WALKING WITH PARKINSON'S DISEASE

Understanding gait disturbances as perceptuomotor coupling between a person and their environment

Université Paris Nanterre

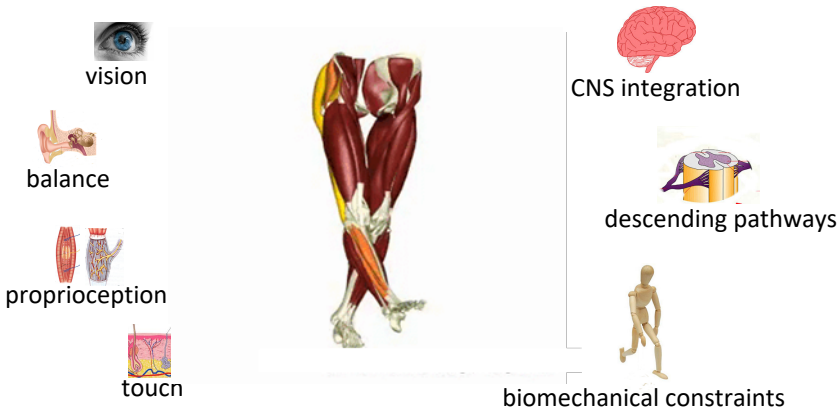
Ross Parry
Assistant professor
Centre de Recherché sur le Sport et le Movement
UFR Sciences et Techniques d'Activités Physiques et Sportives

Outline of presentation

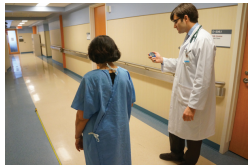
1. Background on PD gait evaluation
2. Methods – data collection / analysis
3. Results from study of gait in daily life situations
4. Discussion and perspectives from this research

1. BACKGROUND

Gait is a highly complex locomotor behaviour (Snijders et al., 2007)




Patient questionnaire


Motor performance test


Posturography

➔ ***No single tool proves to be a reliable measure of gait stability***

(Ambrose et al., 2013; Hamacher et al., 2013)

Parkinson's disease

- PD patients fall at twice the rate of the general older population (Bloem et al., 2001)
- PD gait problems attributed to hypokinesia (slow, reduced ROM) (Morris et al., 1996)
- Gait and postural instability tend to be resistant to treatment (Grabli et al., 2012)

Example: freezing of gait

➔ ***Mechanisms responsible remain poorly understood***

(Nutt et al., 2011, Herman et al., 2013)

➔ ***Need of frameworks to understand gait in context***

(Earhart, 2013; Buttelli et al., 2014)

Ecological approach to human gait

Ergonomics

- Understanding and improving human activity
- Human performance in everyday life situations
- Systematic observations and variations over time

(Theureau and Jeffroy, 1994; IEA, 2016)

Observation in daily life situation

Embodied cognitive science

- Sensorimotor coupling between brain, body and environment
- Emphasis upon subjective experience of an individual

(Gibson, 1979; Varela, 1996; O'Regan et al, 2005: Chemero, 2011)

OBJECTIVES

- Characterise PD locomotor behaviour in everyday situations
- Develop approach / framework for understanding PD gait difficulties in terms of sensorimotor coupling with the environment
- Highlight mechanisms involved in gait disturbances

2. METHODS

- Inductive approach
- Naturalistic research design
- Articulated datasets

Subject characteristics

14 PD patients (11 male, 3 female)

Age 61 yrs (SD=11yrs); disease duration 11yrs (SD=4yrs)

- UPDRS III – OFF 31 (SD=12)
- UPDRS III – ON 12 (SD=11)
- Each patient identified as a freezer (item 4 FGQ)

10 healthy control subjects (8 male, 2 female)

Age 35 yrs (SD=9yrs)

- No pathology impacting upon locomotor function

Data collection

Stage 1

In-depth interview

approx 1 hour per interview
total = 18 hours

Stage 2

Monitoring with onboard system

Direct observations

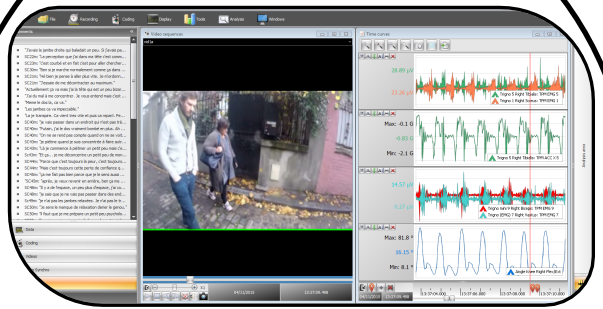
approx. 3.5 hours per observation
total = 61 hours

Stage 3

First person interviews

approx 1.5 per interview
total = 41 hours

Stage 4



Data integration
(patient commentary, video data, onboard signals)

Data analysis

Individual locomotor activity

- *Classify motor behaviour*
- *Record changes over time*
- *Examine effects of medication, thought processes, environment*

(e.g. Ripley, 1967; Birdwhistell, 1970)

Phenomenological analysis

- *Thematic analysis of lived experience*
- *Meaning of behaviour from patient perspective*
- *Characterise sensorimotor perception*

(e.g. Smith et al, 1997; Larkin et al., 2011)

Patterns of muscle activity

- *Amplitude and duration of EMG activity*
- *TAMPs of EMG activity over phases of the gait cycle*
- *Comparison between gait patterns, gait events*

(e.g. Perry & Burnfield, 2010)

3. RESULTS

Different gait patterns in daily life activity

Shuffling gait

Asymmetric gait

Intentional / exaggerated stepping

Habitual gait (ON)

(c.f. Jones et al., 2008; Morris et al., 2001; Patchay et al., 1997; Plotnik et al., 2005)

Different manifestations of freezing of gait

Blockade on gait initiation
(total akinesia)

Blockade on pre-swing
(trembling in place)

Blockade on forward shuffle
(shuffling with small steps)

(c.f. Nutt et al., 2011; Schaafsma et al., 2003)

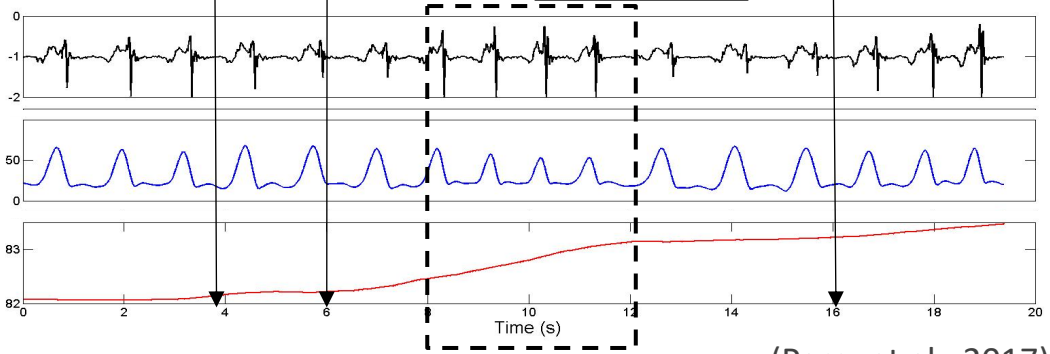
Gait patterns change according to the dynamics of the situation

Encountering a pedestrian

"There it is. I look up and see the person approaching. Knowing someone is going to pass by unsettles me. It's automatic. I'm afraid that someone would bump into me and that I would fall."

