On-the-Road Human Factors Evaluation of the Ali-Scout Navigation System

Stewart Katz, Jill Fleming, Paul Green, David Hunter, and Daniel Damouth

University of Michigan, Ann Arbor, Michigan, USA

1 ISSUES

1. How well did people drive?
- navigation errors
- speed, trip durations
- throttle, headway
- steering wheel angle, lane position

2: Was the Ali-Scout safe, usable, & useful?
- accidents, near misses, critical incidents
- driver ratings, comments

2 METHOD

Experiment 1:

| Session 1: Ali-Scout trip 1 |
| Session 2: Ali-Scout trip 2, |
| (wk apart) verbal guidance |
| (baseline) |

Subjects:

		Age (# men / # woment)		
Time	Traffic	19-30 (young)	40-55 (middle)	65-79 (older)
2-3 PM	moderate	3/3	3/3	3/3
5-6 PM	heavy	3/3	3/3	3/3
9-10 PM	light	3/3	3/3	3/3

Experiment 2:

Session 1: navigation system trip 1, verbal guidance (baseline)	Subjects: 9 Ali-Scout (night), 4 PathMaster (rush hour)

driver   forward scene
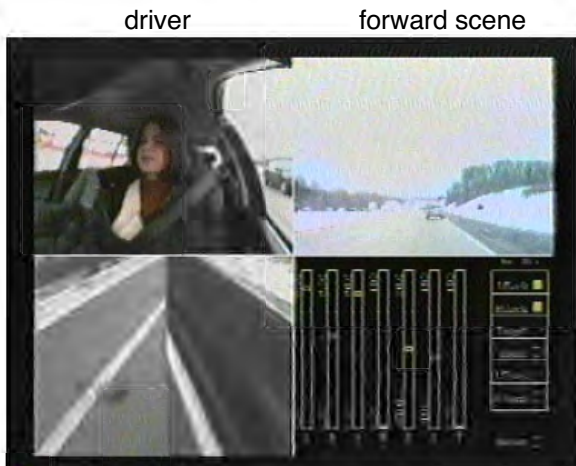
left lane   right lane   engineering data
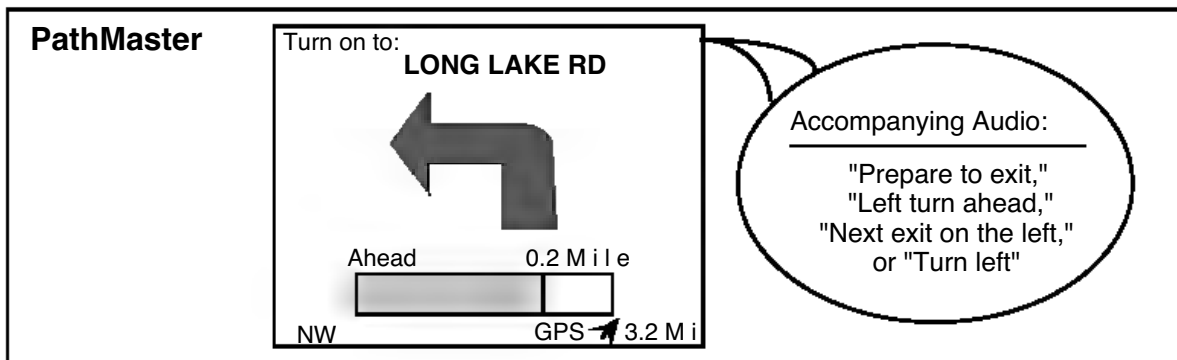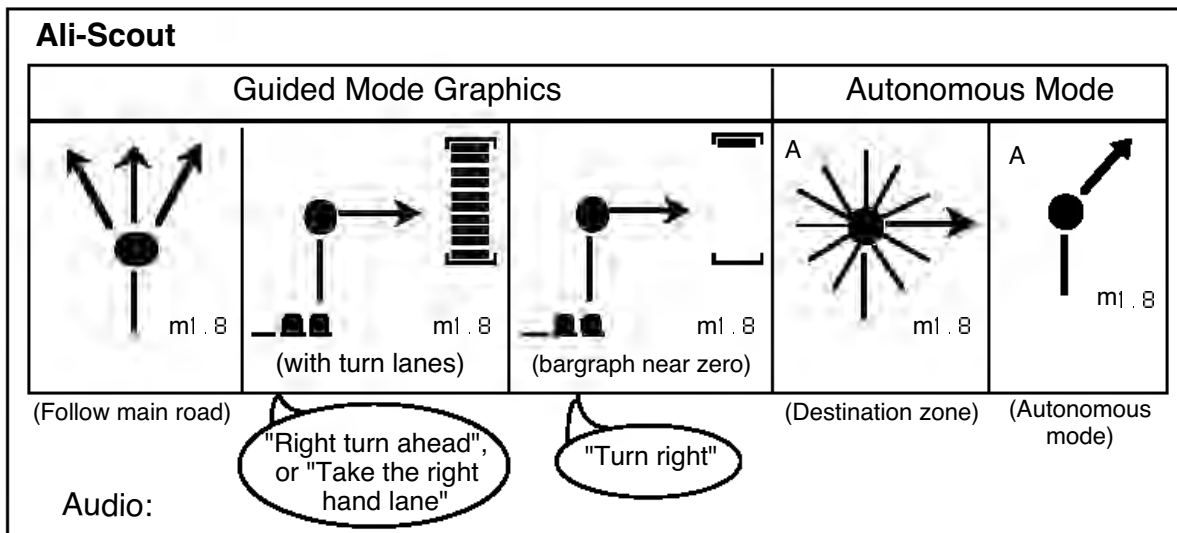tracker   tracker

