Multi-limb dual-task cost in Parkinson disease: Evaluating effects of implicit and explicit cues

T. L. McIsaac, PT, PhD[1], R.G. Cohen, PhD[2], R. C. Bay, PhD[1], J. Gupta, OTR, PhD[1], C.H. Adler, MD, PhD[3]
[1]A.T. Still University Physical Therapy Dept., Mesa, AZ; [2]University of Idaho Psychology & Communication Studies Dept., Moscow, ID; [3]Mayo Clinic College of Medicine, Scottsdale, AZ

ATSU A.T. STILL UNIVERSITY

University of Idaho

MAYO CLINIC

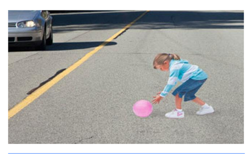
Abstract #1275

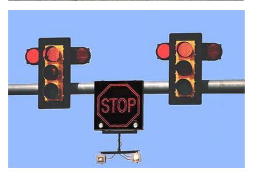
Background and Rationale

Dual tasking requires the ability to shift attention between tasks and to prioritize one task over another.

Framework 1: Dual-task interference while walking is well-known to be exacerbated in people with PD [1].

- The relevance of this framework to *seated activities* in which arm and leg tasks are *uncoupled from postural control* is unclear.





Framework 2: Individuals with PD have difficulty with implicit contextual learning and rely on explicit cues and instruction for improved stepping while walking and to regulate their driving behavior [2-4].

- This suggests a PD-related selective impairment for using contextually implicit cues for attention shift.

Operational definitions:

- Implicit cues: contextual cues gathered from the environment or task and used to shift attention.
- Explicit cues: clear instructions on what task to pay attention.

Decision-making and switching attention are not well addressed with current medications[6], and the effect of medication state on multi-limb dual-task performance is unclear.

Hypotheses

1. PD reduces ability to shift focus between arm tasks and foot tasks based on implicit cues but does not affect ability to shift focus based on explicit task prioritization.
2. The dopaminergic medication state, On versus Off, will result in reduced attention switching to implicit and explicit cues.

Methods: Participants & Clinical Assessments

Participants

- Inclusion criteria:
  - Individuals with PD, Hoehn & Yahr stages 1-3 (n = 15)
  - Healthy age-matched adults (n = 15)
  - Hold a valid driving license and drive at least once/week
- Exclusion criteria:
  - Significant co-morbidities (e.g., diabetes, stroke)
  - Cognitive impairment (< 24/30 Montreal Cognitive Assessment)
  - Impaired vibration sensation at the ankle
- Recruited from local community, local rehabilitation clinics, PD support groups, and fitness centers throughout the Phoenix metropolitan area.
- PD subjects tested in "On" medication state (~1 hr. after dose) and in the practically-defined "Off" state (in the morning prior to first daily dose, ≥12 hrs. from prior)
  - Sessions 1 week apart, counterbalanced for order of session

Clinical Screens of Cognition & Assessments of Functional Mobility

- Montreal Cognitive Assessment (MoCA) – versions 7.1, 7.2, and 7.3
  - Different versions used for On and Off sessions
- Trail Making Tests A & B (TMT-A, TMT-B)
- Stroop (Victoria version)
- Timed Up & Go (TUG), single and dual-task (cognitive: serial-3 subtraction; manual: transporting full water glass)

Methods: Materials & Procedure

Instruments

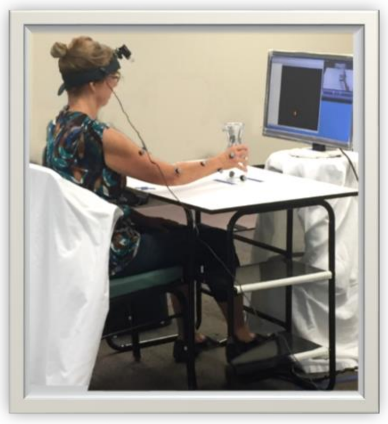
- Motion capture system (Vicon® and MotionMonitor®)
- Instrumented foot pedal and glass carafe
- Head-mounted camera and computer monitor, to control for visual gaze location across single and dual tasks