"I'm worried about losing balance. It stresses me and up I come on my toes."

"Obstacles don't worry me. They're static. People are mobile, that's what worries me. I absolutely need to maintain regular steps and if I have to make shorter ones, I lose stability."



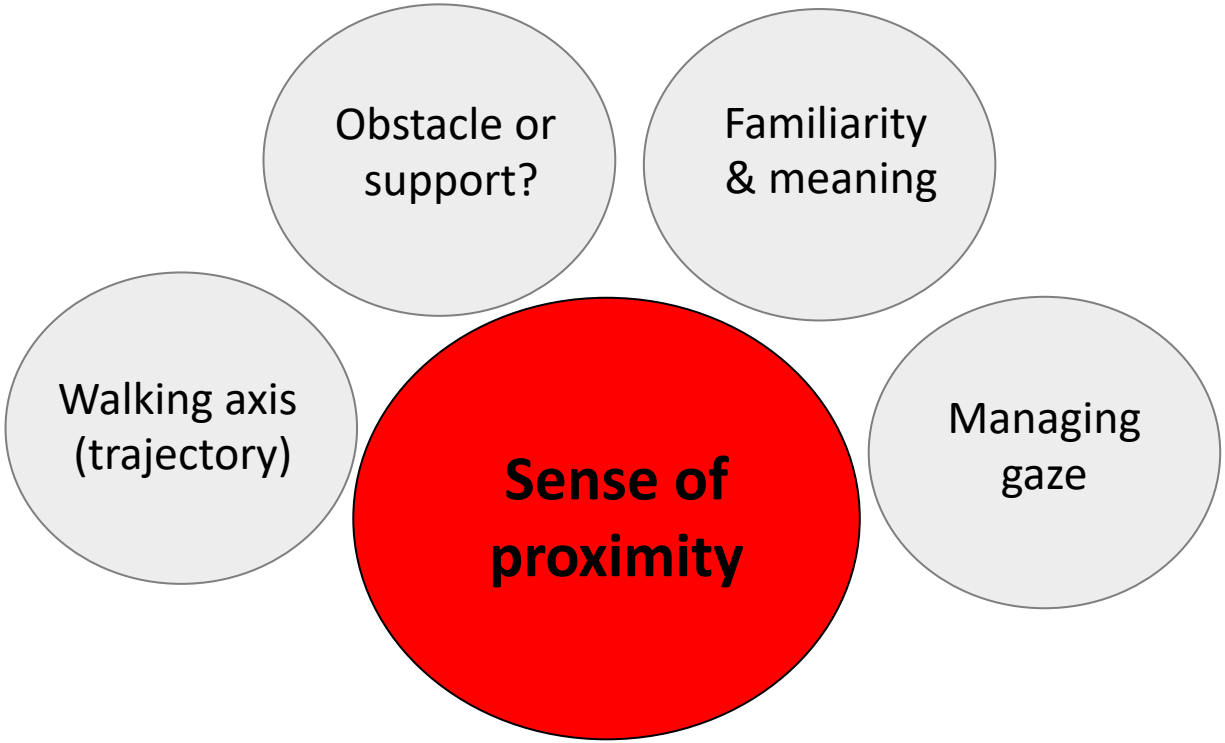
(Parry et al., 2017)

i. ***Relationship between the person and environment?***

ii. ***Coordination of PD gait?***

iii. ***How do these factors drive variations to PD gait?***

i) RELATIONSHIP OF PERSON AND ENVIRONMENT

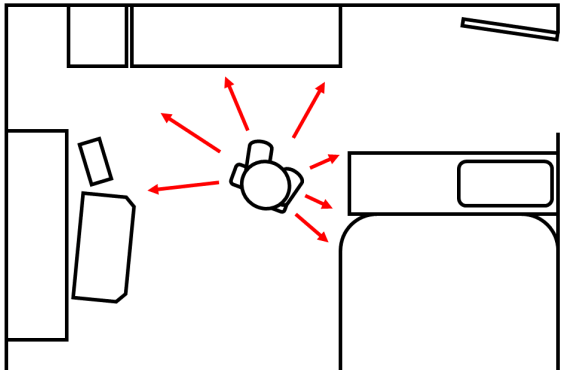


Sense of proximity

- Distance between self and physical surrounds affects stepping ability
- Decreased speed and amplitude in congested environments

"It's the question of space. I don't walk in the same way when I'm inside. Straight away I feel different when I walk, it's incredible. Inside I feel suffocated. I have too many things in here, that's true. I feel completely suffocated here." (5)

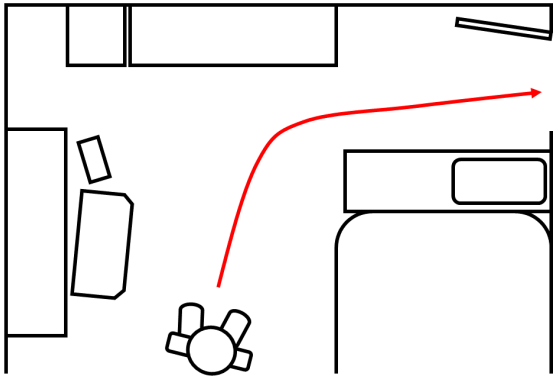
"When I'm around a chair or the sink, it is like the whole perimeter is difficult." (7)



➔ ***Shift in the way of sensing distances between self and environment***

Walking axis / trajectory

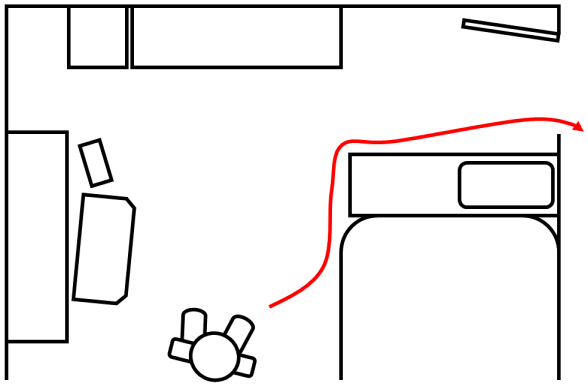
- Navigating about features in different environments a prominent concern
- Difficult to adjust direction accommodate for obstacles



"If I'm in an OFF state and I have to move around on an angle, I could feel particularly unstable. Like if I'm moving about in the kitchen or walking around an armchair. And in the living room there are plants and different furniture, it's when I have to pass around and between things. Wherever there are turns and obstacles." (1)

Obstacle or support?