Quad split image

Navigation systems as installed
Ali-Scout top, PathMaster bottom

Route Description for Experiments 1 and 2:

Start Point	Destination Number/Name	Turns/Maneuvers	Distance (mi)	Road Description (# of lanes)	Speed Limit (mi/hr)	Traffic
TOC Liberty Center	1. SOC Credit Union (exp)1 / Honeybaked Ham (exp 2)	•verbal instructions to I-75 North •guided right onto exit ramp •guided left onto Crooks Rd	•0.4 (•0.4) •2.9 (•2.9) •1.2 (•1.1)	•I-75 : 3 •Exit ramp: 1 •Crooks: 3 reduces to 2	•65 •25 •45	•heavy •moderate •heavy
SOC / Honey-baked Ham	2. Harlan Plaza	•verbal instructions to Crooks Rd •autonomous right onto Long Lake •guided right onto Rochester Rd •guided left onto Wattles Rd	•0.4 •0.1 •2.9 •1.0	•Long Lake: 2 reduces to 1 •Rochester: 2 •Wattles: 1	•45 •45 •40	•heavy •heavy •moderate
Harlan Plaza	3. Cumberland Dr.	•autonomous left out of parking lot •autonomous right onto John R Rd •autonomous right onto Cumberland Dr.	•0.1 •0.5	•Wattles: 1 •John R: 2 •Cumberland Dr.: 1	•40 •45 •25	•moderate •moderate •residential
Cumber-land Dr.	4. Maplewood Plaza	•verbal instructions to Wattles Rd •guided left onto Rochester Rd •guided right onto Rochester Rd split	•0.5 •1.0 •1.7	•Wattles: 1 •Rochester: 2 •Rochester Rd split: 2	•40 •45 •35	•moderate •heavy •moderate

➡️ Autonomous - shows "crow fly" direction and distance (mi) to destination
Guided - gives turn by turn directions

Ali-Scout

Guided Mode Graphics				Autonomous Mode	
(Follow main road)	(with turn lanes)	(bargraph near zero)		(Destination zone)	(Autonomous mode)

Audio: "Right turn ahead", or "Take the right hand lane"   "Turn right"

