Development of Behind-the-Wheel Driving Assessment for Older Adults

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National Older Driver Research Project

- **Determine the "state of the science" in older driver assessment, remediation, and counseling**

Department of Health and Human Services
Centers for Disease Control and Prevention

How do we measure driving performance?

- Currently the criterion standard for behind-the-wheel performance is evaluator judgment
- Pass/Fail
  - Is this sufficient?

Measuring Driving Performance

- Counting errors
- Grading performance

Fixed Route

- Controls for opportunity of environmental exposure
  - ~ 45 – 60 minutes

On-Road

- Graded for complexity of driving situations
  - Progressive grading of driving complexity assesses range of performance under different conditions.
- Ecological Validity – real-life transfer
- Observation of driving behaviors related to specific maneuvers
  - Increased objectivity

Odenheimer (1994), Hunt (1997)

Maneuvers

- Left Turns
- Right Turns
- Lane Changing
- Straight Driving
- Merge (High Speed)

Grade for maneuvers

- Low complexity driving: residential, low traffic volume, non-signalized areas of travel.
- Moderate complexity : increased traffic speeds with higher traffic volumes and signalized, multilane roadways.
- High complexity : higher speeds (highway driving), higher density traffic volumes at moderate speeds, complex maneuvers.

Observed Behaviors

- Vehicle Positioning (forward/back)
- Lane Maintenance
- Visual Scanning
- Speed Regulation
- Signaling
- Yielding
- Gap Acceptance
- Adjustment to stimuli

Scoring Maneuvers

- Each maneuver is scored on a scale of 0-3.
- No errors for maneuver results in score of “3.”
- Any error in any behavior results in a maximum possible score of “2” for that maneuver
- Verbal cueing to complete a maneuver or modify a behavior results in a score of “1”
- A score of “0” is given for a maneuver if intervention is required or warranted

Scoring Errors

Exit lot from behind buildings								
Turn R onto NW 62nd Ave								
R turn (simple)		0	1	2	3	Intervene	VC	
Vehicle positioning								
Visual scanning								
Speed								
Lane maintenance								
Signaling								
Yielding								
Adjustment to stimuli								
Straight Driving (simple)		0	1	2	3	Intervene	VC	
Visual scanning								
Speed								
Lane maintenance								
Adjustment to stimuli								
Vehicle positioning		0	1	2	3	Intervene	VC	
Lane Change (simple)								
Visual scanning								
Speed								
Lane maintenance								
Adjustment to stimuli								
Vehicle positioning								

Global Rating (Criterion Standard)

Safe (3)

Safe with restrictions or recommendations (2)

Unsafe Remediable (1)

Unsafe not remediable (0)

Research Goals

- Establish the reliability and validity of the behind-the-wheel driving performance outcome measure (clinical utility)
- Investigate geographic generalizability
- Investigate the unidimensionality and item hierarchy using modern test theory (Rasch Analysis)

Sample

- Older adults >65
- Minimum state vision requirements
- Seizure-free for past year
  - Independence Drive
  - CAS Frail Elders

Reliability and Validity (Classical Test Theory)

- Inter-rater reliability
- Test-retest reliability
- Internal consistency
- Criterion validity

Demographics

	N=95 frequency (%)
Age	Mean = 75.3 (SD = 6.4)
Gender	
Male	51 (53.7%)
Female	44 (46.3%)
Race	
White	87 (91.6%)
African-American	1 (1.1%)
Hispanic or Latino	3 (3.2%)
Asian	4 (4.2%)
Level of Education	
High school or below	15 (15.8%)
Some college	21 (22.1%)
Bachelors	16 (16.8%)
Post professional	4 (4.2%)
Masters	18 (18.9%)
Doctorate	21 (22.1%)

Cognitive, Functional, and Psychosocial Characteristics

	N=95 Mean (SD)
MMSE	27.2 (2.3)
FIM	125.1 (2.3)
OARS IADL	13.8 (0.6)
UFOV	2.1 (4.2)
Number of Meds	7.0 (1.2)
GDS	2.8 (2.8)
Pain	11.0 (1.5)

