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SUSTAINABLE WINTER SERVICE FOR ROAD USERS

Determining the Most Effective Locations for Illuminated Delineators for Improving Visibility on Expressways under Snowstorm Conditions Using a Driving Simulator

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OBJECTIVES

- This study investigated the effects of the locations of illuminated delineators on the drivers subjective mental workload (overall SMWL) and the subjective visibility assessment under snowstorm conditions.

– Overall SMWL was evaluated using a questionnaire based on the National Aeronautics and Space Administration Task Load Index (NASA-TLX).

– The experiment was conducted on a driving simulator, because it allows assessment of overall SMWL and driving behavior under the same conditions.

FOUR DELINEATION CONDITIONS

- The participants were exposed to four delineation conditions as the main independent variables. Installation was at 50-m intervals on the simulated expressway. In Japan, we drive on the left side of the road .

(1) No illuminated delineators (no delineation)

(2) Illuminated delineators at the median strip (right-side delineation)

(3) Illuminated delineators at the shoulder (left-side delineation)

(4) Illuminated delineators at the left and right sides (both-sides delineation).

SIMULATED VS ACTUAL DRIVING SCENE

DRIVING SIMULATOR

- The experiments were conducted at the Driving Simulator Research Laboratory at Kitami Institute of Technology in Japan.
- This driving simulator is commercially available from Honda Motor Co., Ltd.
- The driving simulator has six axis motion base system using six cylinders, and gives the driver both visual feedback and motion feedback.

PARTICIPANTS

- A total of 36 drivers (15 female, 21 male) divided into three age groups participated. None of participants had experience in a driving simulator, each had normal color vision, and all were compensated for their participation.
- Age 20-39: Fifteen (7 female, 8 male) participants were aged 20 to 39 years, with an average driving experience of 12.7 years and an average driving distance of 9,800 km/year.
- Age 40-59: Fifteen (7 female, 8 male) participants were aged 40 to 59 years, with an average driving experience of 27.5 years and an average driving distance of 7,600 km/year.
- Age over 60: The remaining 6 (1 female, 5 male) participants were over age 60, with an average driving experience of 35.8 years and an average driving distance of 7,200 km/year

ROAD ALIGNMENTS

- We simulated a mountainous 4-km section of the Expressway.
- The section has a horizontal alignment in which there are large curves whose radii range from 700 m to 1,500 m. The grade ranges from 1.5% to 3.7%.
- The section is a fully divided four-lane highway with a lane width of 3.5 m and a shoulder width of 3.0 m.
- The speed limit is 80 km/h under normal conditions, and 50 km/h under hazardous conditions.
- The participants drove through the test section without any leading vehicles, following vehicles or overtaking vehicles.

SIMULATED DRIVING SCENE UNDER SNOWSTORM

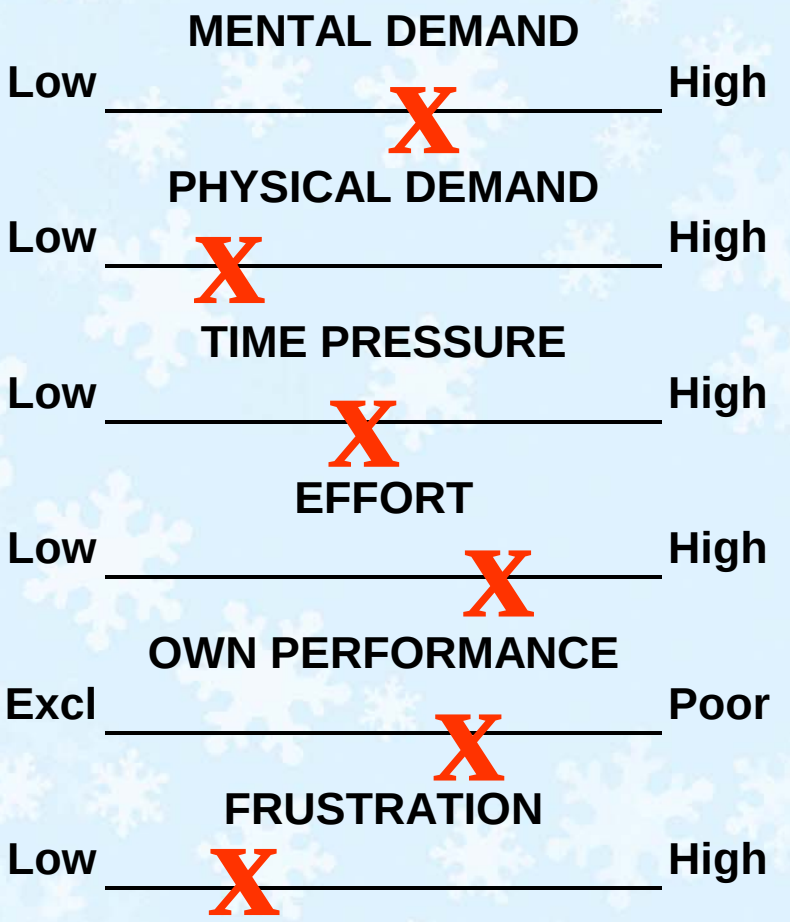
- The scene simulates the hazardous visibility condition of falling snow. The second delineator ahead is slightly visible under this visibility condition.
- We also simulated snow conditions on the road. The height of snow embankments at the shoulder is 1.5 m, and the road surface is covered with snow. The center line and edge line are not visible. Illuminated delineators are installed at 50-m intervals.