- Potential to co-opt environmental features to facilitate locomotion
- Functional significance of their surrounds may change significantly with respect to locomotor ability



"Unconsciously I move towards the wall. Just in case I need to grab onto something if I fall." (5)

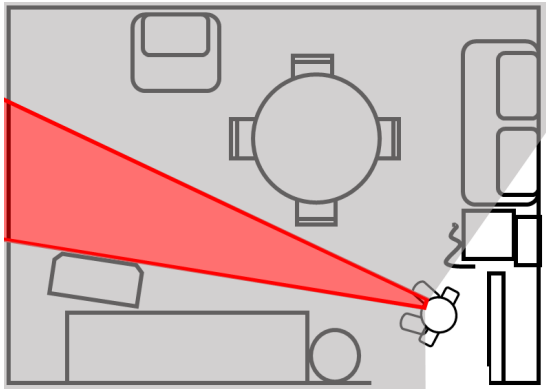
Familiarity & meaning

- Patients had “schemas” for organising movement
- Recall of positive/negative experience influenced gait stability

“I find myself in situations that I’ve already lived. I know a little what’s going to happen. And that makes me afraid, to do the same thing again. I bring on the freezing myself.” (9)

Managing Gaze

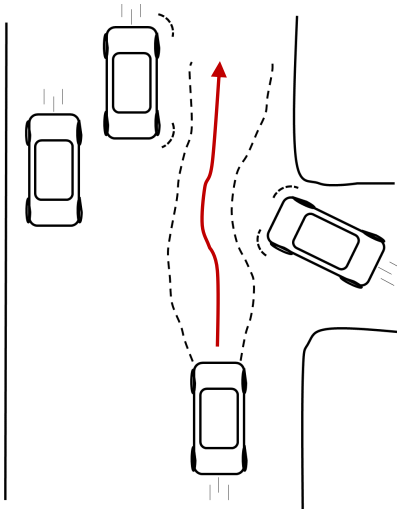
- Concern about appreciating distances
- Visual attention on walking trajectory
- Adjustment of visual behaviour to control for proximity effects



“It’s like you were in a car. You look at the road signs and then at the road. Everything else disappears. You block it out. That’s what I try to do, eliminate the surrounds.” (12)

Locomotor coupling to surrounding environment

Field of safe travel: an unimpeded path defined by features or objects in the terrain (Gibson and Crooks, 1938)



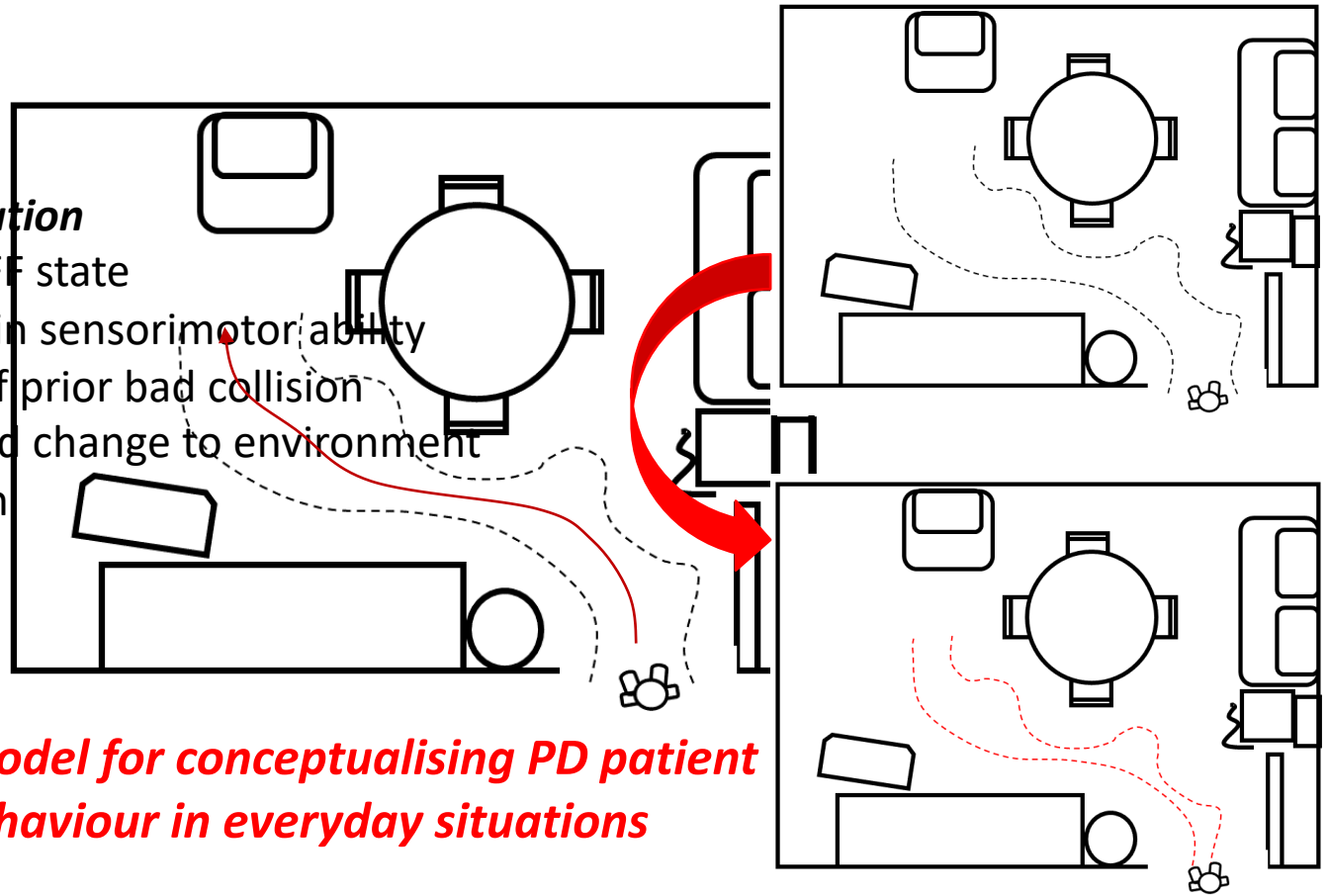
(Gibson and Crooks, 1938)

