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Cognitive and Motor Functions During Driving in Parkinson's Disease

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Attention and Multi-Limb Dual-Task Control During Simulated Driving in Parkinson's Disease

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Introduction

Background

Driving is a complex activity that requires dual-task behaviors involving attention shifting, multi-limb control, and task prioritization strategies to safely navigate a dynamic environment.

Parkinson's Disease (PD) is characterized by motor and non-motor deficits that can impact driving safety and performance.

Experiencing a decrease in the cognitive or motor skills that are necessary for driving can result in elevated crash risk and ultimately lead to driving cessation. As a result, losing the ability to drive can lead to a loss of functional independence and a subsequent decline in one's overall quality of life.

Rationale

- Dual-task interference during walking in PD is well-researched, however, there is a need for an evidence-based understanding of this occurrence in seated dual-task activities, such as the occupation of driving.
- Individuals with PD demonstrate improved outcomes during stepping while walking by relying on explicit cues, but have difficulty using implicit cues to carry out appropriate cognitive and motor commands.
  - Driving requires the control of attention shifts to accurately recognize both implicit and explicit cues to safely operate a vehicle.
- There is limited information on the effects of dopaminergic medication during dual-task performance in adults with PD.
- This quasi-experimental study will serve as evidence to help direct and target interventions and adaptations to prolong driving ability.

Methods: Participants & Clinical Assessments

Participants

Inclusion Criteria:

- 17 male/ female subjects diagnosed with Idiopathic PD; responsive to levodopa Rx
- 13 gender and age-matched healthy controls (HC)
- Possess a valid driver's license; drive ≥ 1x/week

Exclusion Criteria:

- Impaired cognition indicated by <24/30 on the Montreal Cognitive Assessment (MoCA)
- Lower limb sensory loss or other impairments that may affect driving performance
- History of motion sickness or simulator sickness sensitivity

- Study participants recruited from Fox Trial Finder database, local rehabilitation facilities, PD support groups, and community centers throughout the Phoenix metropolitan area
- PD subjects tested during on-medication state (~1 hr after dose) and clinically-defined off-medication state (≥12 hrs from prior medication dose)
- On- and off-medication state sessions conducted 2-7 days apart

Clinical Screens of Cognition & Assessments of Functional Mobility

- MoCA– versions 7.1, 7.2, and 7.3
- 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 cup)
- Driving Habits Questionnaire
- Simulator Sickness Screening Protocol
- Unified Parkinson's Disease Rating Scale (UPDRS) - Motor Subset

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Methods: Materials & Procedure

Instruments

- MiniSim™ desktop driving simulator manufactured by National Advanced Driving Simulator (NADS)
- Driving scenario software: TMT™, ISAT™, MiniSim™

Qualitative Methods/Interview Questions

- Three qualitative questions capturing the subjects' attitudes and beliefs about the importance of driving as an occupation, whether they had planned for driving cessation, and if they were interested in a community program for prolonging driving abilities.

Operational Definitions

- Implicit cues: contextual indicator from the environment
- Explicit cues: verbal or visual instruction

Figure 1: **Study subject participating in driving scenario on MiniSim™, developed by NADs**

Descriptive Statistics

Subject Characteristics & Clinical Assessments

	Healthy Controls (n = 12) Mean (SD)	PD Off Medication Mean	PD On Medication Mean (SD)
Age	68.97 (5.28)	66.96 (6.38)	66.96 (6.38)
DHQ Difficulty	91.827 (8.8)	75 (18.912)	75 (18.912)
DHQ Space	5 (0.86)	5 (2)	5 (2)
MoCA	27 (2.14)	26.76 (2.33)	26.29 (2.49)
TMT-B	64.87 (21.14)	70.09 (29.89)	66.81 (17.64)
Stroop	31.94 (6.19)	31.12 (5.91)	29.87 (5.98)
DTE TUG GS	7.88 (1.43)	8.95 (2.49)	8.17 (2.03)
DTE TUG cog	10.38 (3.08)	10.5 (3.48)	10.02 (2.76)
DTE TUG man	9.88 (2.07)	13.84 (3.24)	12.47 (3.26)
Years of PD	-	5.76 (2.43)	5.76 (2.43)
H&Y	-	2.21 (0.41)	2.21 (0.41)
MDS-UPDRS	-	35.71 (14.73)	28.53 (13.32)
LEDD (mg)	-	532.12 (321.65)	532.12 (321.65)

