Performance under Pressure
Linking Change in Gait and Cognition

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BACKGROUND

- Cognitive processes (such as updating) are compromised when dual-tasks require high demand for cognitive resources.
  - Time for older adults to initiate crossing the street increased to almost twice that of young adults while talking on a cell phone (Neider et al., 2011).
- Change in gait is correlated with brain changes in older adults.
  - Increase in step length variability associated with subclinical infarcts and white matter abnormalities, including those in the basal ganglia (Rosano et al., 2007).
- Dual-task effects on gait speed are influenced by executive control.
  - Decline in gait speed and executive function linked (Atkinson et al., 2007).
  - Verbal IQ, executive attention, and memory were related to gait speed while walking normally on a GAITRite mat (Holtzer et al., 2006).
    - While reciting alternate letters of the alphabet, only an association between speed/executive function and memory with gait speed.
- Central nervous system (CNS) and peripheral nervous system (PNS) play a role in gait change, with PNS more influential in healthy young adults.
  - Gait variability increases with impairment of CNS (e.g., dementia, Parkinson's disease) or overloading of CNS by PNS/locomotor system (e.g. stress, obesity, joint pain) (see Figure 1).
  - Protracted stress can impair the metabolic system, thereby increasing the risk of metabolic syndromes and overloading CNS (Lupien et al., 2007; Rosano, et al., 2007).

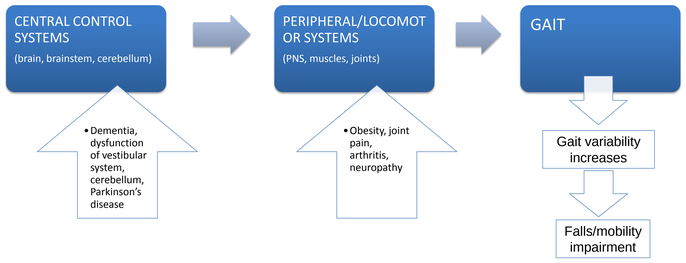

Figure 1. Role of central and peripheral nervous systems on gait (adapted from Rosano et al., 2007).

OBJECTIVES

1.Does dividing attention influence select gait characteristics in a young population?
2.How are these same gait characteristics linked to cognitive function?
3.Do stress or sleep further moderate the time-varying covariations between gait and cognition?

ACKNOWLEDGEMENTS

Funding for this project was made possible by Erich and Shelley Mohr in the establishment of the Mohr Research Chair on Adult Development and Aging (SMH), and by support from the Michael Smith Foundation for Health Research (SWSM) and a doctoral fellowship from the Canadian Institutes of Health Research (JL).

METHOD AND DESIGN

Sample: N = 77, mean age 20.18 (SD 4.08), 76.6% female.

Measures: MSIT (executive function task), DISE (# of stressors), GAITRite mat
- GAITRite mat -- a 16 foot computerized walkway with embedded pressure sensors
  - Gait characteristics measured for two walking conditions (walk only; walk + words) include:
    - Normalized velocity (NV): velocity adjusted for leg length
    - Step length (SL): distance between heel contact points of left and right feet
    - Step width (SW): distance between line of progression and opposite heel contact

Statistical models: Linear mixed models were computed to determine:
- How change in gait variability covaries with change in cognition across the 7 sessions.
- Whether stress and/or sleep hours further moderate any observed time-varying covariations.

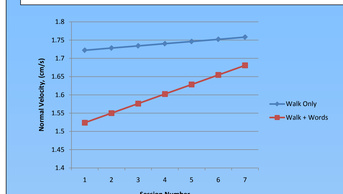

Figure 2a. Normalized velocity change over sessions.

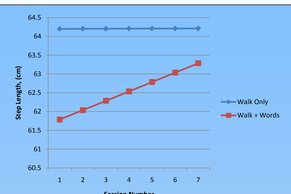

Figure 2b. Step length change over sessions.

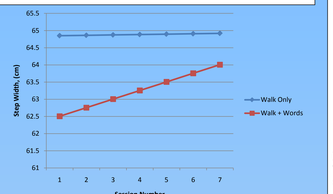

Figure 2c. Step width change over sessions.