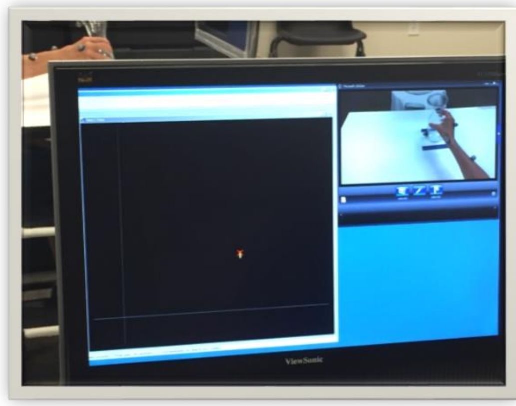
Experimental Tasks

- Arm single-task: on hearing auditory cue, participants reached to, raised and replaced a glass, and returned hand to start position.
- Foot single-task: participants tracked moving target on computer screen by pressing pedal with right foot.
- Dual-task: participants performed arm and foot tasks simultaneously.

Experimental Conditions

- Explicit cue for priority / Instructed priority: No priority; Arm task priority; Foot task priority
- Implicit cue for priority / Accuracy constrained: Reach task - Easy (glass empty); Hard (glass full) Foot-pedal task - Gradual ramp; Steep ramp





Results: Clinical Performance

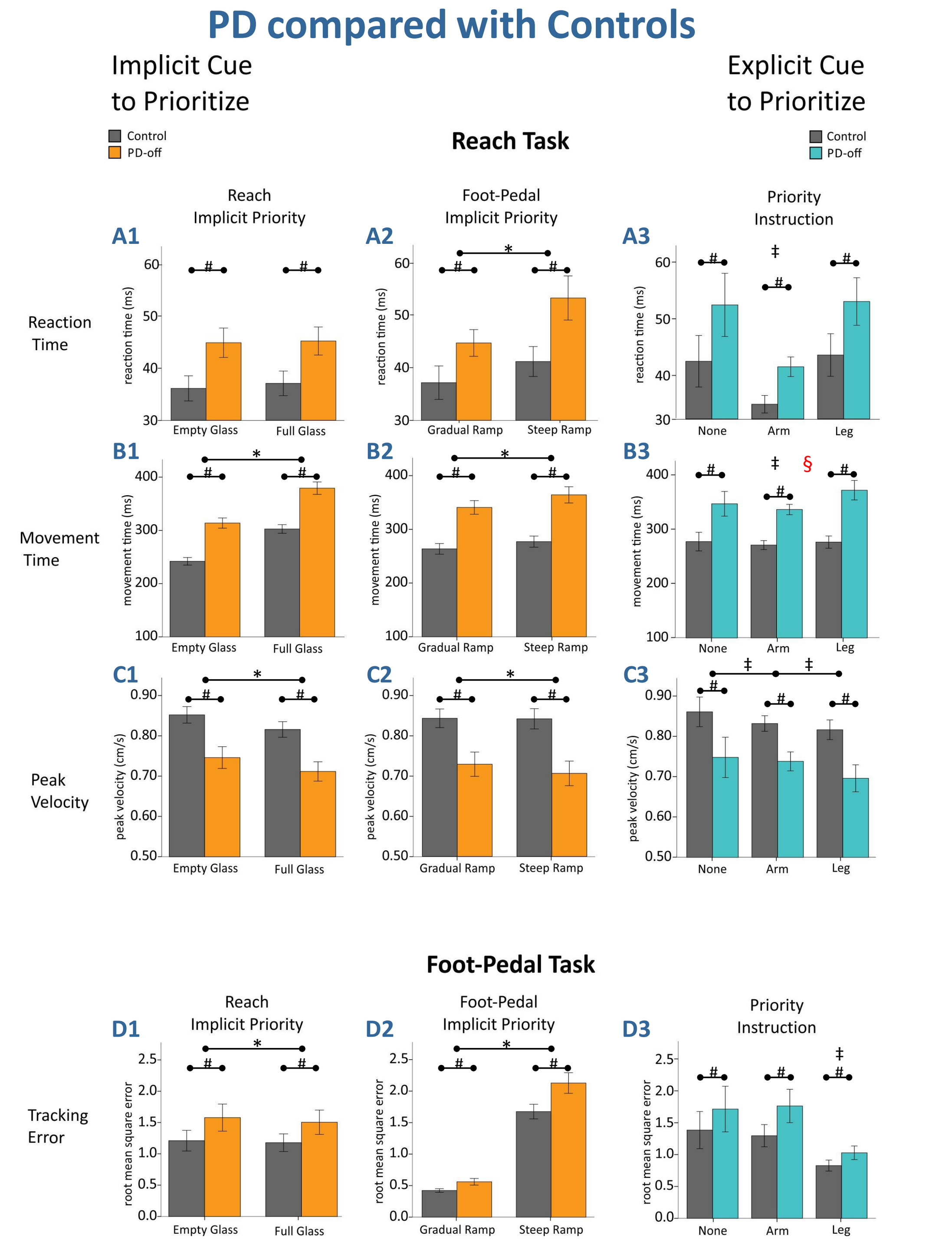
Subject Characteristics and Clinical Assessments

