.

Linking pathological change with the neuropsychological findings is complex. One theory – the dual syndrome hypothesis [1] – is that some cases of PD-MCI are driven by a dysexecutive syndrome mediated by frontostriatal dopaminergic depletion, whereas PDD is the result of temporal and parietal lobe dysfunction caused by acetylcholine depletion and Lewy-body deposition.

3) Abnormalities of reach and grasp

Several abnormalities of reach and grasp have been demonstrated in Parkinson's including delayed onset of finger and thumb opening and increased reliance on visual feedback to guide reaching [2]. No studies have evaluated reach and grasp in PDD or PD-MCI but subtle abnormalities have been identified other neurodegenerative conditions associated with cognitive decline such as AD and corticobasal ganglionic degeneration [3].

Methods and Results

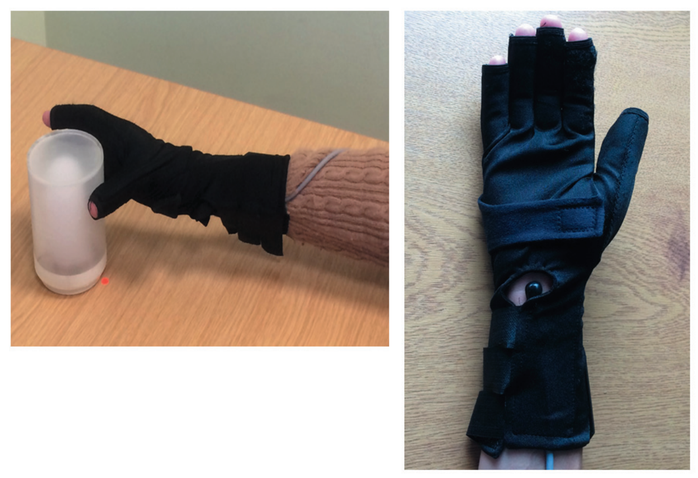


Figure 2: The data gloves contain embedded movement sensors

90 participants will wear gloves that contain movement sensors as they perform reach and grasp tasks; see figure 2. Standard clinical assessments of motor and cognitive function (MoCA/Trails A&B/Judgement of Line Orientation) will be compared to the movement sensor data. The movement data will be analysed by advanced computer programs called evolutionary algorithms, which use Darwinian principles to find a 'classifier' that can differentiate between the groups; see figure 3. Recruitment is underway and 83 people have completed assessments so far. Results should be available by 2015.

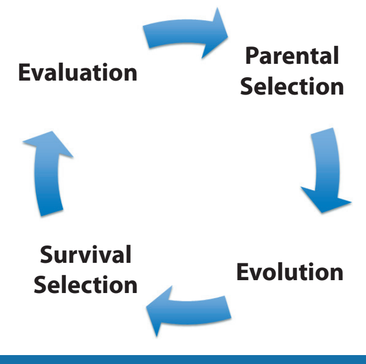


Figure 3: Once initialised, an evolutionary algorithm undergoes repeated cycles of evolution which gradually increased the fitness function of the individual solutions within a population

Conclusion

This project aims to use evolutionary algorithms to analyse movements during a reach and grasp task to differentiate between people with normal cognition in Parkinson's and those with cognitive dysfunction. If successful, this proof-of-concept study will provide insight into how motor function deteriorates with cognitive decline. This information could inform the development of a new cognitive test that is objective and quick to administer. In the future a test of reach and grasp could be used as part of a screening battery for cognitive dysfunction in Parkinson's.

References

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