# Precise evaluation of motor and non-motor dysfunction in Parkinson's disease using the KINARM

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# Parkinson's disease

Common neurodegenerative disease related to loss of dopamine

Clinical exam

- Tremor

- Rigidity

- Akinesia/Bradykinesia

- Postural instability

# Movement Disorder Society-Sponsored Revision of the Unified Parkinson's Disease Rating Scale (MDS-UPDRS): Scale Presentation and Clinimetric Testing Results

## 3.4 FINGER TAPPING

0: Normal: No problems.

1: Slight: Any of the following: a) the regular rhythm is broken with one or two interruptions or hesitations of the tapping movement; b) slight slowing; c) the amplitude decrements near the end of the 10 taps.

2: Mild: Any of the following: a) 3 to 5 interruptions during tapping; b) mild slowing; c) the amplitude decrements midway in the 10-tap sequence.

3: Moderate: Any of the following: a) more than 5 interruptions during tapping or at least one longer arrest (freeze) in ongoing movement; b) moderate slowing; c) the amplitude decrements starting after the 1st tap.

4: Severe: Cannot or can only barely perform the task because of slowing, interruptions or decrements.

3.5  HAND MOVEMENTS

3.6  PRONATION-SUPINATION MOVEMENTS OF HANDS

3.7  TOE TAPPING

3.8 LEG AGILITY

3.9  ARISING FROM CHAIR

3.14  GLOBAL SPONTANEITY OF MOVEMENT (BODY BRADYKINESIA)

# Movement Disorder Society-Sponsored Revision of the Unified Parkinson's Disease Rating Scale (MDS-UPDRS): Scale Presentation and Clinimetric Testing Results

## 3.3 RIGIDITY

0: Normal: No rigidity.

1: Slight: Rigidity only detected with activation maneuver.

2: Mild: Rigidity detected without the activation maneuver, but full range of motion is easily achieved.

3: Moderate: Rigidity detected without the activation maneuver; full range of motion is achieved with effort.

4: Severe: Rigidity detected without the activation maneuver and full range of motion not achieved.

# Movement Disorder Society-Sponsored Revision of the Unified Parkinson's Disease Rating Scale (MDS-UPDRS): Scale Presentation and Clinimetric Testing Results

## 3.12 POSTURAL STABILITY

0: Normal:        No problems:  Recovers with one or two steps.

1: Slight:        3-5 steps, but subject recovers unaided.

2: Mild:          More than 5 steps, but subject recovers unaided.

3: Moderate:      Stands safely, but with absence of postural response; falls if not caught by examiner.

4: Severe:        Very unstable, tends to lose balance spontaneously or with just a gentle pull on the shoulders.

# Hypothesis

Robotic assessment will be a rapid, simple, automated, and objective tool to quantitatively assess the progression of parkinsonian symptoms and track the effects of therapy.

**Impact:** <u>Objectivity and repeatability</u> are vital to improve assessment of the effects of novel drugs or surgical therapeutic neuromodulation in patients (e.g. complete blinding of clinical tests).

# KINARM robotic assessment



Exoskeleton            Endpoint

# Patient group 1

- Initial study in 7 subjects with deep brain stimulators **with advanced PD**

- Randomly tested four conditions

| | |
|---|---|
| **OFF dopamine and OFF Deep brain stimulation** | **OFF dopamine and ON Deep brain stimulation** |
| **ON dopamine and OFF Deep brain stimulation** | **ON dopamine and ON Deep brain stimulation** |