Table 1. *Mean differences in MSIT RT intercepts and slopes as a function of session and gait characteristics.*

Variable		Normalized Velocity			Step Length			Step Width		
		Intercept	Session Slope	NV Slope	Intercept	Session Slope	SL Slope	Intercept	Session Slope	SW Slope
Walk + Words	MSIT RT (control)	521.96*	-13.07*	-90.62*	523.86*	-14.48*	-3.01*	524.26*	-14.50*	-2.97*
	MSIT RT (interference)	829.63*	-27.41*	-112.46*	829.00*	-29.12*	-3.81*	829.52*	-29.10*	-3.72*

•Denotes statistically significant value, $p < 0.10$

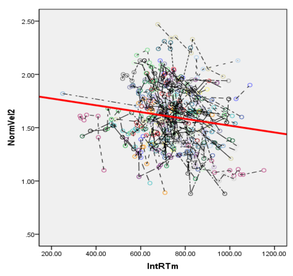

Figure 3a. Relationship between normalized velocity and MSIT RT (interference).

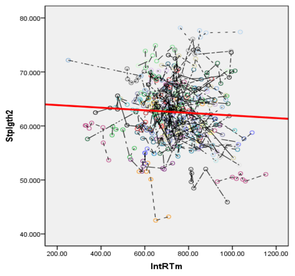

Figure 3b. Relationship between step length and MSIT RT (interference).

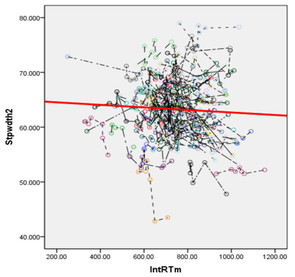

Figure 3c. Relationship between step width and MSIT RT (interference).

Table 3. *Moderating effect of DISE and sleep hours on the time-varying relationship between MSIT RT and gait.*

Variable		Normalized Velocity				Step Length				Step Width			
		Intcpt.	Session Slope	NV Gait Slope		Intcpt.	Session Slope	SL Gait Slope		Intcpt.	Session Slope	SW Gait Slope	
				Slope	Predictor X Slope			Slope	Predictor X Slope			Slope	Predictor X Slope
MSIT RT (interference)	DISE	829.09*	-27.48*	-112.97*	56.40*	831-34*	-29.21*	-4.04*	1.85*	831.09*	-29.21*	-3.96*	1.92*
	Sleep Hours	830.61*	-27.44*	-112.17*	-38.98*	829.38	-29.02*	-3.97*	-1.46*	829.09*	-28.99*	-3.89*	-1.63*

* Denotes statistically significant value, $p < 0.10$; Intcpt = intercept value centered at the baseline session for an individual with average stress and sleep hours.

RESULTS

Question 1: Figures 2a, 2b, 2c
- Walk only condition: significant change across sessions only for NV.
- Walk + words condition: change in gait characteristics over time for NV, SL, and SW.

Question 2: Table 2
- RT (ms) at intercept (time 0) for MSIT interference condition markedly slower than MSIT control.
- RT (ms) for both conditions improved over subsequent sessions (session slope).
- For every one unit increase in gait characteristics (NV, SL, and SW), representing better function, there was a corresponding decrease in RT for both control and interference conditions.

Question 2: Figures 3a, 3b, 3c
- Those who walk faster, have longer step length, and wider step width performed faster (RT) than those who are slower with narrower gait.

Question 3: Table 3
- DISE and sleep hours further moderated the effect between MSIT RT (int.) and select gait characteristics (NV, SL, and SW).
  - A one unit increase in DISE score weakened the relationship between change in gait and change in cognition.
  - In contrast, a one unit increase in sleep hours strengthened the time-varying covariation between gait and cognition.

DISCUSSION

Relevancy
- Gait change exists in a healthy young adult population, which challenges the idea of automaticity in young adult walking.
- A negative association was shown between gait characteristics and executive function tasks (e.g. faster walking was correlated with faster RT on MSIT task)
  - factors that influence PNS in young adults, such as stress levels, show moderating effects on both gait and cognition (Rosano et al., 2007).

Challenges
- Minimal research exists measuring gait change or variability in healthy young adults, therefore limiting the ability for comparison to other studies.

Future Research
- Further research on gait and cognition in young adults will aid understanding as to whether change in older adults is due to PNS changes (sleep, stress), CNS changes (brain atrophy, diminished resources), or both.
  - Basic changes in older adult gait may be a non-invasive indicator for those at risk for cognitive impairment.

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