Reliability of the Behind-The-Wheel Performance Assessment

Measure	Inter-rater Relaibility (n=33)	Temporal Stability (test-retest) (n=10)	Internal Consistency (Chronbach's alpha) N=95
Global Rating	Kappa = .98	Kappa = 1.0	-
Performance Score	ICC = .94	ICC = .95	α = .94
Dichotomous Score	ICC = .88	ICC = .91	α = .88

Criterion Validity

Measure	N	Global Rating
Performance Score	95	r = .84, p <.001
Dichotomous Score	95	r = .73, p < .01

G-G Study

- Two separate road courses
- Same design elements
- Complete repeated-measures crossover design
- Random assignment for course order
- Alternating rater

Course Elements

		Course 1	Course 2
1	Right Turn Simple	RTS 1-8	RTS 1-9
2	Left Turn Simple	LTS 1-7	LTS 1-7
3	Straight Drive Simple	SDS 1-21	SDS 1-16
4	Right Turn Moderate	RTM 1-5	RTM 1-8
5	Left Turn Moderate	LTM 1-4	LTM 1-3
6	Straight Drive Moderate	SDM 1-18	SDM 1-22
7	Lane Change Moderate	LCM 1-7	LCM 1-8
8	Right Turn High	RTH 1-3	RTH 1-3
9	Left Turn High	LTH 1-3	LTH 1-4
10	Straight Drive High	SDH 1-8	SDH 1-20
11	Lane Change High	LCH 1-6	LCH 1-12
12	High Speed Merge	HSM 1	HSM 1
		91	113