- Neurologist blinded

# Assessment of motor performance

**Clinical exam**

**KINARM motor tasks**

**UPDRS: Bradykinesia**

**"Reach toward target"**
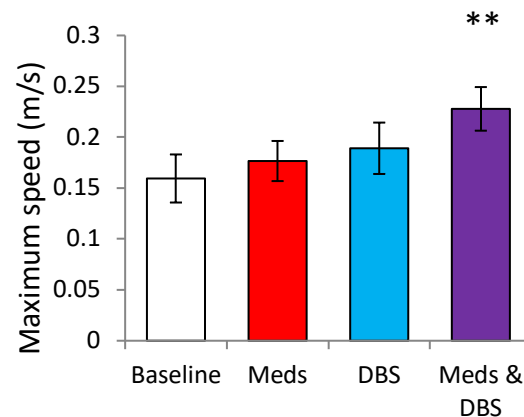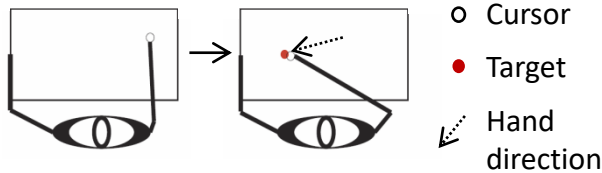
**"Hit the falling targets"**
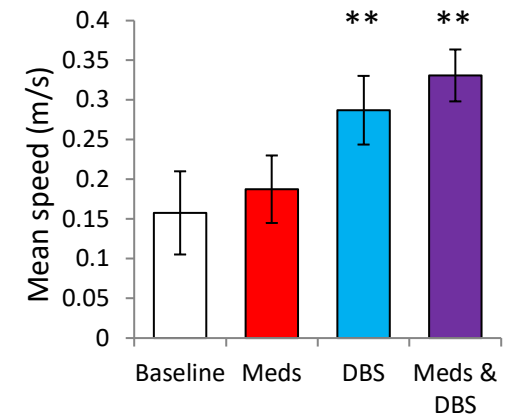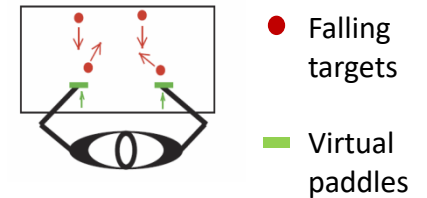
# Assessment of rigidity

**Clinical exam**
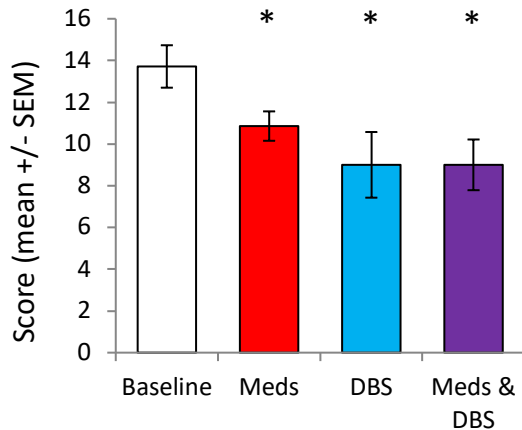
**KINARM rigidity test**

**UPDRS: Rigidity**

**"Allow robot to move your arm for you"**
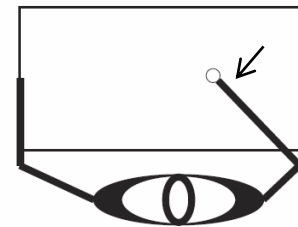


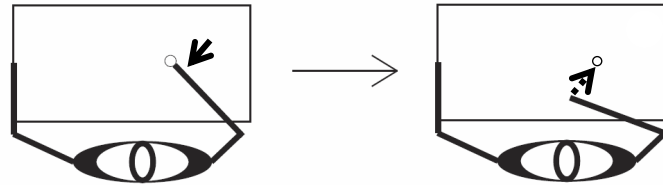↙ External force applied



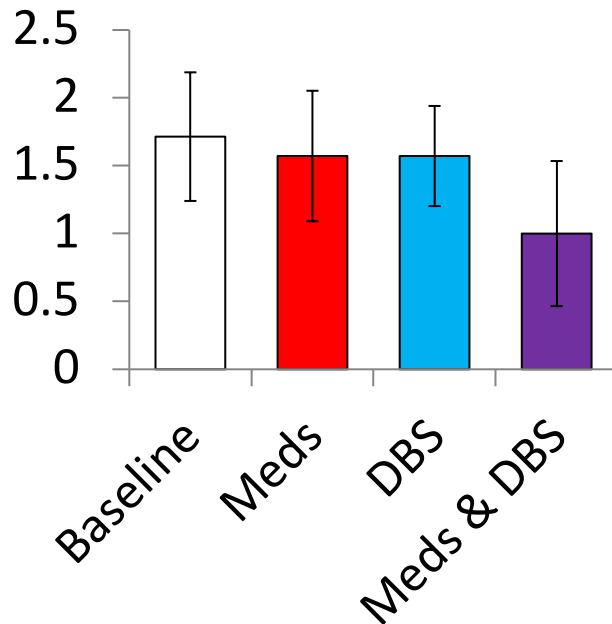Fast passive movement:
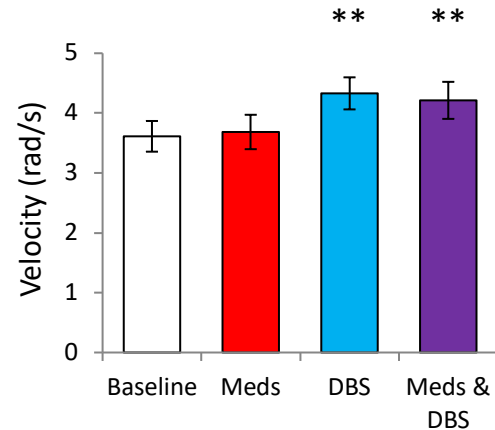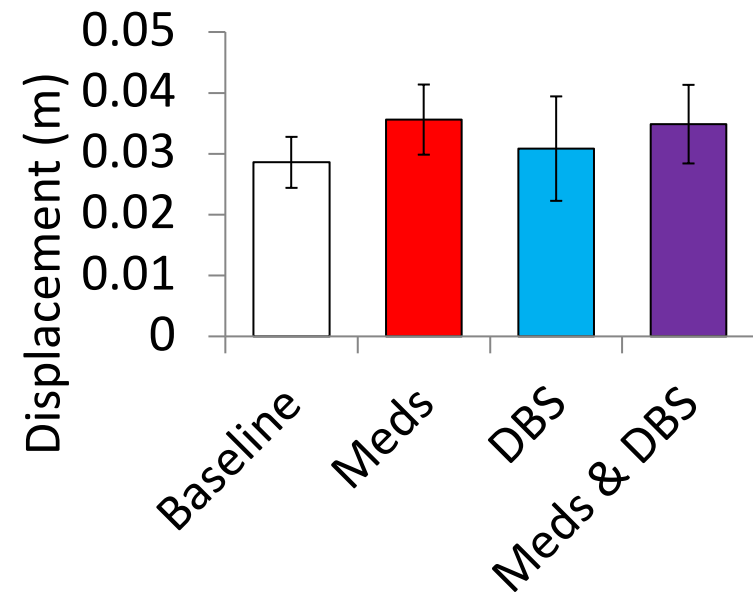