n: sample size; DHQ: Driving Habits Questionnaire; MOCA: Montreal Cognitive Assessment; TMT-B: Trail Making Test B; Stroop: Stroop Color and Word Test; DTE:= Dual Task Effect; TUG: Timed Up and Go Test; TUG GS: TUG duration; DTE COG: Dual Task Effect of TUG Cognitive Task; DTE TUG Manual: Dual Task Effect of TUG manual task; Years of PD: Years with PD Diagnosis; H&Y: Hoehn and Yahr Scale; MDS-UPDRS: Movement Disorders Society Unified Parkinson's Disease Rating Scale; LEDD: Levodopa Equivalent Daily Doses

Table of Spearman's Correlation Coefficients

	Healthy Controls (n = 12)		PD Off (n = 17)		PD On (n = 17)	
	DHQ- Difficulty	DHQ- Space	DHQ- Difficulty	DHQ- Space	DHQ- Difficulty	DHQ- Space
TMT- B	r = 0.385	r = 0.15	r = -0.67*	r = 0.31	r = -0.112	r = 0.353
MoCA	r = -0.501	r = -0.284	r = 0.34	r = -0.108	r = 0.447	r = -0.041
Stroop	r = 0.281	r = 0.34	r = -0.026	r = -0.009	r = 0.220	r = -0.111
DTE TUG GS	r = -0.246	r = -0.228	r = -0.107	r = -0.023	r = 0.430	r = -0.296
DTE TUG cog	r = 0.112	r = 0.077	r = -0.263	r = -0.159	r = -0.080	r = 0.028
DTE TUG man	r = -0.078	r = -0.508	r = -0.239	r = -0.160	r = -0.129	r = -0.261
Years PD	-	-	r = 0.138	r = -0.334	r = 0.138	r = -0.334
H&Y	-	-	r = -0.026	r = -0.635	r = -0.026	r = -0.635
MDS-UPDRS	-	-	r = -0.215	r = -0.533	r = -0.086	r = -0.154
LEDD (mg)	-	-	r = -0.193	r = -0.599	r = -0.193	r = -0.599
Weak = 0 to .30						
Moderate = .30 to .70						
Strong = .70 and above						

* Correlation is significant at the 0.05 level (2-tailed). n: sample size, r: Spearman's Correlation Coefficients; DHQ: Driving Habits Questionnaire; MOCA: Montreal Cognitive Assessment; TMT-B: Trail Making Test B; Stroop: Stroop Color and Word Test; DTE:= Dual Task Effect; TUG: Timed Up and Go Test; TUG GS: TUG duration; DTE COG: Dual Task Effect of TUG Cognitive Task; DTE TUG Manual: Dual Task Effect of TUG manual task; Years PD: Years with PD Diagnosis; H&Y: Hoehn and Yahr Scale; MDS-UPDRS: Movement Disorders Society Unified Parkinson's Disease Rating Scale; LEDD: Levodopa Equivalent Daily Doses

Quantitative Analysis

- Identified relationship between self-reported driving habits and cognitive, motor, and dual-task function in individuals with PD during on- and off-medication states compared to age-matched healthy adults.
  - Correlation between DHQ driving difficulty and TMT-B reveals improved cognitive function in PD subjects during on-medication state and similar behavior compared to HC subjects.
  - Correlation between DHQ driving space and years diagnosed with PD/ stage of disease suggests decreased driving confidence and frequency.

Data analysis from experimental drives is not yet completed

Qualitative Analysis (n=30)

- **How would driving cessation impact your life?** 24/30- Loss of independence; 16/30- Loss of roles/ Habits/ Identity;12/30- Would have a large impact
- **How have you prepared for driving cessation/ what are your supports?** 18/30- Aware of some options; 17/30- No planning/ Have not thought about it; 16/30- Will rely on family and friends
- **Interest level for a class addressing prevention of driving cessation?** 20/30- Helpful/ Learn something new; 6/30- High perceived current driving function/ Not relevant; 6/30- Helpful for support group/ Family/ Spouse

Future Direction for Research

- Complete data reduction/ analysis and identify dual-task deficits
- Disseminate findings: scientific journals, research/professional forums
- Review of literature to identify PT/OT rehab interventions addressing PD driver deficits
- Grant application to explore intervention effects on safe driving skills using simulated driving conditions
- Development of community-based program for drivers with PD and other diagnoses or age-related impairments to prolong independence.

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