- Midline of unimpeded path considered has high “valence”
- Learned perceptual-motor abilities orchestrate locomotion with respect to FOST
- Changes in circumstance (person or environment) affect how the FOST is bounded

Locomotor coupling to surrounding environment

Change in situation

- relative OFF state
- reduction in sensorimotor ability
- memory of prior bad collision
- unexpected change to environment
- inattention



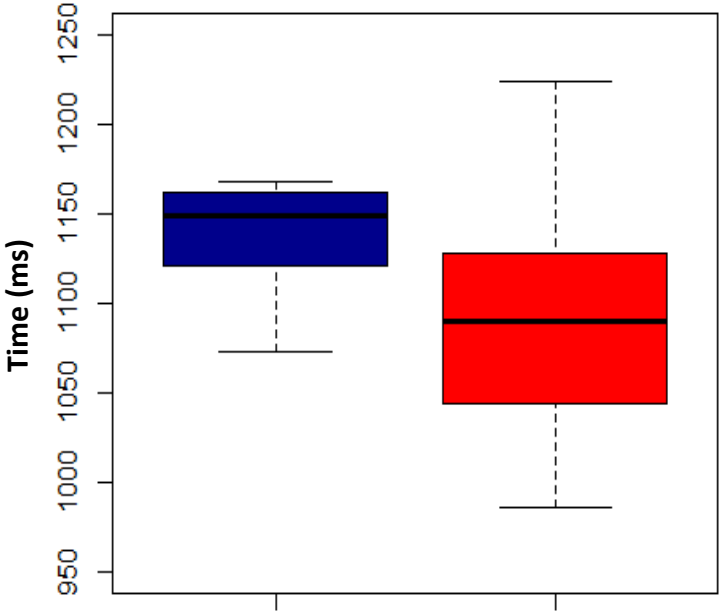
➔ ***FOST as model for conceptualising PD patient locomotor behaviour in everyday situations***

ii) COORDINATION OF PD GAIT

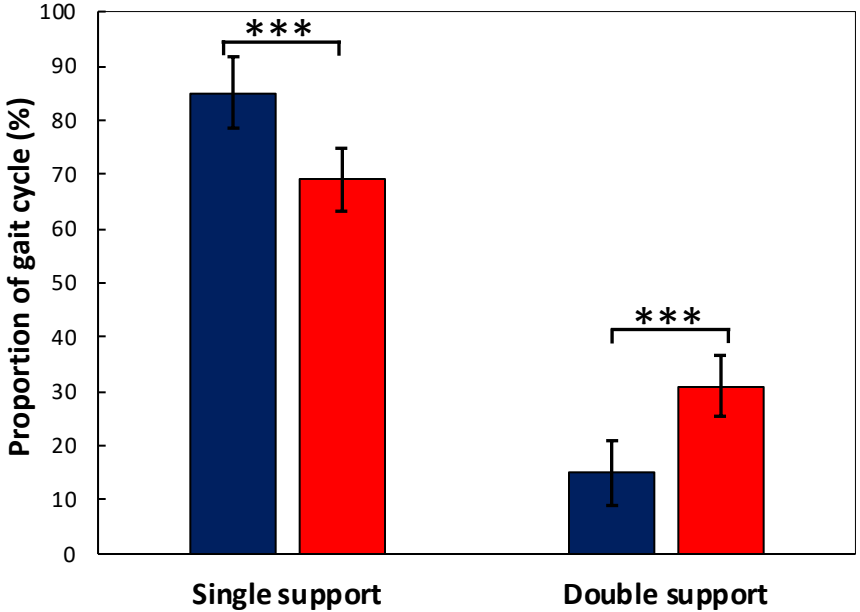
Normal gait: Control group vs PD patients