PathMaster

Turn on to:
LONG LAKE RD

Ahead   0.2 Mile

NW   GPS 3.2 Mi

Accompanying Audio:
"Prepare to exit,"
"Left turn ahead,"
"Next exit on the left,"
or "Turn left"

3 RESULTS

Turn errors and driver uncertainties from Experiment 1 (n= 54):

Route to Dest.	Ali-Scout Mode	Error Description	Number of turn errors by session		Number of uncertainties by session	
			1	2	1	2
2	A	Missed right turn at Long Lake	20	7	16	12
2	G	Turned into street prior to correct turn	2	0	3	0
2	G	Missed left turn at Wattles	3	1	8	4
2	G	Turned before intersection into shopping plaza	1	0	1	1
3	A	Turned right instead of left out of parking lot	3	1	5	0
3	A	Missed left turn onto John R	1	1	10	3
4	G	Missed right turn onto Rochester Rd	2	0	3	2
		total	32	10	46	22

A = autonomous, G = guided

Turn errors (session 1/2)

Sex	Age			Total
	young	middle	older	
women	7/2	7/1	2/1	16/4
men	6/1	6/2	4/3	16/6
Total	13/3	13/3	6/4	32/10

Turn confusions or uncertainties (session 1/2)

Sex	Age			Total
	young	middle	older	
women	12/2	5/3	10/7	27/12
men	6/4	8/3	5/3	19/10
Total	18/6	13/6	15/10	46/22

Subjective Ratings from Experiment 1 and 2:

Ratings		Experiment 1		Experiment 2	
	Statement strongly agree (1) -----> strongly disagree (5)	Ali Scout (n=54)	Past study UMTRI interfaces Auditory/IP/ HUD (n=30+)	PathMaster (n=4)	Matched Ali-Scout (n=6)
Safety	safe for me to use while driving	4.0	5.0/4.7/4.6	4.5	4.0
	safe for an inexperienced driver	2.8	3.7/3.0/2.7	3.3	2.4
	was (not) distracting	3.9		4.3	4.1
System usefulness	would use for daily travel	3.2	4.6/3.4/3.2	3.3	3.6
	would use if in a hurry	3.7	4.5/3.4/3.2	4.0	4.0
	route guidance was helpful	4.3	5.0/4.8/4.0	4.5	4.3
	prefer over road map	4.3	4.8/4.6/4.6	4.3	4.1
	prefer over written instructions	4.1	4.8/4.8/4.7	4.5	4.1
	helpful in locating a new destination	4.6		4.8	4.7
	helpful in driving to familiar locations	2.6		1.5	2.4
Feature usefulness	autonomous mode was useful	3.5			
	guided mode was useful	4.4			
	arrow in autonomous mode was useful	4.2			
	miles to destination was useful	4.5		4.8	4.0
	auditory guidance was useful	4.6		4.3	4.4
	ample time for auditory turn messages	3.7		4.5	3.6
	turn countdown bars were useful	4.0		3.8	3.6
	guided mode turn graphics useful	4.4		4.3	4.1
	"follow current path" graphic useful	4.5			