Slow passive movement:
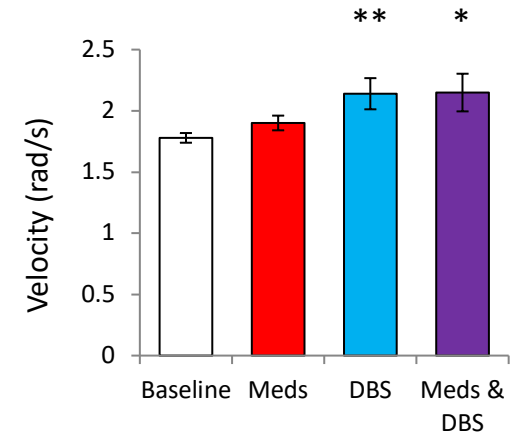
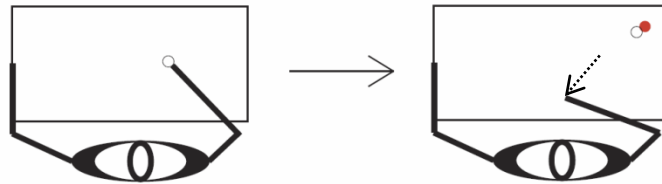# Postural instability

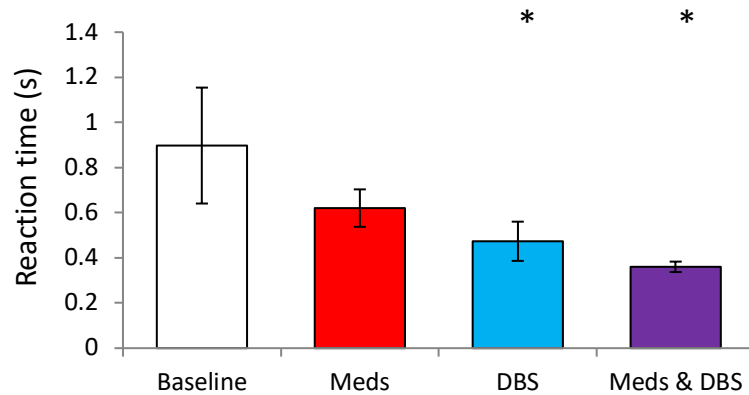"Move your arm back after being pushed"