SUBJECTIVE MENTAL WORK LOAD

- The National Aeronautics and Space Administration Task Load Index (NASA-TLX) was used to estimate driver SMWL.

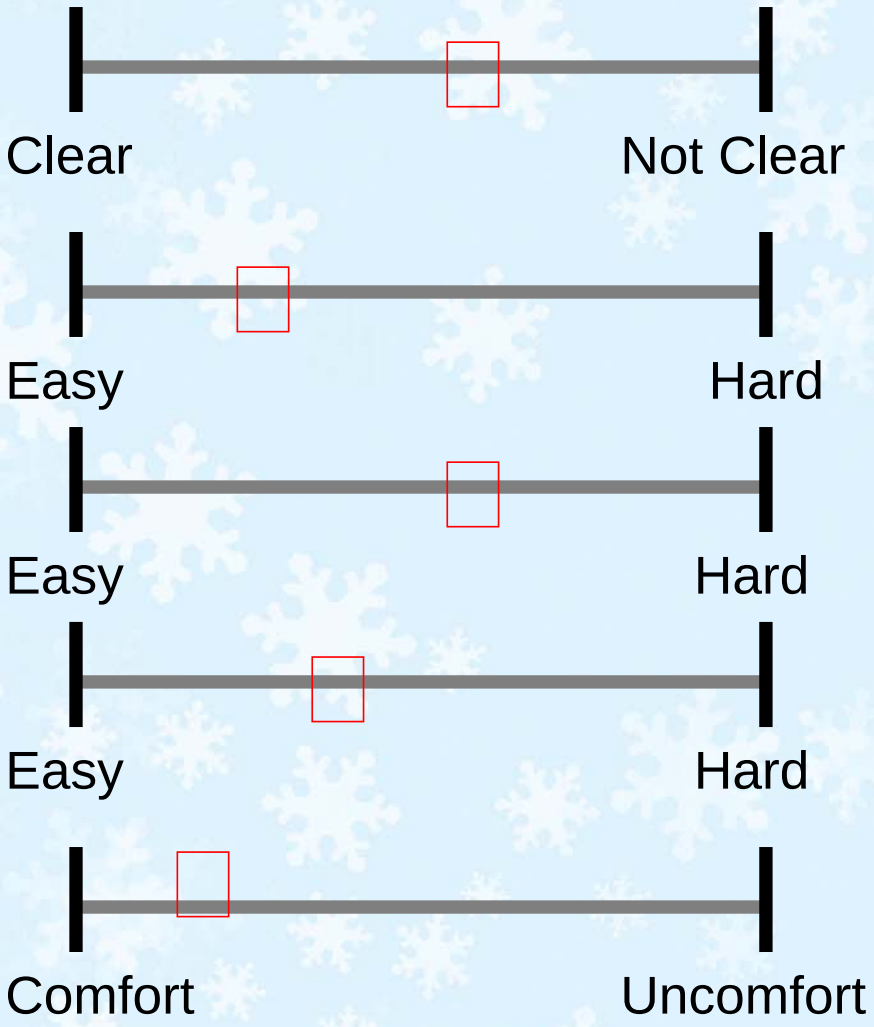
  (Hart, S.G. and Staveland, L.E., Development of NASA-TLX (Task Load Index): Results of Empirical and Theoretical Research, Human Mental Workload, P.A. Hankock and N. Meshkati(Editors), Elsevier Science Publishers B.V. (North-Holland), pp.139-183, 1988)

- The subjects are asked to rate each of these factors.
- Overall workload (SMWL) was computed by averaging six rates.



