



AOTA Critically Appraised Topics and Papers Series
**Driving and Community Mobility
for Older Adults**

**A product of the American Occupational Therapy Association's
Evidence-Based Literature Review Project*

CRITICALLY APPRAISED PAPER (CAP)

Focused Question

What is the evidence for the effect of automobile-related modifications on the driving ability, performance, and safety of the older adult? Modifications include changes by the industry that enhance or hinder the driving ability, performance, and safety of the older adult.

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Liu, Y. C. (2001). Comparative study of the effects of auditory, visual and multimodality displays on drivers' performance in advanced traveler information systems. *Ergonomics*, 44(4), 425–442.

PROBLEM STATEMENT (JUSTIFICATION OF THE NEED FOR THE STUDY)

State the problem the authors are investigating in this study.

There is a need for research investigating a driver's needs and limitations during different driving conditions and to design display technology capable of presenting advanced traveler information system (ATIS) information to the majority of drivers in a very safe and efficient way. To date, research has dealt only with single display modalities or focused on navigation systems, but the effectiveness of a multimodality display in the ATIS context remains unexplained.

RESEARCH OBJECTIVE(S)

List study objectives.

To explore whether driver reaction and performance vary as a function of display modality under different driving load or information complexity conditions, and to investigate whether differently aged drivers have different performances when operating different in-vehicle displays.

DESIGN TYPE:

Mixed factors randomized (age, display modality, driving load, information complexity)

Level of Evidence:

I

Limitations (appropriateness of study design):

Was the study design type appropriate for the knowledge level about this topic? *If no, explain.*

Yes

No

SAMPLE SELECTION

How were subjects selected to participate? Please describe.

Convenience—volunteers

Inclusion Criteria

- Formal vision test with > or = 20/40 near and far vision
- Understand normal speech in a moving vehicle
- Have a valid driver's license
- Drive at least 2 times a week, 8000 km per year

Exclusion Criteria

- Prone to motion sickness
- Experience with a driving simulator

Sample Selection Biases: *If yes, explain.*

Volunteers/Referrals

Yes

No

Attention

Yes

No None were reported, and all groups received the same attention

Others (list and explain):

SAMPLE CHARACTERISTICS

Age 18–25, *N* = 16; age 65–73, *N* = 16

N = 32

% Dropouts	<input type="text" value="NR"/>		
#/(%) Male	<input type="text" value="16"/>	#/(%) Female	<input type="text" value="16"/>
Ethnicity	<input type="text" value="NR"/>		
Disease/disability diagnosis	<input type="text" value="NA"/>		

NR = Not reported.

Check appropriate group:

<20/study group	20–50/study group <input checked="" type="checkbox"/>	51–100/study group	101–149/study group	150–200/study group
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Sample Characteristics Bias: If no, explain.

If there is more than one study group, was there a similarity between the groups?

Yes

No

Were the reasons for the dropouts reported?

Yes

No

NR

INTERVENTION(S)—Included are only those interventions relevant to answering the evidence-based question.

Add groups if necessary.

Group 1

Brief Description	Both groups completed 6 experimental driving scenarios with visual-only, auditory-only, or multimodality display of information under high- or low-load driving conditions.
Setting	Institutional setting within a driving simulator
Who Delivered?	NR
Frequency?	Each scenario lasted about 10 minutes and consisted of 2 sessions of about 5 minutes each with presentation of simple and then complex information. Participants were allowed short rest breaks between scenarios
Duration?	Length of experiment varied

Intervention Biases: Explain, if needed.

Contamination

Yes

No

Co-intervention

Yes

No

Timing

Yes

No

Site

Yes

No

Use of different therapists to provide intervention

Yes

No

NR The researchers reported that a tester collected data on a check sheet to record turn direction, turn street name, and navigation-related errors; however, they did not specify if the same person did this each time.

MEASURES AND OUTCOMES—Included are measures relevant to answering the focused question.

Name of measure:

Objective data collected by the STI (Systems Technology, Inc.) simulator in every 10 feet.