Change to relative duration of phases in gait cycle

Comparison of stride time

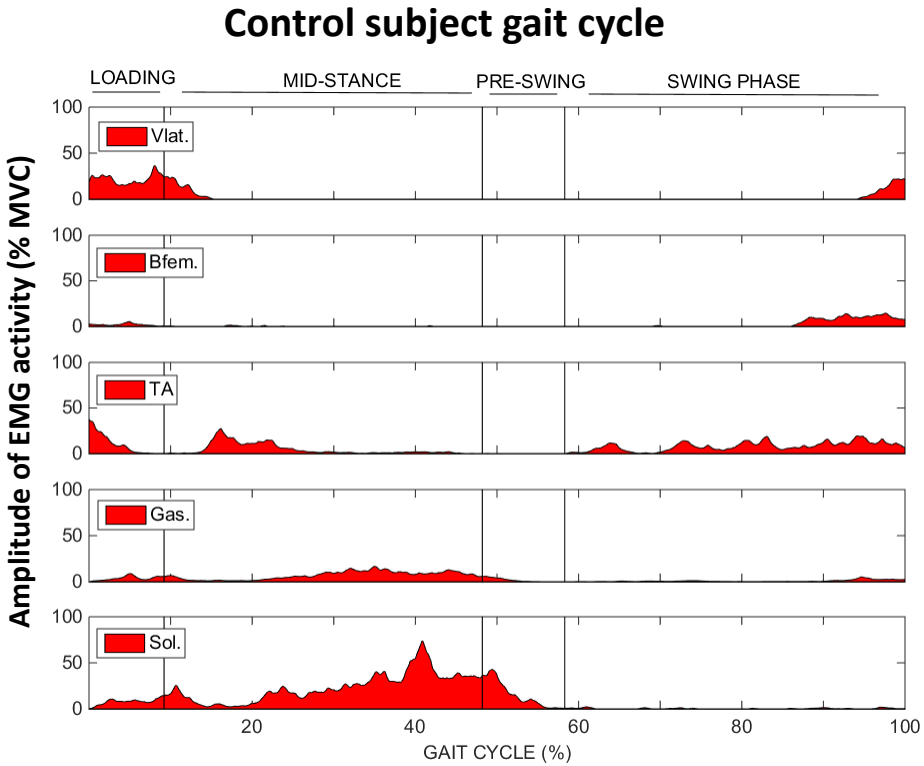


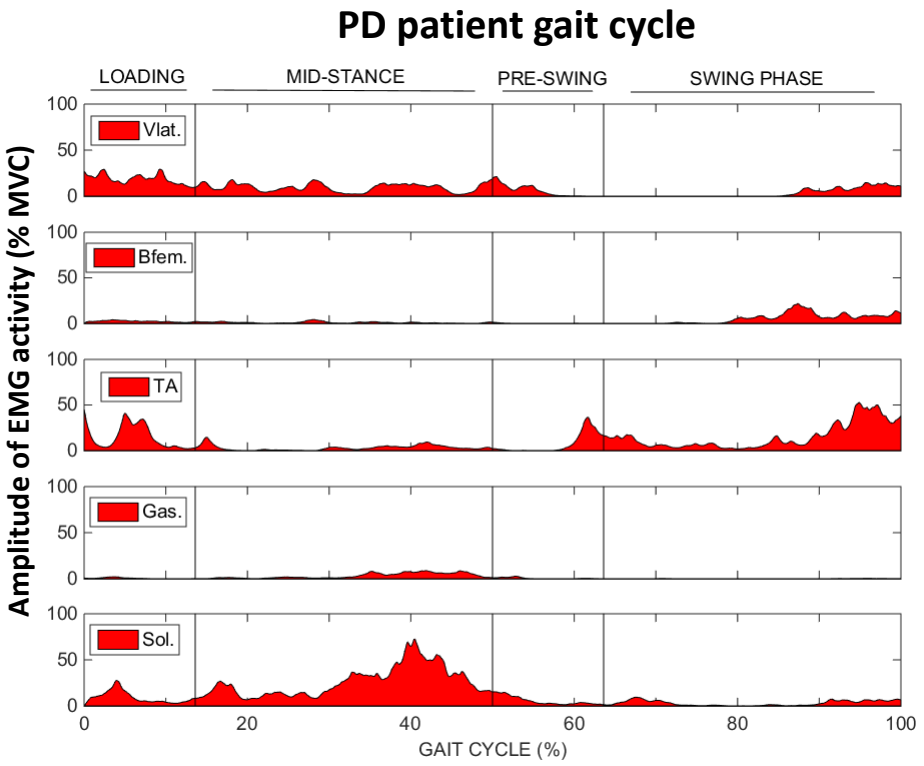
Relative duration of gait cycle phases



(c.f. Hass et al., 2012)

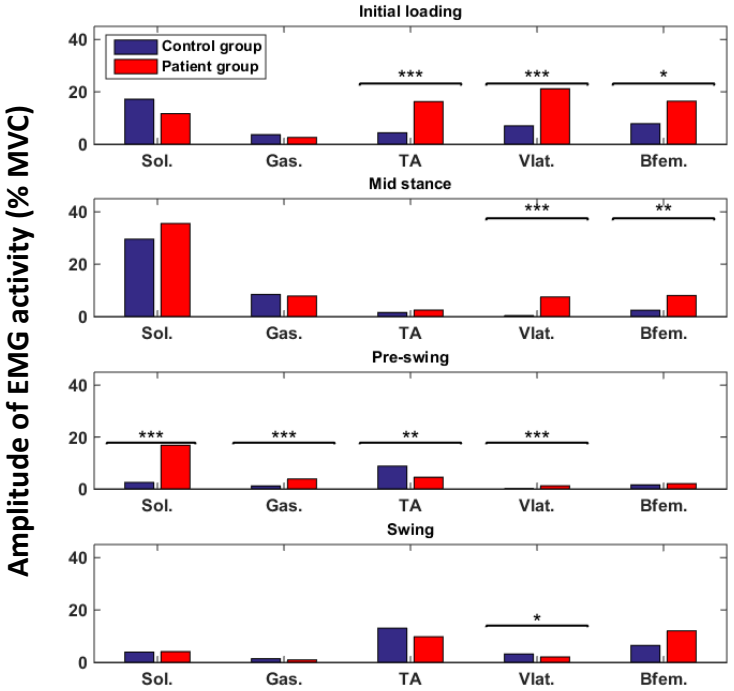
Example patterns of muscle activation: control subject v PD patient