	PD (n = 15) Mean (SE)		HC (n = 15) Mean (SE)	p-value PDoff v HC	p-value PDon v PDoff
Medication State	Off	On	-	-	-
Age (years)	68.4 (2.3)	-	66.5 (1.6)	.475	-
Duration PD (years)	5.1 (0.7)	-	-	-	-
LEDD (mg/day)	754.6 (188.9)	-	-	-	-
Hoehn & Yahr (0-5)	2.2 (0.1)	2.1 (0.1)	-	-	.301
MDS-UPDRS III (0-132)	33.5 (2.3)	25.5 (2.5)	-	-	**<.0001**
MoCA (24-30)	27.2 (0.4)	27.5 (0.4)	27.0 (0.3)	.626	.498
Trail Making Test-A (s)	36.0 (3.2)	30.9 (2.3)	30.6 (1.9)	.127	.089
Trail Making Test-B (s)	81.9 (12.5)	71.8 (7.4)	66.8 (5.1)	.216	.257
Stroop-Dots (s)	15.1 (1.1)	13.5 (0.6)	13.8 (0.7)	.318	.136
Stroop-Words (s)	19.0 (1.0)	18.3 (0.9)	17.7 (1.1)	.347	.455
Stroop-Colors (s)	29.9 (1.5)	27.6 (1.2)	27.5 (1.5)	.240	**.032**
TUG (s)	10.0 (0.9)	9.1 (0.7)	6.9 (0.3)	**.0001**	**.007**
TUG cognitive (s)	12.2 (1.4)	10.5 (0.7)	7.7 (0.3)	**.0001**	**.026**
TUG manual (s)	13.3 (1.2)	12.5 (1.6)	8.5 (0.4)	**<.0001**	.432

Values represent mean (SE). PDoff: subject with Parkinson disease in Off medication state; PDon: subject with Parkinson disease in On medication state; HC: healthy control subject; LEDD: levodopa equivalent daily dose; MDS-UPDRS III: Movement Disorders Society Unified Parkinson Disease Rating Scale Motor Part; MoCA: Montreal Cognitive Assessment; TUG: Timed Up and Go; TUG cognitive: TUG with concurrent serial-3 subtractions; TUG manual: TUG with concurrent transport of full water glass.

The difference in MDS-UPDRS motor scores between the On and Off medication state sessions confirms that participants responded to medication.

Results: Multi-limb Dual-Task Performance PD compared with Controls



Main effect of Disease; * Main effect of Implicit Priority; ‡ Main effect of Instructed Priority; § Interaction of Disease and Instructed Priority; Error bars represent 95% confidence intervals. Level of significance set at *p* = .05

The effect of Disease appeared in all measures of the Reach task (panels A-C) and the Foot-Pedal task (panel D)

Reach reaction time was greater with implicit cues to prioritize the Foot-Pedal task (A2), but was similar with implicit cues to prioritize the Reach task (A1).

Reach movement time was longer when subjects were implicitly cued to prioritize the Reach task (B1) (Full v Empty Glass) and when implicitly cued to prioritize the Foot-Pedal task (B2) (Steep v Gradual Ramp).