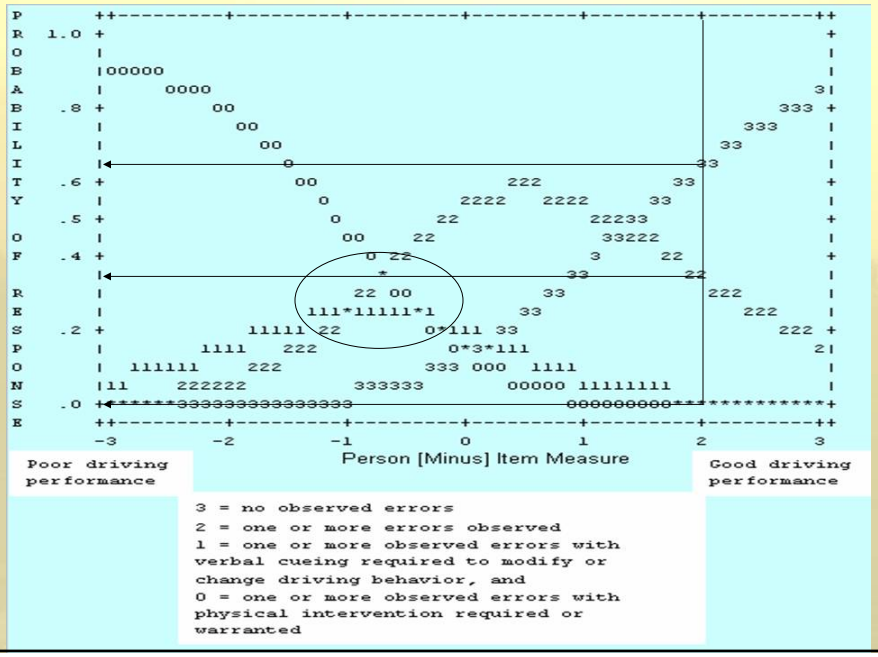
Generalizability

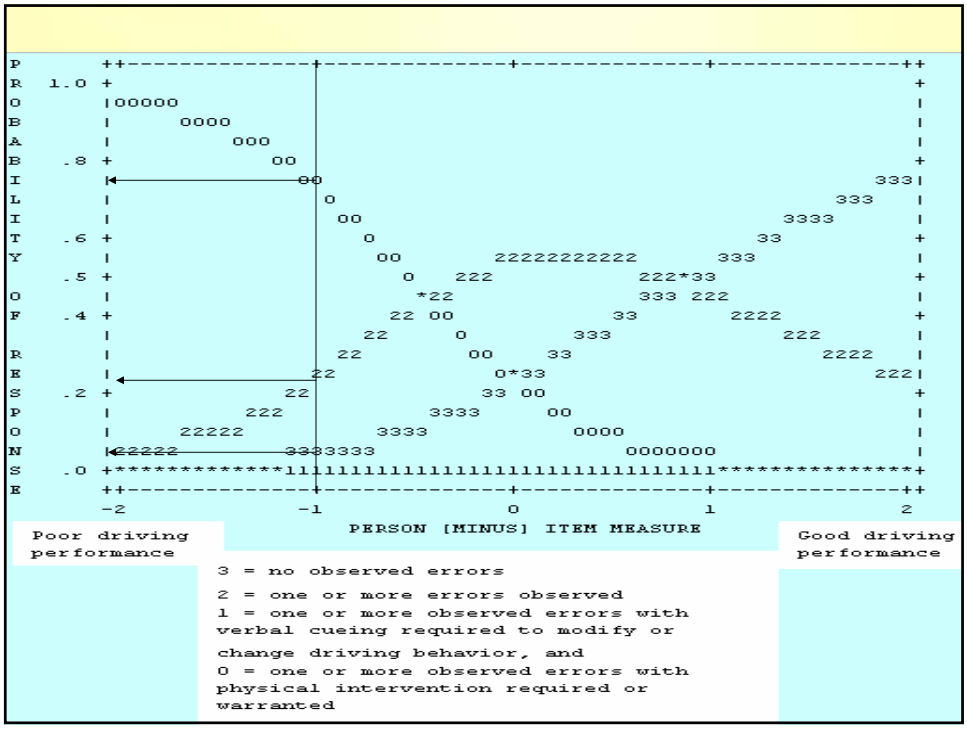
- Generalizability coefficient: ICC = .89
- $F = 2.34$, ($p = .134$); $\alpha = .05$

Item Response Analysis (Modern Test Theory)

- Evaluate rating scale
- Review item/person fit and item hierarchy
- Investigate unidimensionality

Rating Scale





Person Summary

SUMMARY OF 105 MEASURED PERSONS

	RAW SCORE	COUNT	MEASURE	MODEL ERROR	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	226.3	91.0	1.61	.19	1.09	.3	1.09	.3
S.D.	29.5	.0	.82	.06	.31	1.3	.40	1.4
MAX.	267.0	91.0	3.90	.43	1.98	4.0	2.47	5.3
MIN.	108.0	91.0	-.46	.11	.52	-2.4	.52	-2.2

REAL RMSE	.22	ADJ.SD	.79	SEPARATION	3.54	PERSON RELIABILITY	.93	
MODEL RMSE	.20	ADJ.SD	.79	SEPARATION	3.93	PERSON RELIABILITY	.94	