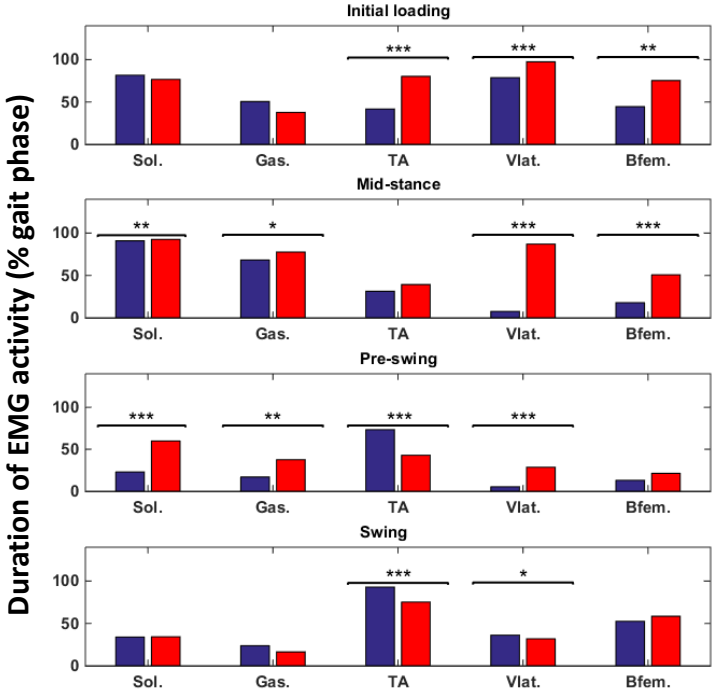


PD patients have greater amplitude and duration of muscle activity

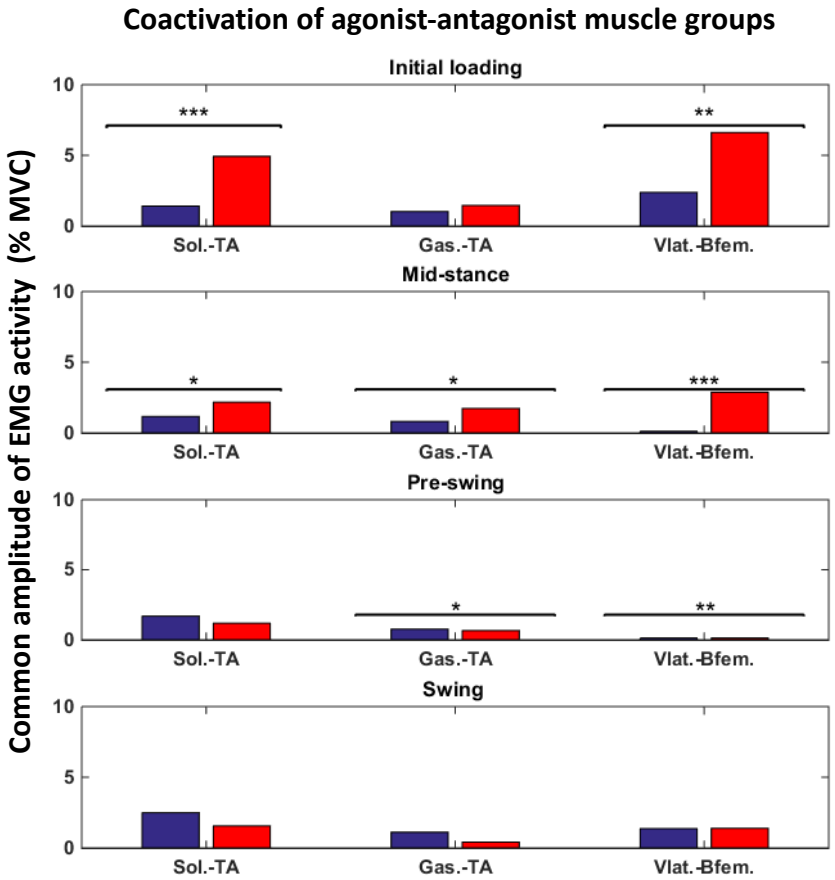
Amplitude of muscle activation in each phase



Relative duration of muscle activation in each phase



PD patients have increased agonist-antagonist coactivation



Coordination of PD gait during daily activity

- Prolonged muscle activation supports balance (Martino et al., 2015; Schmitz et al., 2009)
- Activation across knee associated with stability on anteroposterior axis (Shiratori & Latash, 2000)
- Cocontraction a strategy to reduce joint deviation in case of unforeseen perturbation (Latash, 2008; Schmitz et al., 2009)

