WHEN NO DIFFERENCE MAKES A DIFFERENCE: OLDER DRIVERS, MEDICAL CONDITIONS, AND FREEWAY RAMP NEGOTIATION

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ABSTRACT

Exploratory analyses of vehicle kinematic data contained in the SHRP2 Naturalistic Driving Study database contrasted the performance of older drivers with and without potentially impairing medical conditions including COPD, neuropathy, and Parkinson's disease, during the negotiation of freeway ramps and acceleration lanes in the Tampa/St. Petersburg, FL, area. Two sets of ramps identified in the SHRP2 Roadway Information Database were defined as exhibiting 'more favorable' versus 'less favorable' geometric design characteristics, with correspondingly lower versus higher levels of driving task demand for ramp negotiation. It was hypothesized that reducing the demand for negotiating ramps would have a greater benefit for the drivers with medical conditions than for drivers without medical conditions, as reflected in measures of speed, acceleration, and brake applications. Results demonstrated significant main effects of ramp design on driver performance but the only effect of driver group was that the older drivers with medical conditions allowed a longer gap between themselves and a lead vehicle than drivers without medical conditions. No interactions between driver group and ramp design were found.

RESEARCH PLAN

The technical approach for this exploratory study included the following research activities:

- Identify and select a sample of older (SHRP2) drivers with and without potentially impairing serious medical conditions more prevalent among the aged, whose driving behavior and exposure (in their own vehicles) were recorded over an extended period of time.
- Identify (single-lane) ramps and acceleration lanes on freeways in an area common to all of the drivers in the analysis set.
- Develop and apply a criterion to classify each facility as a relatively more demanding (less favorable) versus less demanding (more favorable) design for drivers, taking into account the tactical and operational task demands to negotiate each ramp and traverse the acceleration lane to merge with traffic on the mainline.
- Select an analysis set that provides a contrast between examples of 'more favorable' versus 'less favorable' facilities, and specify (via GPS coordinates) a reference point for each one – the end of the painted nose at the ramp gore.
- Obtain vehicle kinematic information from VTTI – speed, acceleration, and braking events – for each traversal of each facility by every driver in the sample for 15 seconds before and 15 seconds after a driver traversed the reference coordinate.
- Test for main effects and interactions of design level (more versus less favorable) and driver group (with and without medical conditions) on each kinematic data element.
- Identify key findings and interpret analysis results in light of study limitations.

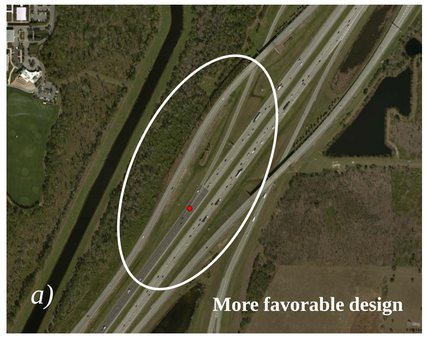
CLASSIFICATION METHOD AND SPECIFIC DESIGN CHARACTERISTICS FOR THE ANALYSIS SET

- Single lane entrance ramps and terminals of controlled access roads of functional class 1 and 2.
- The minimum length of acceleration lane given by the Green Book (AASHTO 2011) was compared to the available acceleration length at each facility. For each ramp, the minimum length was compared to the sum of the length of the speed change lane.
- 24 ramps were identified that could be sorted into two groups: those with design elements that were relatively more favorable to drivers (n = 13) versus those that were relatively less favorable to drivers (n = 11).
- Less favorable design: controlling curves on the ramp proper with radius ≤80m (262ft), which may result in a larger steering wheel angle and potential for steering error; short gap acceptance length (≤90m (295ft)); a split on the approach of the ramp where drivers are required to make two maneuvers in relatively quick succession; an obstructed view of the traffic on the freeway approaching the gore due to a left curved freeway alignment before the entrance ramp; and part of the speed change lane on a right curve, such that drivers may have difficulties in merging since they are required to align their car with the highway to afford mirror view of overtaking traffic and monitor the available gap, while steering as necessary to maintain position in the speed change lane.
- The variability in ramp geometry was much greater before the gore (red dot). This suggested separate analyses of driver behavior 15 s before and after this point.
- No ramps were deficient with respect to AASHTO design criteria.