## UPDRS


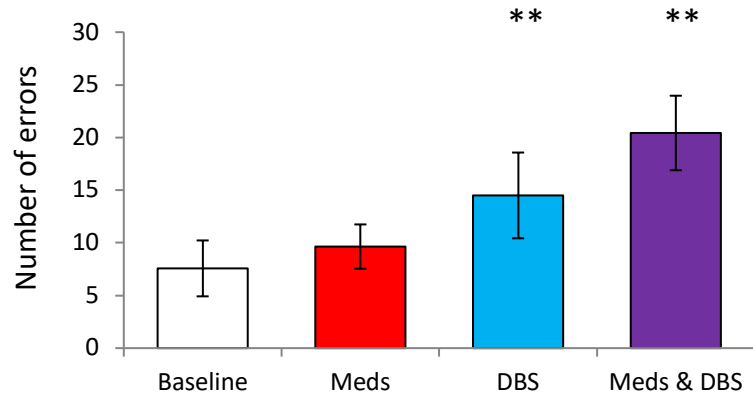
## Displacement

# KINARM task errors 1

**"Reach away from target"**
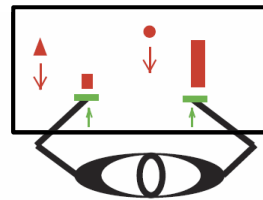


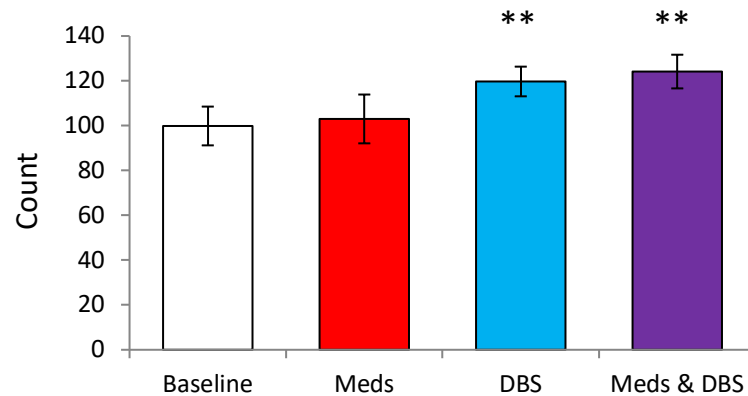**Reaction time**

* *

**Direction errors**

** **

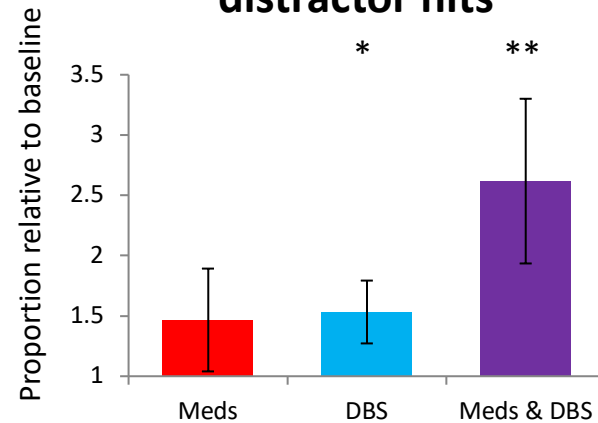# KINARM task errors 2

**"Hit targets but not distractors"**



Targets to hit

Distractors to avoid

## Objects hit



## Relative change in distractor hits

# Highlights

- So maybe KINARM is a **precise** and **objective** assessment?

- Possibly be adopted for clinical users and **standardized reports** are generated that compare a subject's performance to other patients or healthy controls?

- Can it be used to measure a **broader base of sensory, motor and cognitive impairments** due to disease progression or the effect of treatment?