➔ ***Consistent with neuromuscular activity to manage instability***

iii) UNDERSTANDING GAIT VARIATION

Shuffling gait

Asymmetric gait

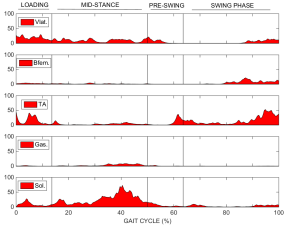
Intentional / exaggerated stepping

Total akinesia

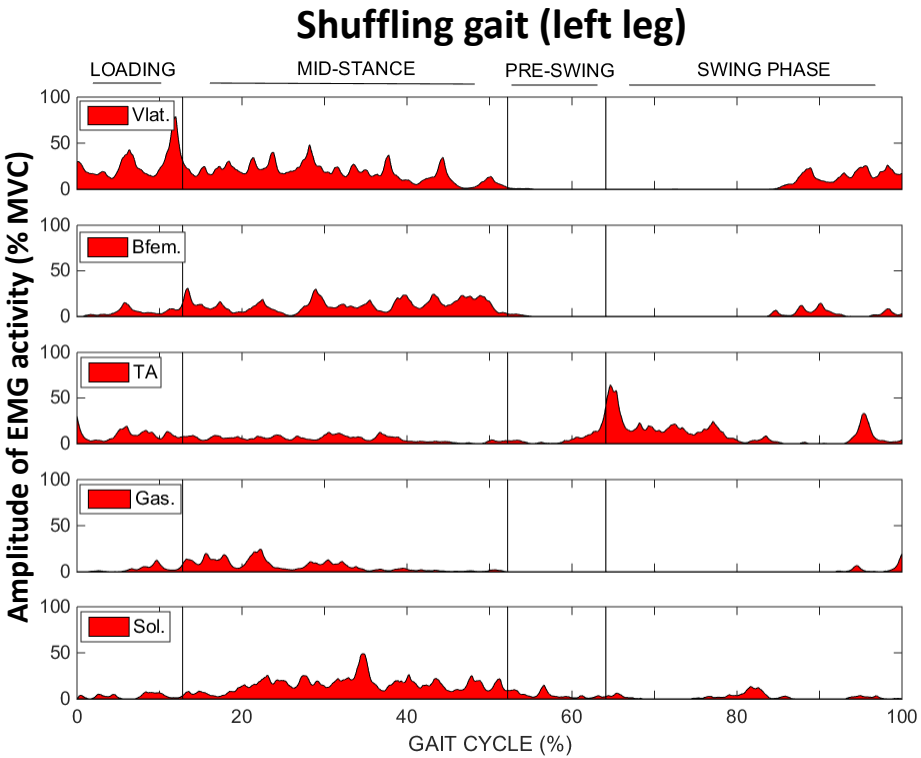
Trembling in place

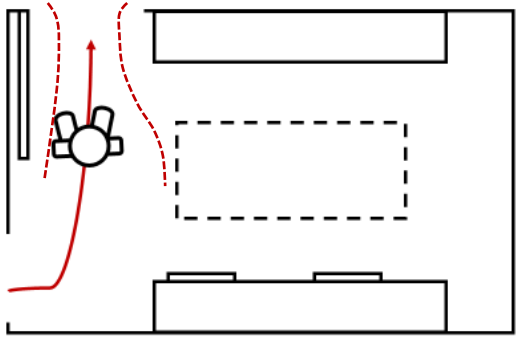
Shuffling with small steps

Shuffling tendencies associated with increase to knee muscle activity



Example: PD normal

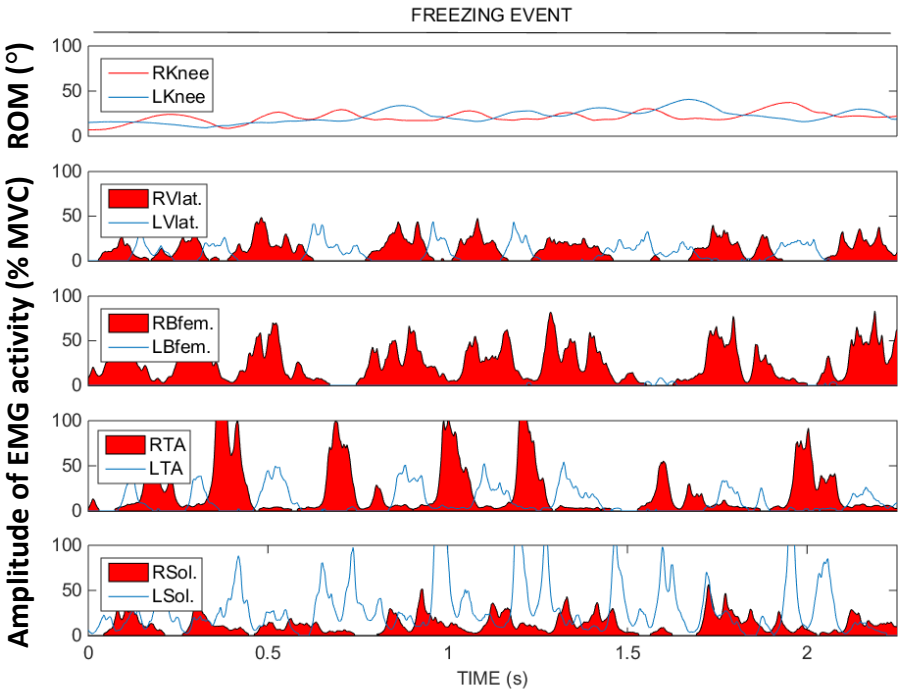


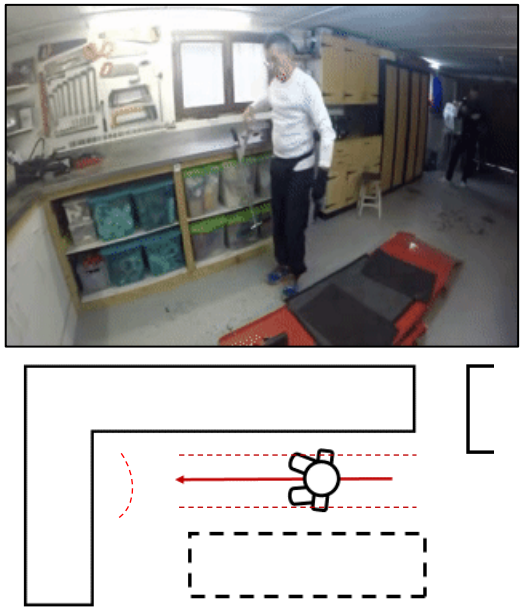


"I feel like the amplitude of my movements are too big for the door. I think especially about how my arms move." (14)

➔ ***Exaggeration of underlying changes to muscle activity in proximity to FOST***

Blockade on forward shuffling with strong increase in muscle activation

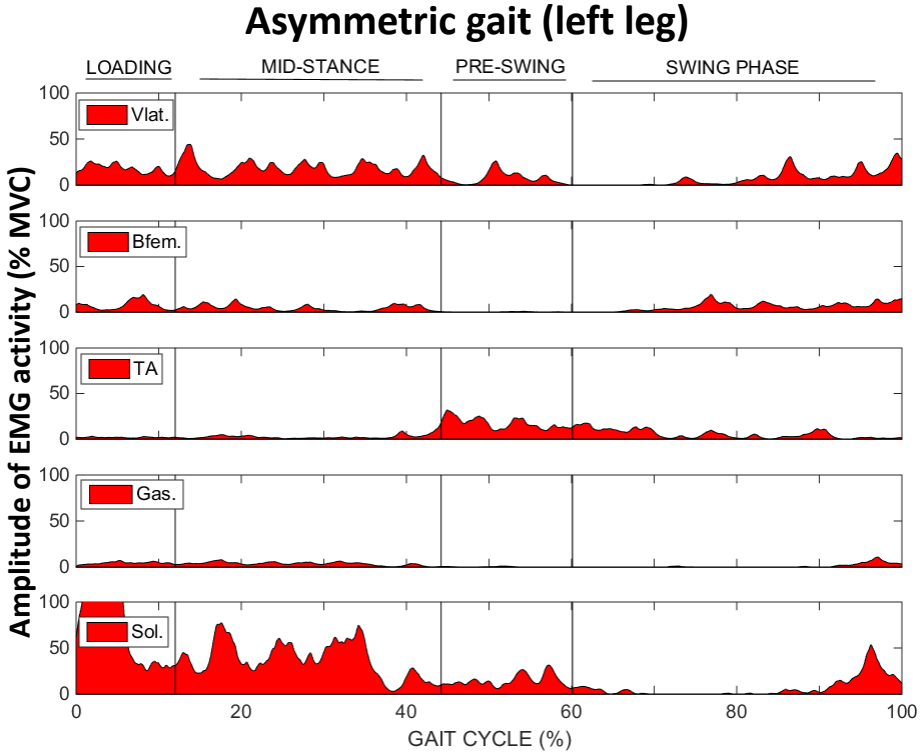


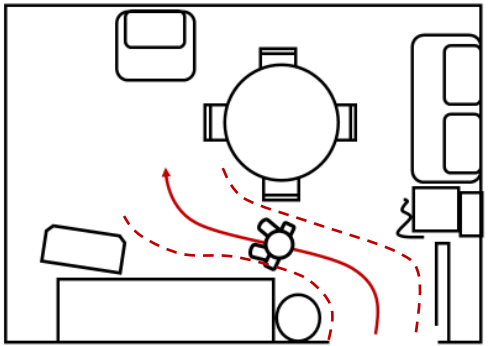


"I push myself forward but my legs feel stiff. As I continue the muscles become more contracted. I can feel it through the thighs." (10)