Outcome(s) measured (what was measured?):

Objective data included the following: response time (i.e., time elapsed between presentation of information and pushing the correct button); number of missed button pushes; total of correct turns; mean velocity (i.e., average vehicle speed); mean absolute velocity deviation; variance in lateral acceleration; variance in steering wheel position; variance in lateral lane position (i.e., position of the vehicle center with respect to the road's central dividing line); frequency of major lane deviation (i.e., center point of the vehicle crosses either the central line or the road boundary)

Is the measure reliable (as reported in article)?

Yes

No

NR Reliability of the simulator to collect this data was not specified, except that it collected data every 10 feet.

Is the measure valid (as reported in article)?

Yes

No

NR Validity was reported for the following objective measures: mean velocity is a somewhat face valid measurement of task demands; variance in lateral acceleration is indicative of a vehicle that has come off lane center track due to driver inattention; variance in steering wheel position occurs with changes in driver attention; frequency of major lane deviation is a face valid measure of driving task interference resulting in performance degradation.

How frequently was the measure used for each group in the study?

Every 10 feet, data was being collected regarding the participant's performance.

Name of measure:

Objective data collected by a tester on a recording check sheet

Outcome(s) measured (what was measured?):

Navigation-related errors (i.e., number of near missed turns, number of missed turns, and number of wrong turns); turn direction and name of turn street

Is the measure reliable (as reported in article)?

Yes

No

NR

Is the measure valid (as reported in article)?

Yes

No

NR

How frequently was the measure used for each group in the study?

Data collected during all scenarios/trials

Name of measure:

Modified 3-point scale SWAT workload assessment and a Likert 7-point preference rating scale

Outcome(s) measured (what was measured?):

Time stress (i.e., amount of time available for completion of the driving and navigation tasks); visual effort (i.e., amount of visual scanning required); psychological stress (i.e., feelings of confusion, frustration, danger and anxiety); and overall workload (i.e., combination of all the three subjective workload ratings)

Is the measure reliable (as reported in article)?

Yes An article (Reid & Nygren, 1988) that developed the SWAT was cited that may speak to reliability of the assessment

No

NR

Is the measure valid (as reported in article)?

Yes An article (Reid & Nygren, 1988) that developed the SWAT was cited that may speak to validity of the assessment

No

NR

How frequently was the measure used for each group in the study?

Taken at the end of each segment (i.e., at the midpoint and at the end of each scenario)

Measurement Biases

Were the evaluators blinded to treatment status? *If no, explain.*

Yes

No

Recall or memory bias? *If yes, explain.*

Yes

No

Others (list and explain):

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Limitations (appropriateness of outcomes and measures) If no, explain.

Did the measures adequately measure the outcome(s)?

Yes

No

RESULTS

List results of outcomes relevant to answering the focused question.

Include statistical significance where appropriate ($p < 0.05$).

Include effect size if reported.

Age effect

There was significant interaction between age and display modality for the response times ($p = 0.0002$) and also the number of missed button pushes ($p = 0.0001$). For driving performance, only the variance of steering wheel position was significantly different between the age groups and the display modalities ($p = 0.0494$). The older group had the largest steering wheel angle variance when using the visual display ($p = 0.0160$) for auditory versus visual and ($p = 0.0018$) for visual versus multimodality.

Response times and number of missed button pushes

Interaction between display modality and information complexity was significant ($p = 0.0001$). Users of the multimodality display produced fewer misses than those of the auditory condition or the visual condition ($p = 0.0001$).

Total number of correct turns

Significant differences were found in the high driving load condition. The visual display showed the lowest percentage of correct turns ($p = 0.0248$) for auditory versus visual and ($p = 0.0022$) for visual versus multimodality. The difference between auditory display and multimodality display was not significant.

Navigation-related errors

Auditory display accounted for the largest number of wrong turns. The visual display accounted for the largest number of missed turns, and the multimodality display accounted for very few navigation-related errors. Using the complex information visual display produced zero wrong turn error, while in the simple information condition most of the navigation-related errors with the multimodality display were found in the low driving load.

With the high driving load condition, participants drove faster using the auditory display ($p = 0.0021$). Mean absolute velocity deviations were much lower with the multimodality display ($p = 0.0001$). Significantly greater variance in lateral acceleration ($p = 0.0266$) and variance in steering wheel position ($p = 0.0199$) was found. Significant interaction was found between display modality and information complexity ($p = 0.048$) in the variance of lateral acceleration. Difference between the auditory display and the multimodality display in the complex information condition was not significant, nor was there significant differences between the 3 different displays in the simple information condition.