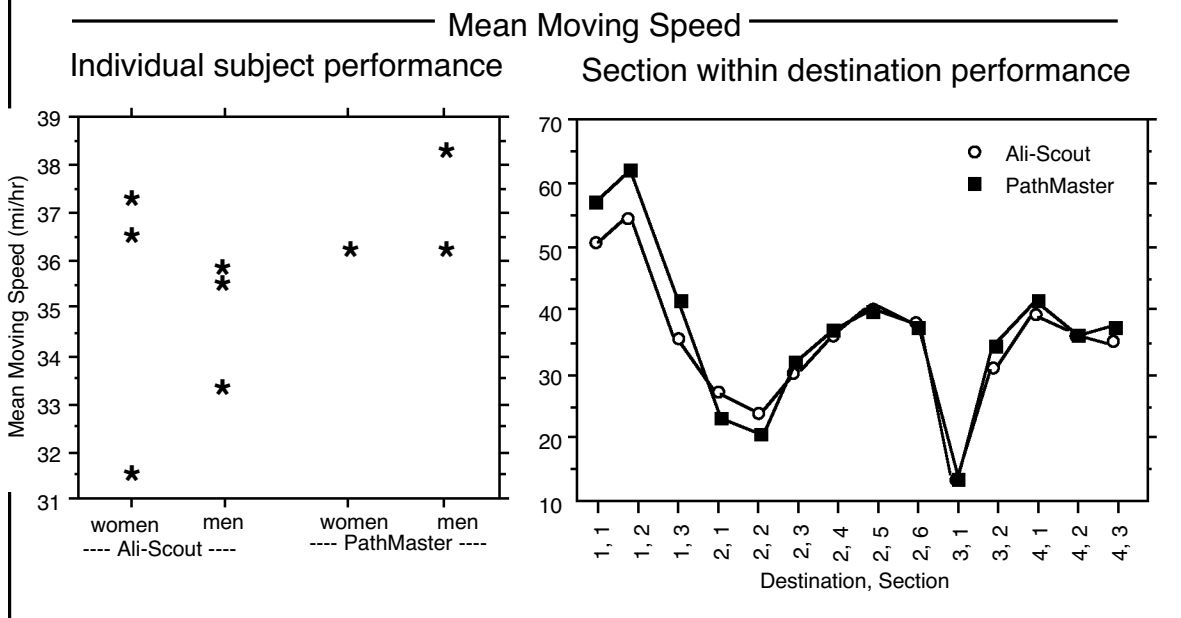# Significant Driving Performance Results for Experiment 1 and 2:

Experiment 1:

Example output for one dependent variable (see report for others)

Mean Moving Speed

Individual subject performance — Section within destination performance
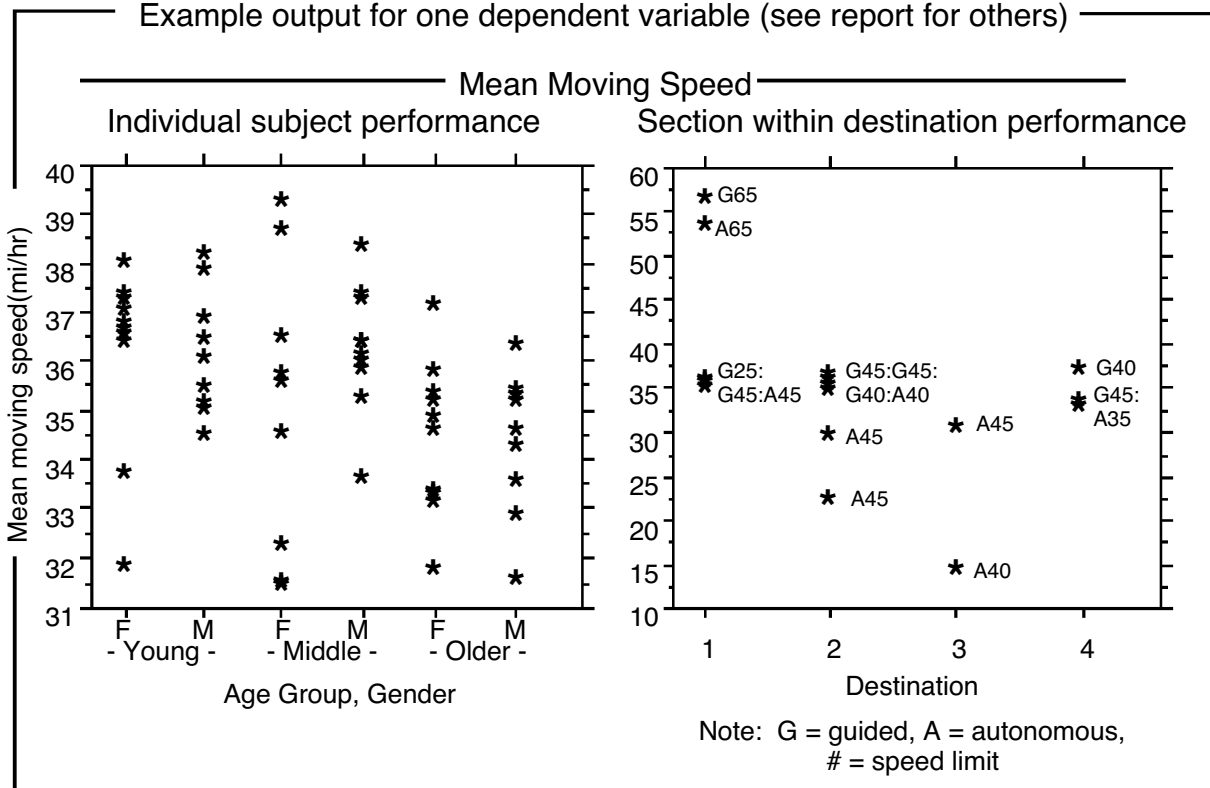
Experiment 2:

Example output for one dependent variable (see report for others)

Mean Moving Speed

Individual subject performance   Section within destination performance

4 | CONCLUSIONS

Q: What factors affected driving with the Ali-Scout and the PathMaster?
A: Almost everything
- very large differences between sections (of test route) within destinations due to speed limit and road geometry
- 25% differences in trip times due to time of day (rush hour - greatest, evening - least), mostly due to traffic
- larger headways when traffic density was lower (10% range)
- SD of lane position was lower at night (even though it was more difficult to see)
- middle-aged subject's driving behavior resembled younger subjects more than older subjects
- younger drivers drove faster, more variably, and had more headway (not less) than older subjects
- as drivers became more familiar with the route, speed variance increased

Q: How did the interface alter driving performance?
A: Ali-Scout was not as good as PathMaster or verbal guidance
- verbal (baseline) guidance led to trip times 6% faster than Ali-Scout
- PathMaster trips took 15% less time that Ali-Scout, but this may reflect a group difference, not an interface difference.
- PathMaster subjects (n=3) were much less variable than matched Ali-Scout subjects (n=6) in lane position maintenance (1.0 vs. 0.4 ft)

Q: Were the Ali-Scout and PathMaster safe to use?
A: Ali-Scout-usually; PathMaster-possibly yes
- no crashes or near misses with Ali-Scout but 4 critical incidents (in response to auditory instructions, drivers changed lanes without looking)
- no PathMaster incidents (but the data set was small)
- drivers rated Ali-Scout as safe for themselves but not novices
- PathMaster was rated safer, but not as safe as UMTRI interfaces

Q: Were the Ali-Scout and PathMaster useful?
A: Yes, but there were many turn errors with the Ali-Scout
- drivers preferred the Ali-Scout over maps or written instructions for trips to unfamiliar destinations; however, other interfaces (UMTRI, PathMaster) were rated higher
- 8% of the Ali-Scout turns were wrong for the first session, 2% for the second (errors+uncertainties =21% for trip 1, 6% for trip 2)
- numerous errors when looking for destinations
- 3/4 of the turn errors were in autonomous mode
- error rates were lower for PathMaster and UMTRI interfaces

System	Mean Price Subjects were Willing to Pay
Ali-Scout	$593
PathMaster	$300
UMTRI IP/HUD/auditory	$1,125/$723/$937

Ali-Scout Problem	Lesson Learned
Late messages led to turn errors and uncertainties	Auditory message timing is more critical than any other feature
Subjects made lane changes without checking traffic	Voice messages may be interpreted as commands to be obeyed
Relatively more turn errors in autonomous mode; lack of understanding autonomous graphics and chime	All driving should be in a guided mode
Graphics were misunderstood (e.g. miles to destination, follow current path)	Pretesting of graphics is needed