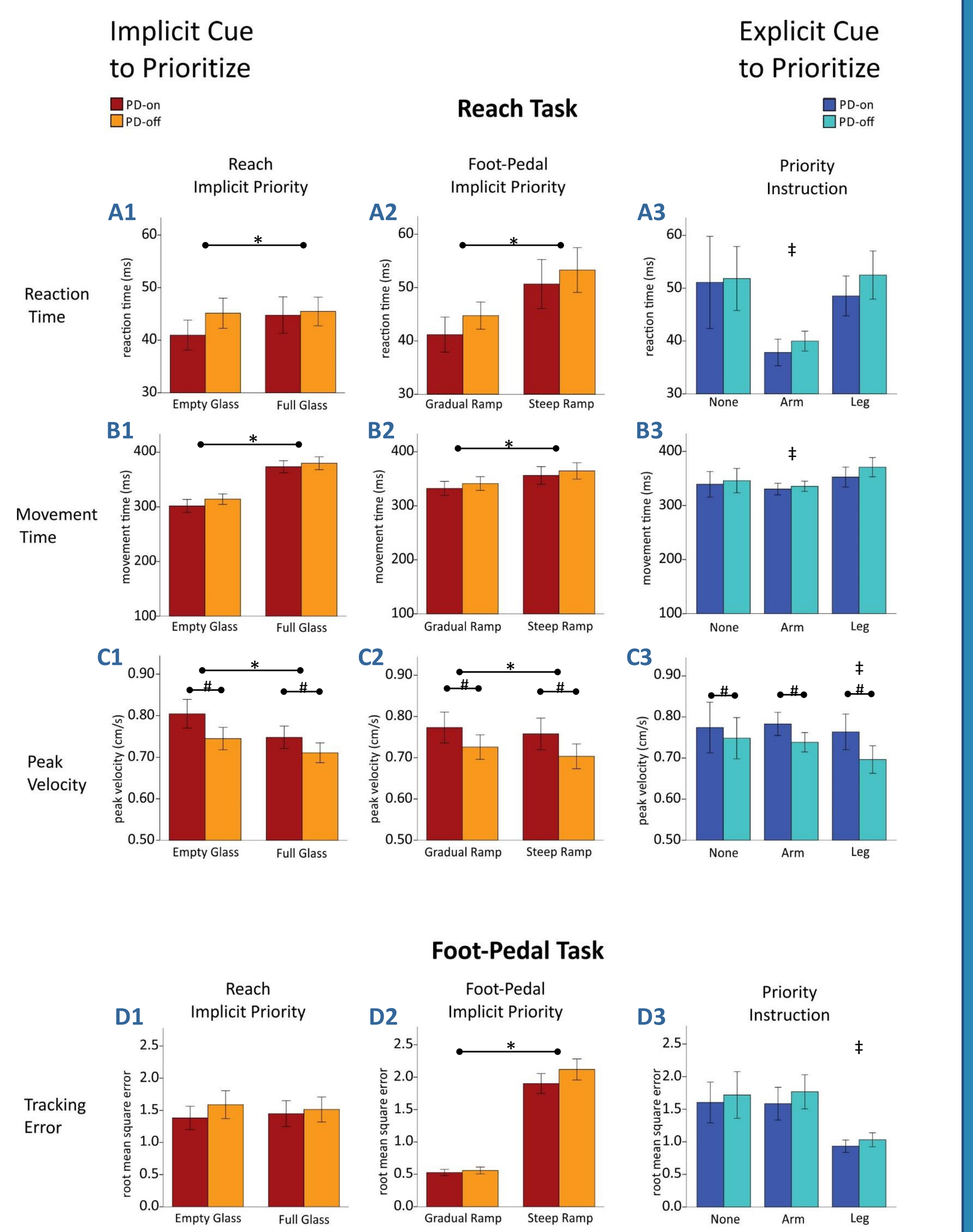
Reach peak velocity was lower (C1) when subjects were implicitly cued to prioritize the Reach task (Full v Empty Glass) and when implicitly cued to prioritize the Foot-Pedal task (C2) (Steep v Gradual Ramp).

Tracking error of the Foot-Pedal task was greater with implicit cues to prioritize the Reach task (D1) (Full v Empty Glass) and with implicit cues to prioritize the Foot-Pedal task (D2) (Steep v Gradual Ramp).