## Require testing in a larger and less severe patient group

# TRANSLATION TO THE CLINIC
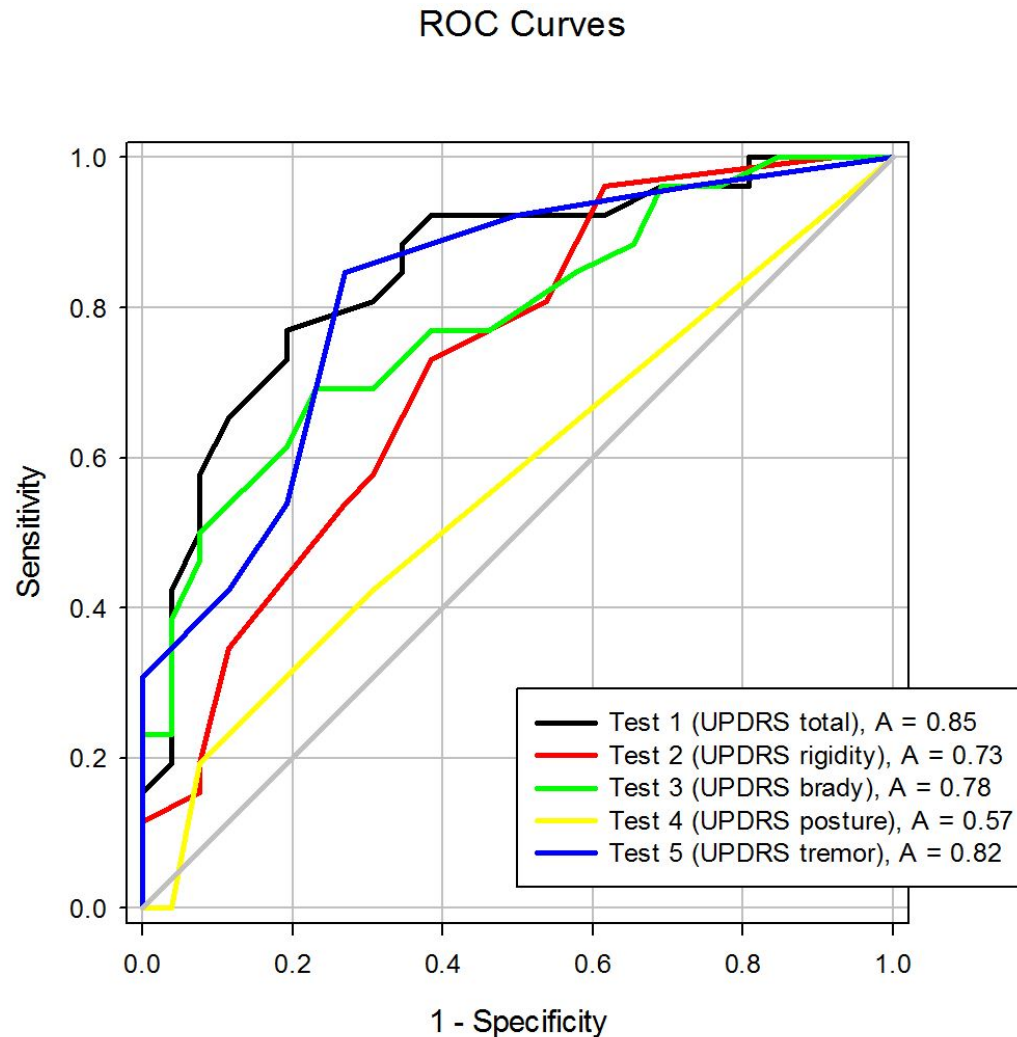


Are we capturing all the data???

# Patient group 2

- Study in 26 subjects with **moderate** PD (addition of Dr. Stuart Reid)
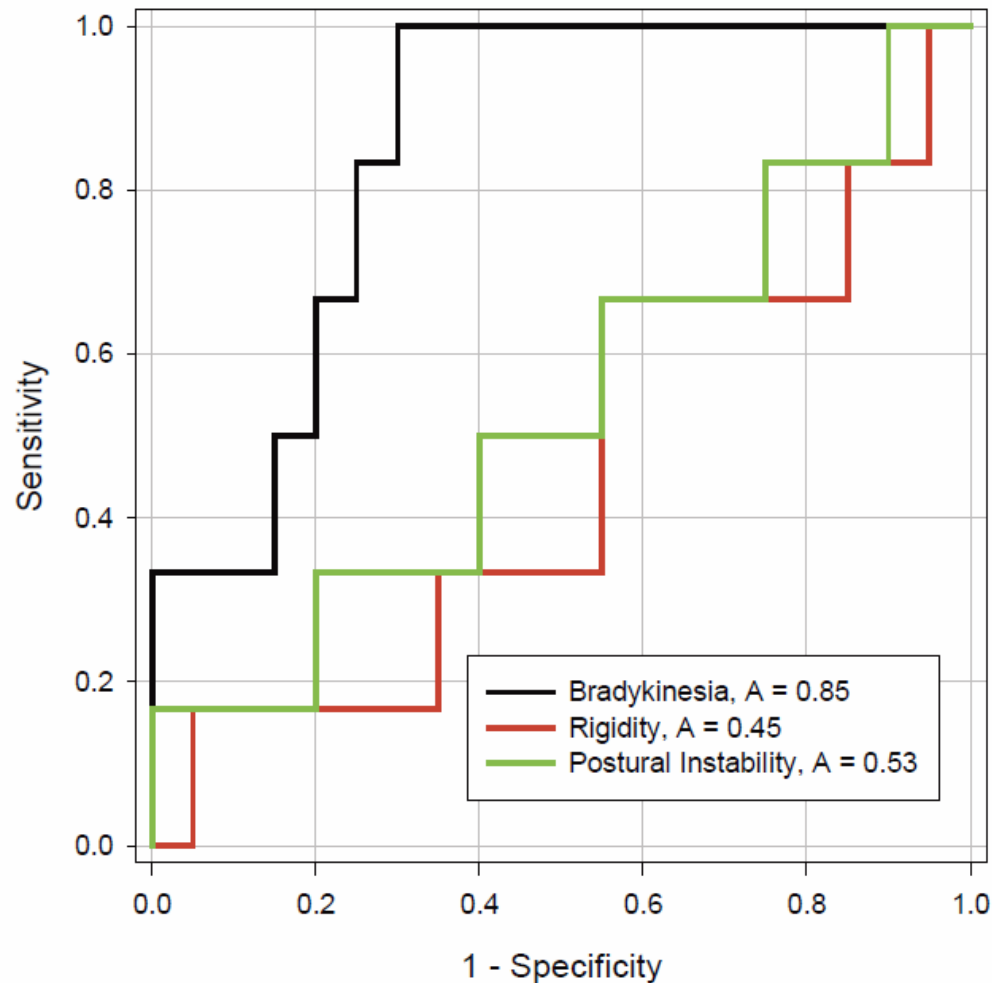
- Tested two conditions