Characteristics and design level designation for all ramps in the analysis

RAMP LINKID	R [m]	Type of Speed Change Lane (SCL)	Ramp Configuration	Favorable/Unfavorable Designation	Actual Acceleration Length [m]	Green Book Minimum Acceleration Length [m] (highway speed V=100km/h)
22631314	565	Parallel	Direct	Favorable	301	40
22644692	335	Parallel	Direct	Favorable	276	40
773870213	80	Parallel	Loop	Unfavorable (Rs80M)	250	255
22631315	75	Parallel	Loop	Unfavorable (Rs80M)	230	255
106177151	700	Parallel	Direct	Favorable	345	40
37889827	50	Weaving section additional lane	Loop	Unfavorable (Rs80M)	110	115
37889983	280	Parallel	Direct	Favorable	320	40
37889866	50	Weaving section additional lane	Loop	Unfavorable (Rs80M)	110	285
875068381	190	Taper	Direct (spaghetti)	Favorable	490	110
763564766	50	Taper	Loop	Unfavorable (Rs80M)	374	285
22397261	180	Parallel	Direct	Favorable	250	110
773870646	75	Parallel	Loop	Unfavorable (Rs80M)	310	255
784337050	75	Parallel	Loop	Unfavorable (Rs80M)	310	255
127635758	1400	Parallel	Direct	Favorable	480	40
711420179	190	Taper	Direct	Favorable	313	110
711420186	210	Parallel	Semidirect	Unfavorable (Speed change lane on a curved section)	110	110
23178683	*	Taper	Scissors	Unfavorable (Lgs90m and split on the approach of the ramp)	430	255
122662310	900	Taper	Direct	Favorable	336	40
122662311	950	Parallel	Semidirect	Favorable	310	40
23199005	150	Taper	Semidirect	Unfavorable(Lgs90m)	252	205
122620541	285	Taper	Semidirect	Favorable	205	40
122676273	285	Taper	Direct	Unfavorable (Lgs90m and sight restrictions)	295	40
711530892	1500	Parallel	Semidirect	Favorable	232	40
888224263	820	Parallel	Direct	Favorable	480	40

*A lane split (300m in advance of the painted nose) controls speed on the ramp



DRIVER SAMPLE

- SHRP2 NDS drivers in the Tampa/St. Petersburg area between the ages 65-84
- Combined Medical Conditions Group (57% male, n = 13): Parkinson's disease (n = 1), peripheral neuropathy (n = 6), or COPD (n = 6)
- Control group (61% male, n = 23): no reported medical conditions
- There were no significant group differences in functional status: (bilateral) visual acuity and contrast sensitivity; the rapid pace walk (measuring lower limb strength and mobility, as well as balance); and the cognitive measures Trail-making (Part B), Visualizing Missing Information (a version of the Motor Free Visual Perception Test/Visual Closure subtest), and Useful Field of View (subtest 2).

RESULTS AND CONCLUSIONS

Separate analyses (ANOVA) for behaviors before and after the gore tested the hypothesis that reducing the demand for older drivers in negotiating freeway ramps would have a greater benefit for those with medical conditions than for controls, narrowing differences between groups as reflected in measures of speed, acceleration, and number of brake applications.

MAIN EFFECTS ($p < .05$)

Before drivers reached the gore:

- Higher maximum acceleration for more favorable designs (F=27.99; df=1,89)
- More brake applications for less favorable designs (F=4.53; df=1,89)
- Greater cumulative time headway >3.5 s for less favorable designs (F=8.09; df= 1,89)
- Greater cumulative time headway >3.5 s for drivers with medical conditions (F=5.70; df=1,89)

After drivers reached the gore:

- Higher maximum speed for more favorable designs (F=5.37; df=1,89)

There were no significant group X ramp interactions.

Study Limitations

1. The sample of drivers was small and self-selected based on their exposure to specific freeways/ramps.
2. No information was available concerning other, operational factors that could affect instantaneous driving task demand.
3. Medical conditions information was self-reported.

Key Findings

- Main effects of design confirm "operational effects of geometrics," i.e., driving task demand clearly varied from one set of ramps to the other.
- Absence of between-group differences and group X design interactions:

  a) Suggests that diagnosed medical conditions prevalent among older drivers need not, in and of themselves, connote performance (or safety) deficits if age-normal function is preserved.

  b) Reinforces the message that functional status, rather than medical diagnosis, is the proper focus in discussions of aging and safe driving.

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