Biostatistics 699 Final Project: Elderly Driver Ingress Strategy Study

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Introduction

Along with age comes a degradation in sensorimotor function, and tasks that are considered trivial by much of the general population are actually difficult for some of the elderly. Senior drivers may find it hard to enter or exit vehicles due to related physical degradation. Thus, it is important for automobile designers to keep the interests of the elderly in mind. We want to identify factors that potentially influence ingress performance and quantify these effects.

- **Aim #1:** Test the hypothesis that neither ingress strategy nor mobility impairments affect driver ingress time in the elderly.
- **Aim #2:** Identify the human capacities that best explain the variation in ingress time between drivers.

Study Design

Forty-eight older-aged community-dwelling drivers with varying degrees of sensorimotor dysfunction were recruited (all subjects were screened by a physiatrist for eligibility, and subjects with a BMI exceeding 35 kg/m^2 were excluded).

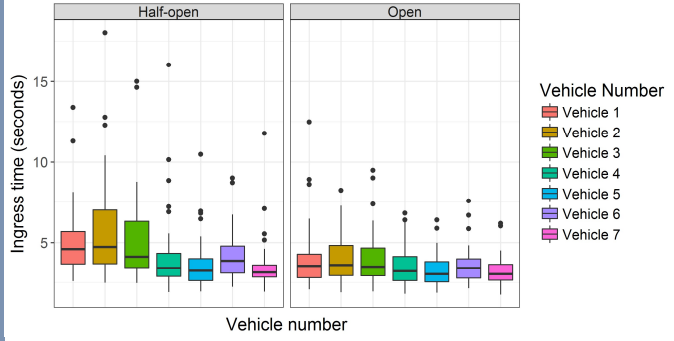
- **Visit #1:** Basic demographic information was gathered and the subjects were evaluated for their various human capacities involving strength, mobility, and cognition.
- **Visit #2:** Subjects were measured on ingress and egress performance, under 7 different vehicle models and 2 door conditions (wide-open and half-open). Standard motion analysis techniques involving surface markers were used.

Table 1: Study Characteristics

Trait		Count (%) or Median (Range)
Total		48 (100%)
Group	**Osteoarthritis (OA)**	12 (25.0%)
	Diabetic Peripheral Neuropathy (PN)	12 (25.0%)
	Control	24 (50.0%)
Gender	**Female**	21 (43.75%)
	Male	27 (56.25%)
Age (years)		76.00 (67.00 – 89.00)
Weight (kg)		79.15 (49.90 – 131.50)
Ingress time (sec)		3.56 (1.74 – 18.03)
Ingress strategy	**One foot**	575 (90.27%)
	Two feet	62 (9.73%)
One leg balance time (left leg, sec)		7.00 (0.00 – 30.00)

Methods

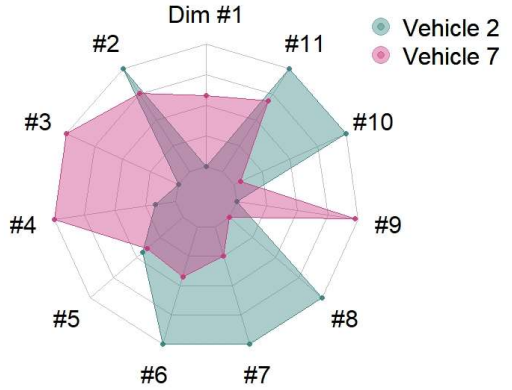
Figure 1: Boxplots of ingress times by door configuration and vehicle number.



Fit a linear mixed model with a random intercept for each subject, and adjusted for demographics, human capacities, mobility impairment group, vehicle setup, and ingress strategy.

- Selected the most representative human capacity variable in each group (strength, mobility, & cognition) by examining pairwise correlations.
- Used the peak performance for repeated measurements.
- Continuous variables were centered at the mean.
- Inspected vehicle dimensions that led to the biggest differences in ingress time.
- The final model includes the following covariates: ingress strategy, left leg balance time, age, mobility impairment group, gender, door condition, weight, maximum isometric hip abduction strength, vehicle dimension #8, and vehicle dimension #9.

Figure 2: Radio chart comparing the dimensions of Vehicle 2 and Vehicle 7.



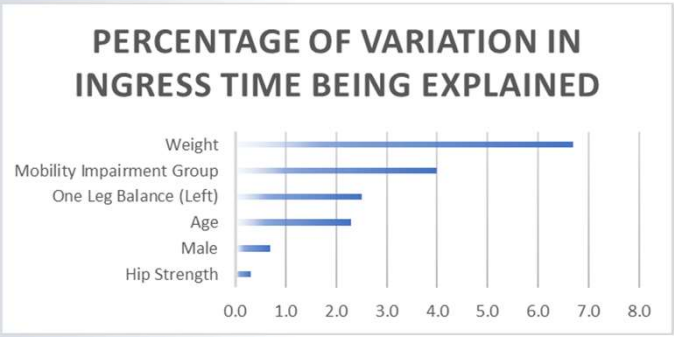
- Analyzed marginal R-squared values to determine the human capacities that best explain the variation in ingress time.

Results

Table 2: Linear Mixed Model Results

Parameter Name		Parameter Estimate	95% CI
Ingress strategy (two-feet vs one-foot)		0.76**	(0.23, 1.28)
One leg balance time (seconds, left leg)		0.20	(-0.34, 0.75)
Age (years, centered)		0.09*	(0.01, 0.17)
Group	**PN vs Control**	-0.11	(-1.34, 1.12)
	OA vs Control	0.42	(-0.81, 1.66)
Gender (Male vs Female)		-0.83	(-1.99, 0.34)
Weight (kg, centered)		0.08**	(0.04, 0.12)
Door condition (wide-open vs half-open)		-0.89**	(-1.10, -0.68)
Max isometric hip abduction strength (N·m, centered)		-0.023	(-0.048, 0.001)
Vehicle dimension #8 (centered)		0.012**	(0.005, 0.018)
Vehicle dimension #9 (centered)		-0.023**	(-0.032, -0.014)

* p < 0.05; ** p < 0.01



Conclusions

The two-feet strategy significantly increased ingress time compared to using a one-foot strategy. Mobility impairment group may not have been significant, but it was one of the best variables at explaining variation in ingress times. Ingress time increased with advancing age and heavier body weight. Wide-open door vehicles reduced ingress time compared to half-open door vehicles. Strength and cognitive capacities did not affect ingress time significantly. Vehicle dimension 8 was associated with increased ingress time while vehicle dimension 9 was associated with decreased ingress time, which might be informative to vehicle designers.

References

- Bodenmiller, F. M., Hart, J. M., & Bhise, V. D. (2002, March 04). Effect of Vehicle Body Style on Vehicle Entry/Exit Performance and Preferences of Older and Younger Drivers 2002-01-0091. Retrieved from https://www.sae.org/publications/technical-papers/content/2002-01-0091/