Preliminary results for the use of sensitive devices to assess the effect of medication on attentional demands of precision and power grips in individuals with Parkinson’s disease

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I. PURPOSE
Parkinson’s disease is a degenerative disease of the nervous system affecting 0.3 % of the entire population and 1% of the people over 60 years in industrialized countries. This is an age related disease which is rare before age of 50 yrs and the prevalence increases to up to 4 % in higher age groups[1]. A number of other studies have reported that patients with Parkinson’s disease (PD) experience difficulties with fine motor coordination in the upper extremity[2-5]. Deficits in fine motor control are a common early symptom in people with Parkinson’s disease (PD)[6] and may serve as an ideal marker for the response to therapeutic interventions and progression of the disease. However, subtle upper extremity motor symptoms and changes in these symptoms are not well quantified by standard clinical measures[7]. The long-term goal of this research is to develop sensitive clinical markers that can be used to accurately assess disease progression and the response to therapeutic interventions. The purpose of this study was to examine the effects of medication on the attentional demands of precision (Pre) and power (Pow) grips in individuals with PD. We hypothesized that the attentional demands of the grip tasks would be greater during the ‘off medication’ state (OFFMeds) compared to the ‘on medication’ state (ONMeds). This was assessed by examining the changes in performance of the cognitive task when the participants were asked to keep performance on the motor task constant.

II. MATERIALS & METHODS
9 participants with PD (Hoehn-Yahr stage 1-2) with a mean age of age of 68.2(+/-13.5) yrs were tested both ONMeds and OFFMeds. Participants were excluded if they had any other neurological condition, severe arthritis in the hands or had a deep brain stimulator implanted. The order of testing for precision/power grasp and single/dual conditions was randomized. The dominant extremity was always tested first. In order to assess force control during precision and power grip, we used an instrumented twist cap device (see adjoining figure). The twist-cap device consists of four 6-axis force/torque transducers (ATI Industrial Automation, Nano25) patterned radially about a central axis. One side of the transducers is rigidly fixed to the rotor of a magnetic particle brake (Placid Industries, B15), which is driven by a linear amplifier (Trust Automation, TA105). The twist cap itself is made up of circular quadrants which are interchangeably attached to the other side of the transducers, one per transducer. Small gaps between each quadrant allow the transducer to detect an individual finger’s motion exclusive of the force production of other digits. In this study two sizes of twist caps were used: The small cap had a radius of r=12.5 mm and the large cap had a radius of r=42.5 mm. (Figure 1)

Figure 1 Twist cap device with finger placements
Participants were asked to twist the small cap (the same size as a soda bottle cap) and the large cap (the same as peanut butter jar) in clockwise and counter clockwise directions, under conditions of varying external resistance. Performance on the motor task was quantified using peak force levels (PF) and the time to reach peak force (TTP). To assess attentional demands of the motor task, participants performed an auditory analogue of the Stroop test while performing the motor task. In this test, participants listened to a series the words “high” or “low” in either high or low pitches. They were instructed to indicate the pitch of the word. In the dual task conditions, participants were instructed to focus on the motor task. Response latency (RL) and accuracy for the auditory task were recorded during single and dual task conditions. Dual task cost (DTC) for all outcome variables was calculated as the percent difference between the RL for the dual and single task conditions, normalized to the RL for the single task condition. Data were analyzed using repeated measures ANOVA.

III. RESULTS

There were no significant differences in the force variables between single and dual task conditions for either grip task (both p>0.32) (Figure 2). There was a significant effect of medication on PF (both p<0.005), but not on TTP (both p>0.13).

Changes in the performance of the auditory task were primarily reflected in the greater RL during the dual task condition compared to the single task condition (p=0.01). RL was reduced with medication for the single task condition only (RL_{single} p<0.01), RL_{dual} (p>0.42) (Figure 3).

RL DTC for both grips were greater (p<0.005) when participants were ‘ONMeds’ Mean[95%CI]: Pre=25.7[14.7-36.7], Pow=37.08[26.5-47.7]) compared to ‘OFFMeds’ (Pre=12.6[1.5-23.6], Pow=10.98[0.4-21.6]) (Figure 4).
IV. DISCUSSION

Participants with PD were able to keep performance on the motor task constant under single and dual task conditions, suggesting appropriate prioritization when instructed. This has been observed with deficits in walking as well as speech. Common clinical strategies during rehabilitation include directing attention to the reduced stride length during walking [8] or the reduced volume of speech [9] using external cues or by directing attention to these deficits to actively correct these. Medications affected single task RL favourably but not the dual task RL. Thus contrary to our initial hypothesis, a greater RL DTC was seen during the ‘ONMeds state’ compared to the ‘OFFMeds’ state. This may indicate that the common dopaminergic medication used in this population may not be as effective in improving mechanisms of attention such as set shifting [10-12] that is necessary for complex activities that require multitasking. The advantage of using sensitive devices such as force sensors is that it may not have been possible to assess if the performance on the motor task remained constant, purely on clinical examination.

V. CONCLUSIONS & FUTURE DIRECTION

These data suggest that force control during both grip tasks remains attentionally demanding even on medications. Since a large proportion of people with PD first notice symptoms in their hand, we are examining fine motor control in greater detail to identify a task that would help unmask subtle deficits, monitor them as a possible marker of disease progression as well as assess effects of neuroprotective therapies including medication and exercise. As a first step, these data will help us understand the effects of medication on the attentional demands of precision and power grips. We believe that adding a cognitive task during assessment of motor control using sensitive devices helps make the task challenging to be able to unmask subtle deficits. Our next step will be to mount such sensors on haptic devices to be able to monitor force and displacement simultaneously to make the task more sensitive to early changes.

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