| OFF dopamine |
|:---:|
| **ON dopamine** |

- Neurologist not blinded

# If a patient took a dopaminergic medication could the neurologist detect it with the UPDRS?



ROC Curves

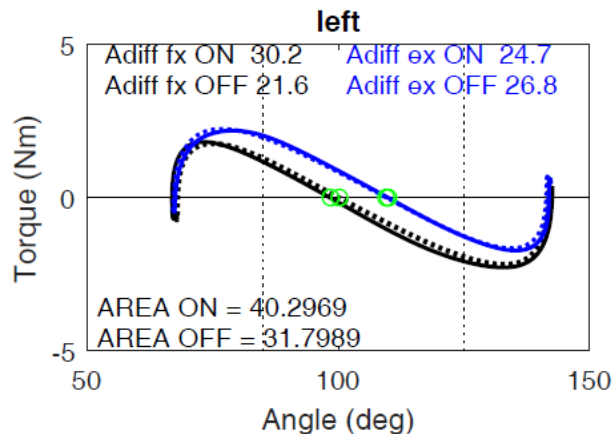# If a patient took a dopaminergic medication could the KINARM detect?



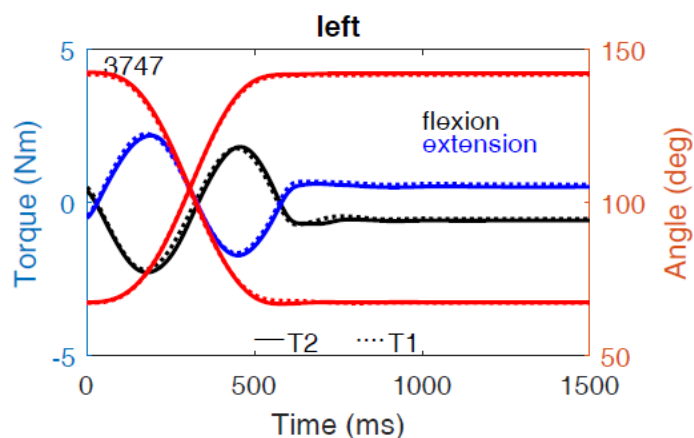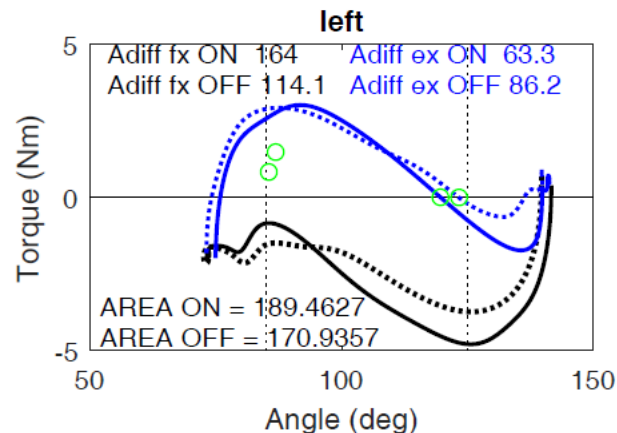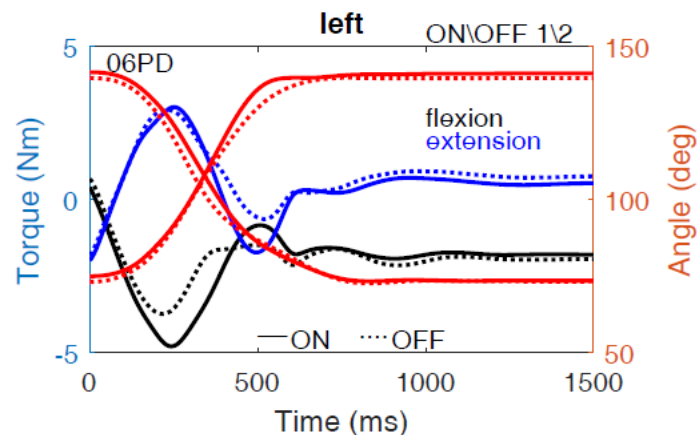**What happened to rigidity???**