Variances in lateral lane position and in steering wheel position and the frequency of major lane deviations also varied significantly with information condition and display type ($p = 0.0023$); ($p = 0.0002$) ($p = 0.0001$). Participants using the visual display had the largest mean absolute velocity deviation ($p = 0.0001$) and participants made the largest number of major lane deviations in the multimodality display condition ($p = 0.0251$). Significant interactions were found between information complexity and display modality for variance in steering wheel position ($p = 0.0351$) and variance for the mean absolute velocity deviations ($p = 0.0003$). Complex information presented on the visual display resulted in greater variance in steering wheel position than when the same data were presented on the multimodality display ($p = 0.0320$) for visual versus modality, ($p = 0.0559$) for auditory versus multimodality.

Subjective workload and preference

Both the complex information and high driving load condition had more time stress, visual effort, and combined workload. Participants also disliked receiving complex information in all 3 display modalities ($p = 0.0097$). Modality x driving load was significant in the time stress ratings ($p = 0.0149$). Visual display received a higher time stress rating than auditory display ($p = 0.0442$), but the visual display rating didn't significantly differ from that of the multimodality display ($p = 0.0558$). Three displays significantly differed in visual effort ($p = 0.0001$), psychological stress ($p = 0.0129$), combined workload ($p = 0.0013$), and preference ratings ($p = 0.0001$).

Was this study adequately powered (large enough to show a difference)? *If no, explain.*

Yes

No

Were appropriate analytic methods used? *If no, explain.*

Yes

No

Were statistics appropriately reported (in written or table format)? *If no, explain.*

Yes

No

CONCLUSIONS

State the authors' conclusions that are applicable to answering the evidence-based question.

Effect of age on performance

All the statistics regarding driver performance with the various conditions and modalities suggest that for older drivers especially, ATIS user interfaces should be designed as to not increase the driver's workload and that information be kept simple. The multimodality task appears to have a trend toward fulfilling these criteria. Older drivers experience higher driving attention demands while driving, but in contrast younger drivers reported low mental workload and may have low risk perception, and tended to drive faster especially using the auditory displays.

Overall performance and preferences for display modalities

Workload and preference rating appear to support the hypothesis that multimodality displays have better results due to smaller attention demands. Results also suggest that under complex information conditions, the multimodality display imposes the least in attentional demands on attention. This display may be good for helping drivers follow regulatory designing information. Results also confirm the theory that different modalities represent separate attentional resources and thus should lead to improved task-sharing performance. This argues for the multimodality ATIS interface. More investigation is needed to study why users made more navigational errors with the multimodality system when under low driving workloads. Researchers concluded that it may have been a result of the user becoming relaxed with the system while under low stress and thus perceiving low risk and driving less carefully. Finally the researchers recognized that a trade-off seems to exist between the objectives of driving safely and perceiving/detecting the information correctly on the visual display.

Were the conclusions appropriate for the Study Design (Level of Evidence)? *If no, explain.*

Yes

No

Were the conclusions appropriate for the statistical results? *If no, explain.*

Yes

No

Were the conclusions appropriate given the study limitation and biases? *If no, explain.*

Yes

No

IMPLICATIONS FOR OCCUPATIONAL THERAPY

This section provides guidance about clinical practice, program development, and other implications of the study findings as they relate to the focused question.

This study investigated 2 different areas worth applying to clinical practice. The first area is that of age effect on driving performance. One implication of this study is that any information given to the client during driving scenarios should be simple so that it will not increase the driving workload. A clinical implication of this is that practitioners should be mindful in the workload involved with technology selected to aid clients in driving or driving rehabilitation (especially with older drivers) in order to improve their driving performance rather than inadvertently hinder it.

The other area investigated in this study was an ATIS that had the best results for driving performance. If practitioners choose to use ATISs with clients, according to trends of this research and other current evidenced-based literature available, a multimodality system may be the optimal choice.

This work is based on the evidence-based literature review completed by Joseph M. Pellerito, Jr, MS, OTR with contributions from Stacey Schepens, OTR.

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For more information about the Evidence-Based Literature Review Project, contact the American Occupational Therapy Association, 301-652-6611, x 2052.



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