FIVE SUBJECTIVE VISIBILITY ASSESSMENT ITEMS

- **Road Direction**:
  - How clearly could you see where the road was going?
- **Shoulder Position**:
  - How easy was it to recognize your position relative to the shoulder?
- **Median Position**:
  - How easy was it to recognize your position relative to the shoulder?
- **Position in Lane**:
  - How easy was it to recognize the position of the vehicle in the lane?
- **Driving Comfort**:
  - How comfortable was it to drive the test section?



EXPERIMENTAL DESIGN

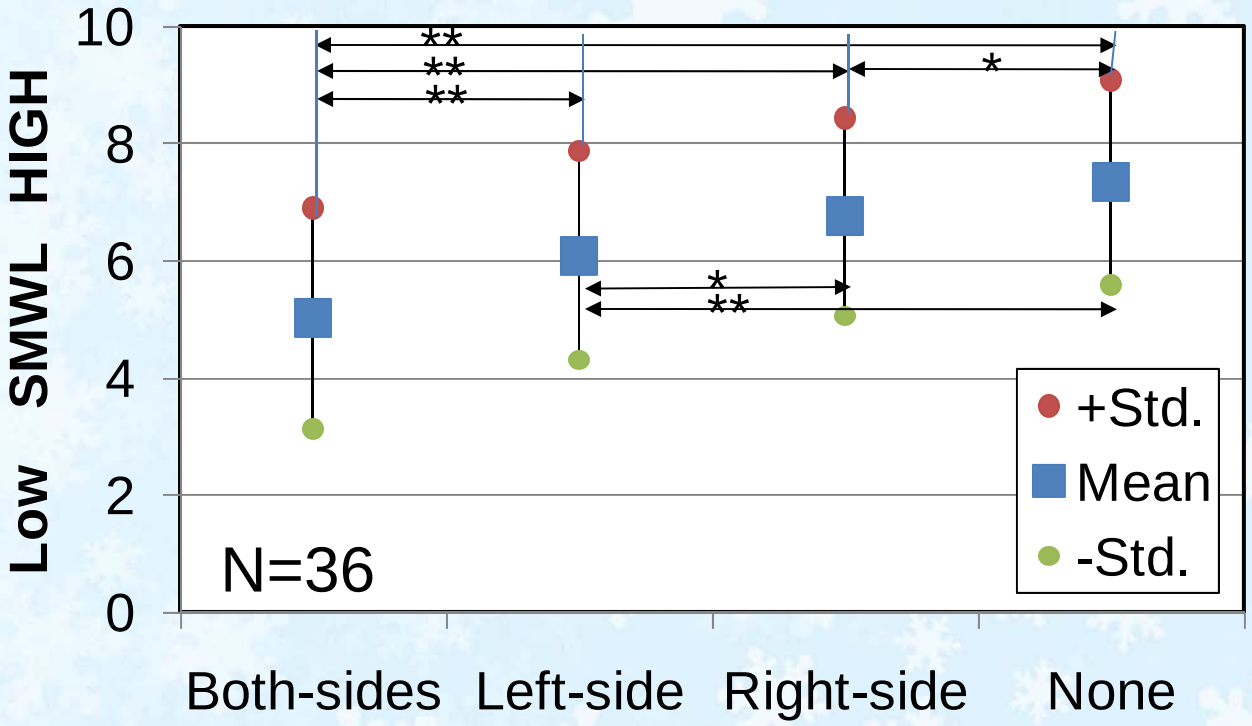
- The study employed a **repeated-measures design** as the experimental design. The four delineator conditions are randomly assigned to a sequence of treatments for each participant.
- **Dependent variables**
  - Overall SMWL of each driver
  - Five subjective visibility assessment items
  - Vehicle behavior data regarding vehicle control.
- **Major independent variables**
  - Four delineation conditions: (1) both-sides delineation, (2) left-side delineation, (3) right-side delineation, and (4) no delineation.