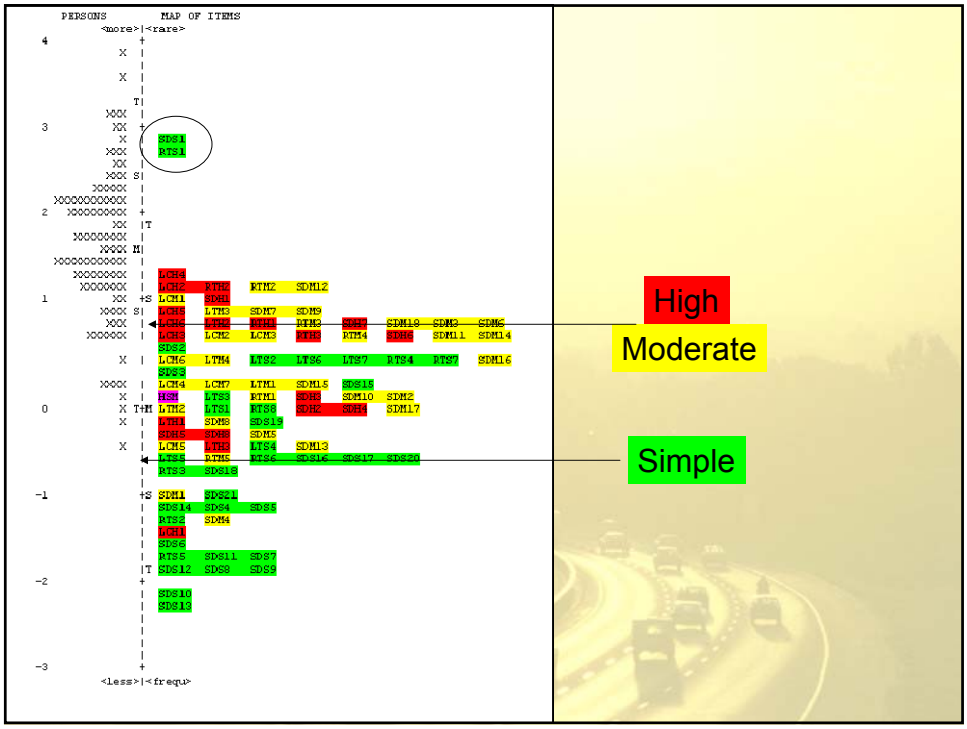
S.E. OF PERSON MEAN = .08

SR = (4Gp + 1)/3
Where Gp = separation index (3.54)
SR = 5.05

Theoretical Hierarchy of Item Difficulty

Items (level of complexity)	Item abbreviation (# observed)
High Speed Merge (High)	HSM (1)
Lane Change (High)	LCH (6)
Left Turn (High)	LTH (3)
Right Turn (High)	RTH (3)
Straight Drive (High)	SDH (8)
Lane Change (Moderate)	LCM (7)
Left Turn (Moderate)	LTM (4)
Right Turn (Moderate)	RTM (5)
Straight Drive (Moderate)	SDM (18)
Left Turn (Simple)	LTS (7)
Right Turn (Simple)	RTS (8)
Straight Drive (Simple)	SDS (21)
Total items	91