➔ ***Strongly exaggerated cocontraction and breakdown of forward locomotion***

Asymmetric gait with increased Sol. in loading, TA in pre-swing

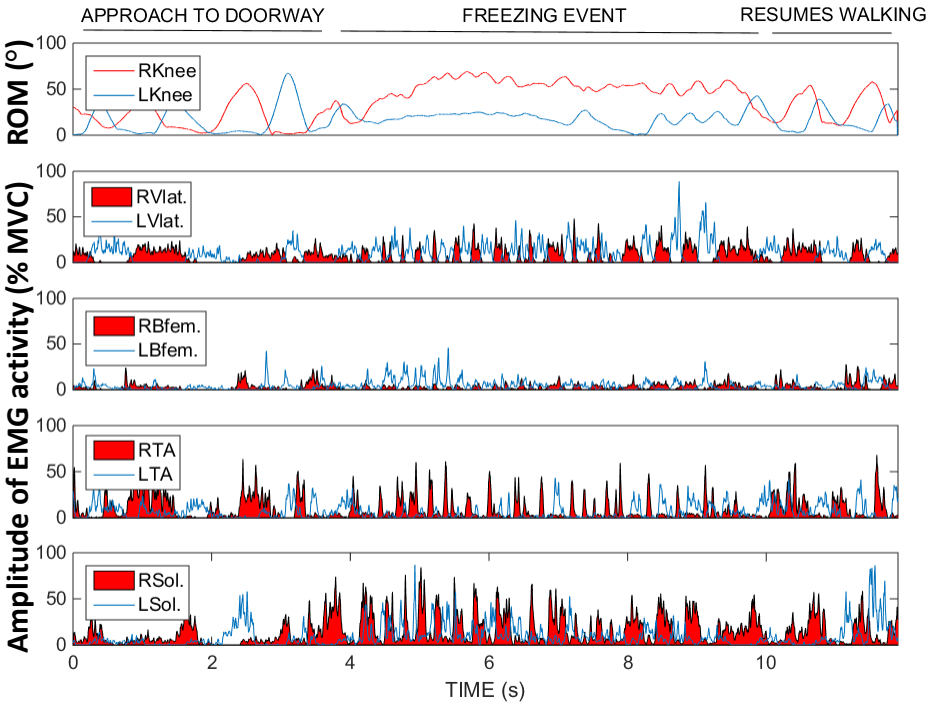


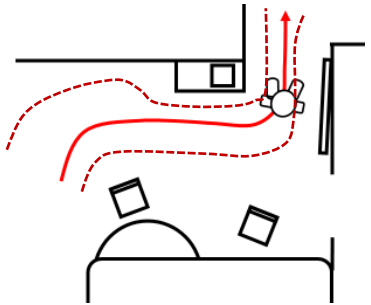


"I drag the leg but it's not all the time. But as soon as there is a turn to take, walking is no longer instinctive." (12)

➔ ***Exaggerated ankle activation to increase stability on mediolateral axis***

Blockade upon pre-swing with recurrent Vlat. activity





"Passing through a tight space. Here, I need to concentrate on my leg to get past. I think to myself 'zen'. (8)

➔ ***Reflects underlying hyperactivity of Vlat. in pre-swing phase provoked at FOST***

Understanding PD gait variation

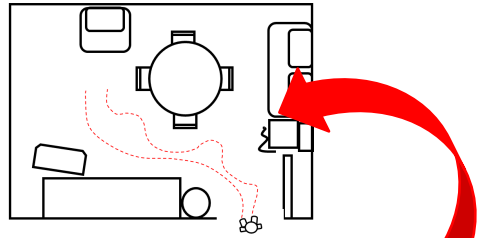
- Gait disturbances associated with increased muscle activity
- In patterns which would reinforce stance phases, postural stability

➔ ***Exaggeration of underlying changes***
➔ ***Provoked in proximity to FOST***

4. DISCUSSION AND PERSPECTIVES

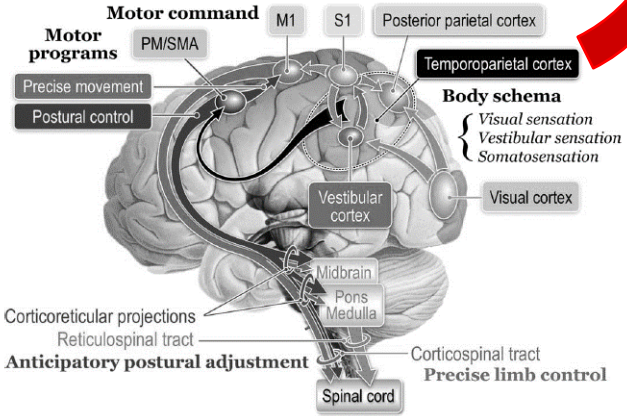
Perception of environment during locomotion

- PD patients poor at judging and recalling walking distances, especially those with FoG *(Ehgoetz Martens et al., 2014)*



- Changes in visuomotor processing region, e.g. the temporoparietal cortex

(Assmus et al., 2003; Herman et al., 2013; Kostic et al., 2012; Tessitore et al., 2012)



➔ ***Targeted visuospatial retraining for PD patients.***

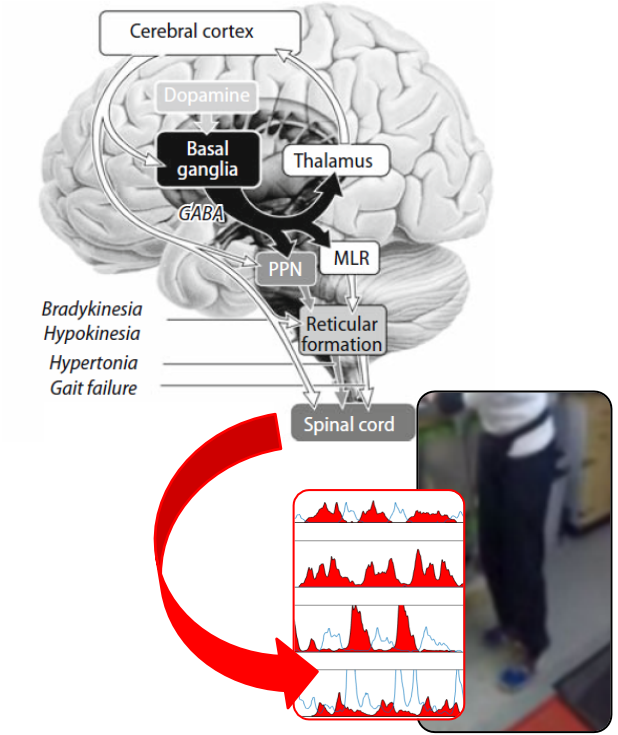
(brain image from Takakusaki et et al. 2013)

Dysregulation of muscle tone control system

- PD gait was strongly linked to prolonged muscle activity

- Problems of gain in muscle tone adaptation provoke gait dysfunction *(Takakusaki et et al., 2008)*

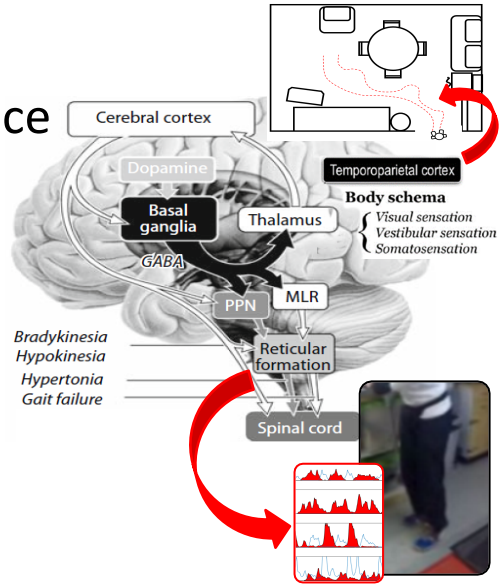
➔ ***Muscle activity patterns for monitoring PD gait?***



(image adapted from Takakusaki et et al. 2008)

WALKING WITH PARKINSON'S DISEASE

- Dynamic coupling between walking abilities and the corresponding possibilities for safe passage afforded by that environment
- Trend for prolonged duration of muscle activity in mid-stance phases and increase in agonist-antagonist coactivation
- Modulation of these mechanisms contribute to the emergence of gait disturbances(shuffling, freezing etc.)



(image adapted from Takakusaki et et al. 2008; 2013)

THANKYOU!

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