Reach reaction time and movement time were both reduced when subjects were explicitly instructed to prioritize the Arm task (A3, B3). Peak velocity was highest with no explicit instruction for priority, lower with explicit instructions to prioritize the Arm task, and least with Leg task explicit priority (C3). Foot-Pedal tracking error was reduced with explicit instructions to prioritize the Leg task (D3).

Interaction of Disease and explicitly instructed priority (B3) shows that subjects with PDoff had relatively greater movement time of their reach when the Leg task was explicitly instructed for priority than did controls.

Results: Multi-limb Dual-Task Performance Effect of Medication State



Main effect of Medication State; * Main effect of Implicit Priority; ‡ Main effect of Instructed Priority; Error bars represent 95% confidence intervals. Level of significance set at *p* = .05

The effect of Medication state only appeared in Reach peak velocity (C2, C3, C4).

Reach reaction time and movement time were both longer when subjects were implicitly cued to prioritize the Reach task (A1, B1) and greater when implicitly cued to prioritize the Foot-Pedal task (A2, B2).

Reach peak velocity was slower when subjects were implicitly cued to prioritize the Reach task (C1) and when implicitly cued to prioritize the Foot-Pedal task (C2).

Tracking error of the Foot-Pedal task was greater with implicit cues to prioritize the Foot-Pedal task (D2), but error was similar with implicit cues to prioritize the Reach task (D1).

Reach reaction time and movement time were both reduced when subjects were explicitly instructed to prioritize the Arm task (A3, B3), and Foot-Pedal tracking error was reduced with explicit instructions to prioritize the Leg task (D3).

Conclusions

- Participants with PD had reduced performance in all measures of both the Reach and the Foot-Pedal tasks than healthy control subjects.
- In general, both groups were able to utilize implicit cues and explicit instruction to prioritize that task over the other
  - In most conditions performance declined on the task that was not cued or instructed for prioritizing
  - Velocity of reaching was not improved with explicit instruction to prioritize the arm task compared with no instruction
- Dopaminergic medication improved performance only on peak velocity of reaching, not on reaction time, movement time or foot-pedal tracking error.
- Small sample size is a limitation that may obscure significance.
- Experimental tasks may not have had sufficient ecological validity for implicit contextual processing. Studies are underway with PD subjects to test the use of implicit contextual and explicitly instructed cues in a driving simulator.

References

1. Yogev-Seligmann G, Hausdorff JM, Giladi N. Do we always prioritize balance when walking? Towards an integrated model of task prioritization (2012) *Movement Disorders 27(6):765-770.*
2. van Asselen M, Almeida I, Andre R, Januário C, Gonçalves AF, Castelo-Branco M (2009) The role of the basal ganglia in implicit contextual learning: A study of Parkinson's disease. *Neuropsychologia 47, 1269-1273.*
3. Scally K, Charlton JL, Iansek R, Bradshaw JL, Moss S, Georgiou-Karistianis N (2011) Impact of external cue validity on driving performance in Parkinson's disease. *Parkinsons Dis 2011, 159621.*
4. Ginis P, Nackaerts E, Nieuwboer A, Heremans E. Cueing for people with Parkinson's disease with freezing of gait: A narrative review of the state-of-the-art and novel perspectives. *Annals of physical and rehabilitation medicine.2017* Sep 7. pii: S1877-0657(17)30404-9. doi: 10.1016/j.rehab.2017.08.002. [Epub ahead of print]
5. Li L, Diaz-Brage P, Fernandez-Lago H, Fogelson N (2018) Processing of implicit versus explicit predictive contextual information in Parkinson's disease. *Neuropsychologia 109:39-51.*
6. Kehagia AA, Barker RA, Robbins TW (2013) Cognitive impairment in Parkinson's disease: the dual syndrome hypothesis. *Neurodegener Dis 11, 79-92.*

Acknowledgements

- This study was supported by a grant from the National Institute for Neurological Disorders and Stroke (1 R15 NS098340-01A1)
- The authors thank the study participants who volunteered their time.
- The authors thank graduate students and alumni for help in data collection (Jessica Hayes, David Hayes, Cassandra Manzo, Jonathon Bodam, Allison Christ, Marlowe Banatao, Brian Infiesto, Rhett Urseth, and Wade Weisnicht)

A.T. STILL UNIVERSITY | ATSU
ARIZONA SCHOOL OF HEALTH SCIENCES