	Item	Measure (Logits)	Error	Infit MnSq	Z STD		Item	Measure (Logits)	Error	Infit MnSq	Z STD
1	SDS1	2.81	0.12	1.23	1.5	47	SDM2	0.11	0.16	1.14	0.7
2	RTS1	2.73	0.11	1.58	3.6	48	HSM	0.11	0.16	1.55	2.3
3	LCH4	1.23	0.11	0.98	-0.1	49	SDM10	0.08	0.17	1.39	1.7
4	RTM2	1.19	0.11	0.76	-1.8	50	SDH3	0.08	0.17	**1.76**	3
5	LCH2	1.15	0.12	0.62	-3	51	LTS1	0.06	0.17	1.15	0.8
6	RTH2	1.11	0.12	**2.11**	5.8	52	SDM17	0.03	0.17	1.12	0.6
7	SDM12	1.07	0.12	0.72	-2	53	LTM2	0	0.17	1.12	0.6
8	SDH1	1.03	0.12	1.55	3.2	54	RTS8	0	0.17	**1.96**	3.6
9	LCM1	0.99	0.12	0.64	-2.7	55	SDH2	-0.06	0.17	1.2	1
10	LTM3	0.93	0.12	0.8	-1.4	56	SDH4	-0.06	0.17	1.27	1.2
11	SDM9	0.9	0.12	0.68	-2.2	57	SDS19	-0.09	0.18	0.67	-1.6
12	LCH5	0.87	0.12	1.03	0.2	58	SDM8	-0.09	0.18	1.49	2
13	SDM7	0.79	0.13	1.47	2.6	59	LTH1	-0.12	0.18	1	0.1
14	LCH6	0.77	0.13	1.03	0.3	60	SDH5	-0.22	0.19	**1.83**	3
15	LTH2	0.74	0.13	0.83	-1.1	61	SDH8	-0.26	0.19	1.26	1.1
16	SDM6	0.72	0.13	0.68	-2.1	62	SDM5	-0.33	0.19	1.6	2.3
17	RTH1	0.72	0.13	0.8	-1.3	63	SDM13	-0.37	0.2	1.8	2.8
18	RTM3	0.7	0.13	0.58	-2.9	64	LCM5	-0.41	0.2	1.21	0.9
19	SDM18	0.67	0.13	0.85	-0.9	65	LTH3	-0.41	0.2	**1.73**	2.6
20	SDM3	0.65	0.13	1.28	1.6	66	LTS4	-0.49	0.21	1.21	0.9
21	SDH7	0.65	0.13	1.1	0.6	67	SDS16	-.54|	0.21	1.01	0.1
22	SDS2	0.63	0.13	0.67	-2.1	68	LTS5	-0.58	0.21	0.85	-0.6
23	LCM3	0.61	0.14	0.57	-2.9	69	SDS20	-0.58	0.21	1.36	1.4
24	SDH6	0.6	0.14	1.05	0.4	70	RTS6	-0.63	0.22	**1.93**	3.1
25	SDM14	0.6	0.14	1.12	0.7	71	SDS17	-0.63	0.22	1.55	2
26	LCH3	0.56	0.14	1	0.1	72	RTM5	-0.63	0.22	0.99	0
27	RTM4	0.52	0.14	1.53	2.6	73	RTS3	-0.73	0.23	0.89	-0.4
28	SDM11	0.52	0.14	0.88	-0.7	74	SDS18	-0.73	0.23	0.86	-0.5
29	LCM2	0.5	0.14	0.59	-2.6	75	SDM1	-0.95	0.25	0.97	0
30	RTH3	0.5	0.14	1.52	2.6	76	SDS21	-0.95	0.25	**1.93**	3
31	LTS2	0.48	0.14	0.79	-1.2	77	SDS5	-1.08	0.26	1.03	0.2
32	LTS6	0.48	0.14	0.49	-3.4	78	SDS4	-1.15	0.27	0.88	-0.4
33	LTS7	0.48	0.14	0.62	-2.4	79	SDS14	-1.15	0.27	**1.9**	2.8
34	RTS7	0.48	0.14	0.57	-2.7	80	RTS2	-1.22	0.27	0.83	-0.6
35	SDM16	0.46	0.14	1.58	2.7	81	SDM4	-1.22	0.27	1.24	0.9
36	LTM4	0.46	0.14	1	0	82	LCH1	-1.38	0.29	1.41	1.4
37	RTS4	0.44	0.14	0.64	-2.1	83	SDS6	-1.56	0.31	1.64	2
38	LCM6	0.4	0.15	1.06	0.4	84	RTS5	-1.66	0.32	0.97	0
39	SDS3	0.38	0.15	1.21	1.1	85	SDS11	-1.66	0.32	0.92	-0.2
40	LCM4	0.35	0.15	0.89	-0.5	86	SDS7	-1.77	0.34	0.88	-0.3
41	SDS15	0.33	0.15	0.85	-0.8	87	SDS8	-1.89	0.36	0.91	-0.2
42	SDM15	0.33	0.15	**1.72**	3.1	88	SDS9	-1.89	0.36	1.65	1.9
43	LCM7	0.31	0.15	1.17	0.9	89	SDS12	-1.89	0.36	0.91	-0.2
44	LTM1	0.26	0.15	0.91	-0.4	90	SDS10	-2.17	0.4	0.79	-0.5
45	LTS3	0.16	0.16	1.2	1	91	SDS13	-2.34	0.43	0.93	-0.1
46	RTM1	0.16	0.16	0.65	-1.9						



Rasch Summary

- Collapsed rating scale
  - Separation ratio: ~ 5 distinct strata
- 90% of items and 97% of persons fit the model
- Driving performance is not a unidimensional construct (PCA)
  - Sample size too small for number of items

Conclusion

- Standardization of BTW assessment procedures:
  - provides a valid and reliable outcome measure of driving performance
  - Supports geographic generalizability (limited)
  - Clinical utility with increased objectivity

Conclusion

- The Rasch analysis provided
  - Evidence for refining the rating scale
  - Empirical information about the proposed hierarchy of driving complexity used to design the road course
  - Fit of items and persons
  - Information about the unidimensionality of the construct

Future Directions

- Increase sample to include more diverse range of performance (cognitive impairment)
- Compare young versus old and control for common errors
- Explore the separation strata for overall classification of driving performance (refined Global Rating Scale)
- Geographic generalizability exploring other facets (e.g. weather, number and types of maneuvers)
- Explore the behavioral level of the driving assessment

Thank You!

National Older Driver Research and Training Center, University of Florida

CDC Department of Health and Human Services
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