EXPERIMENTAL PROCEDURES

- The 36 participants were randomly assigned to the sessions.
- The experimenter briefly explained the schedule and aims of the experiment. Each participant drove through a training section. The participants were instructed to drive the experimental section at a constant 50 km/h.
- Each participant had one experimental run under each of the four delineation conditions. The four delineation conditions were randomly assigned to a sequence of runs.
- After each run, the participant had to fill out a questionnaire concerning mental workload and subjective visibility assessments.

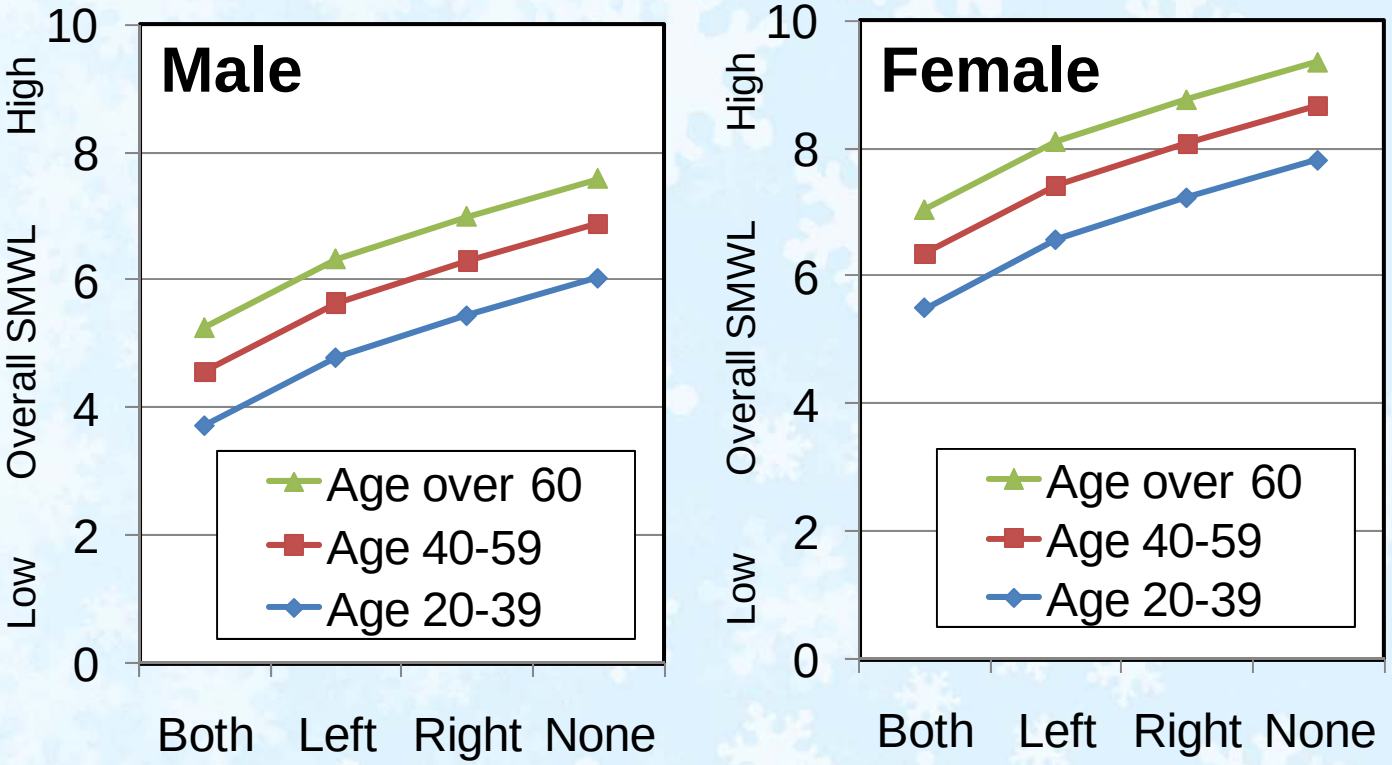
RESULTS: OVERALL SMWL

- The average overall SMWL for both-sides delineation was 5.02 (n=36). The second best score was for left-side delineation, the third was for right-side delineation, and the worst was for no delineation.
- One-Factor Repeated Measures ANOVA (.=0.05) was performed to compare the delineation conditions. Post hoc tests showed significant differences in overall SMWL among all pairs of the four delineation conditions