# It was deigned for spasticity!
## So we are redesigning analysis to better capture rigidity...
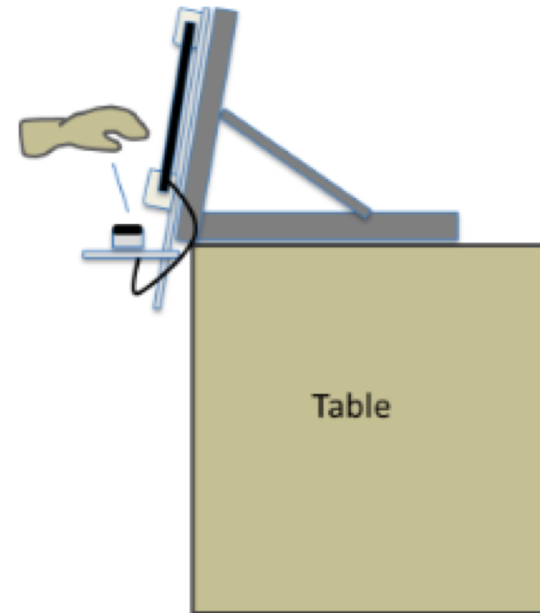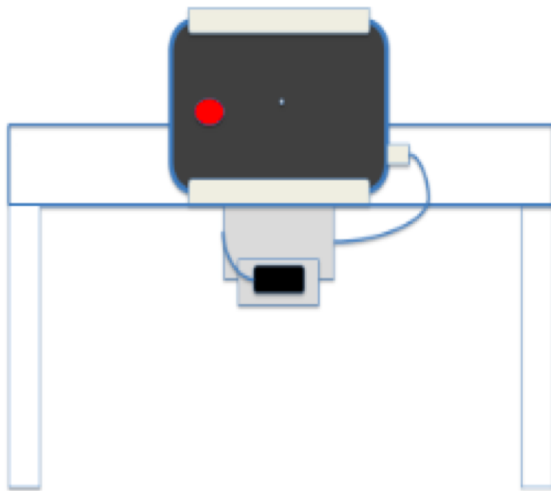


**Healthy subject**

**Subject with PD**

# TRANSLATION TO THE CLINIC



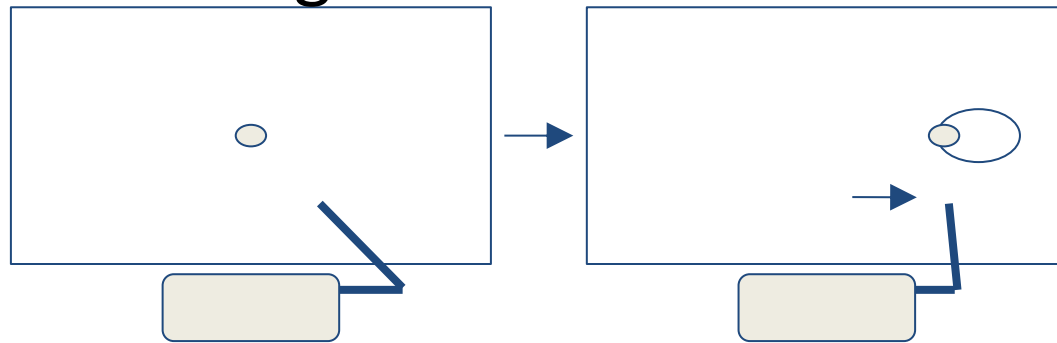Can we capture the data in the clinic and not the lab???

# Patient group 3
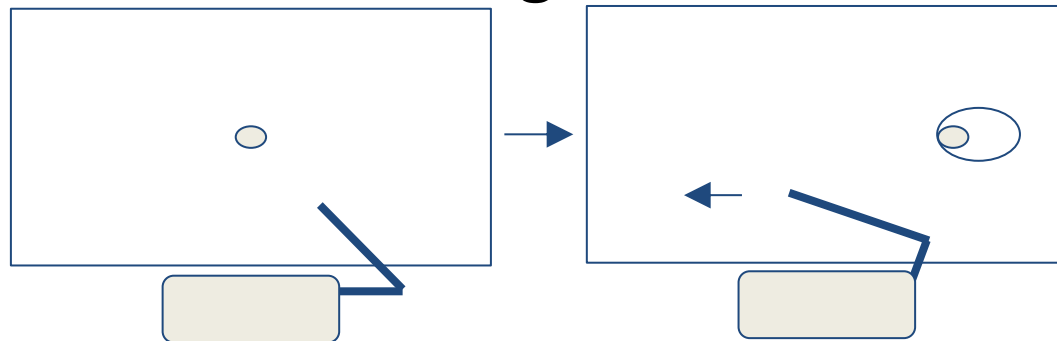
- Study in 24 subjects with **severity range of** PD



Hand tracker used to capture bradykinesia, dyskinesia, and tremor in the clinic
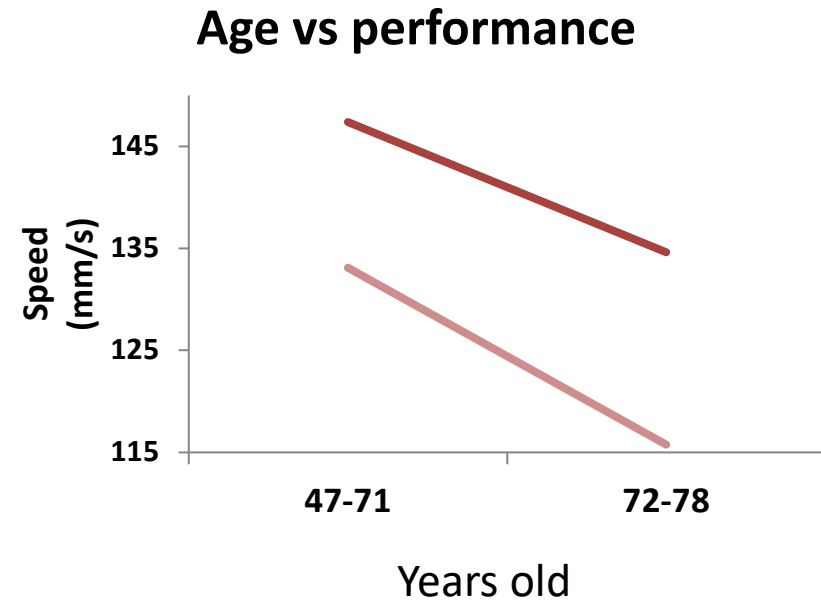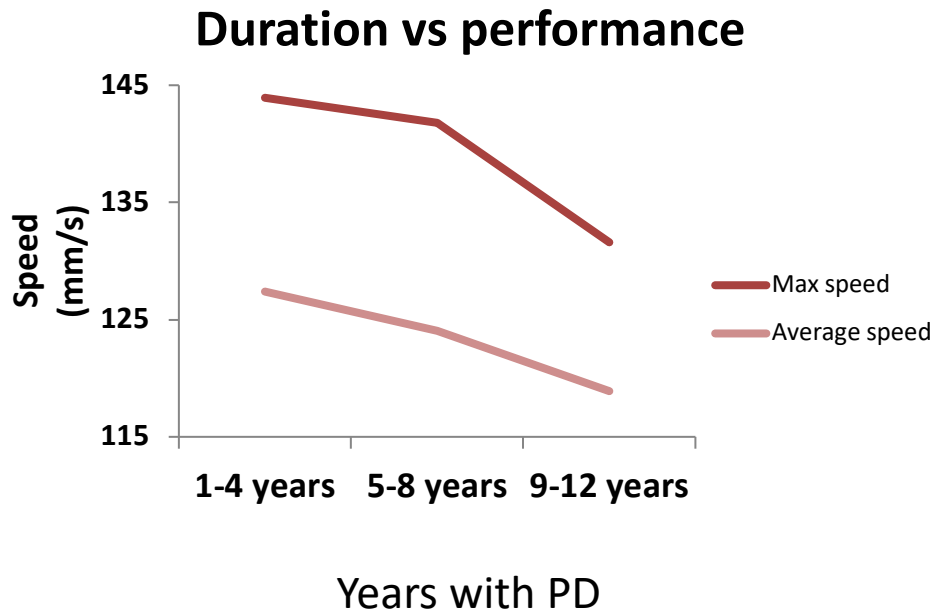
# Task



Reaching task

Reverse reaching task

# Disease progression



Reaching task

# Comparison to KINARM

- 16 patients in group 2 also underwent hand tracker
- Correlate UPDRS OFF and ON meds
- rho significant if red shading

| | | Reaching | Reverse Reaching |
|---|---|---|---|
| KINARM | OFF | -0.1275 | -0.396 |
| | ON | 0.0614 | 0.0963 |
| Hand tracker | OFF | -0.5393 | -0.5694 |
| | ON | 0.526 | 0.3711 |

# Discussion

**KINARM**

- – Need to optimize data collection and processing for <u>patients with PD</u>

- – There is utility in measuring a subgroup of signs with mobile hand tracking

# Acknowlegdement

- Personnel
  - **Pauline Gaprielian:** Masters Student
  - **Dr. Stephen H. Scott:** Developer of KINARM
  - **Dr. Giovanna Pari:** Movement Disorders neurologist
  - **Dr. Stuart Reid:** Movement Disorders neurologist
  - **Kim Moore:** KINARM research assistant
- Funding
  - 2013/14 AHSC AFP Innovation Fund