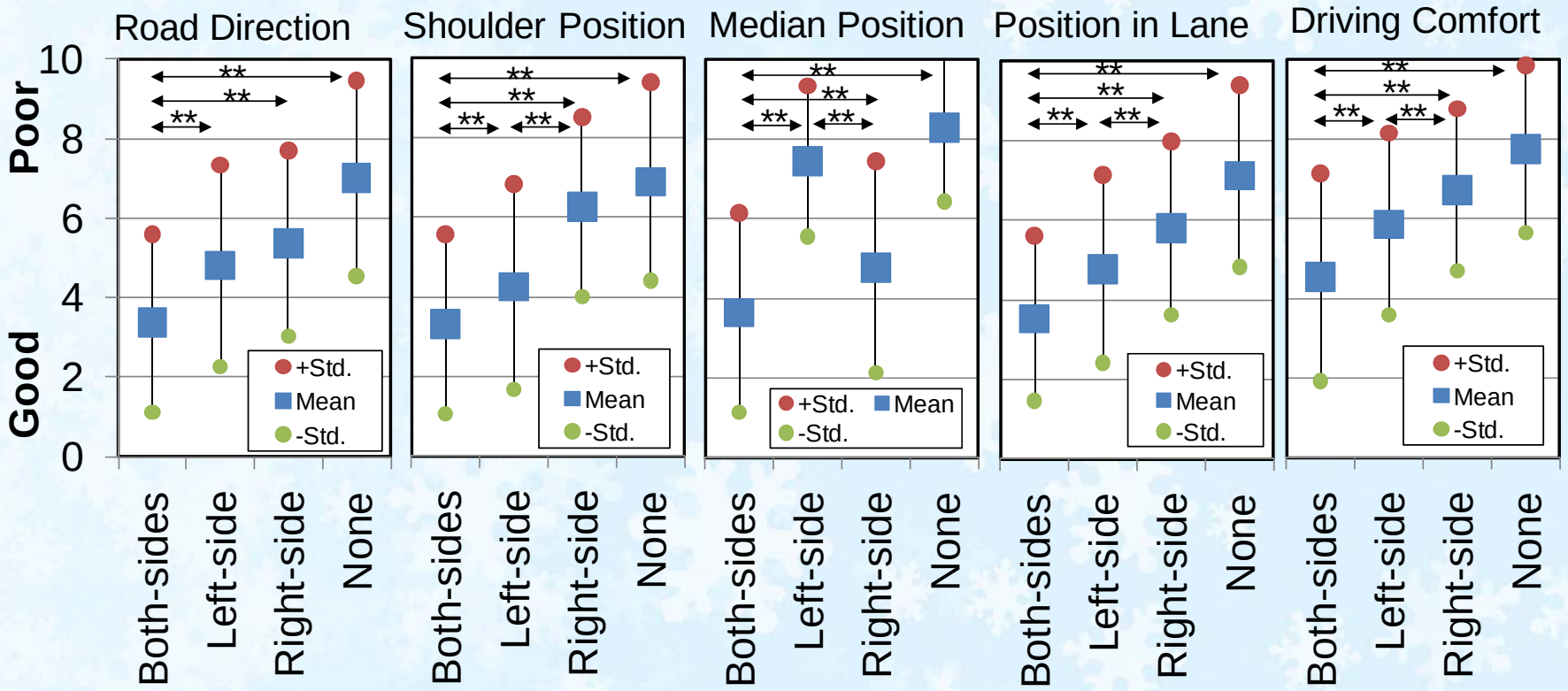


EFFECTS OF PARTICIPANT ATTRIBUTES ON OVERALL SMWL

- Multiple-regression analysis was applied to clarify the effects of explanatory variables on overall SMWL. The overall SMWL increases with increases in age group. Female driver had a higher mental work load than male driver under the same age group.



RESULTS: FIVE SUBJECTIVE VISIBILITY ASSESSMENT ITEMS



N=36

DISCUSSION AND CONCLUSIONS

- In this study, using the driving simulator, we found that both-sides delineation improved driver subjective mental workload and driver subjective visibility assessment. Shoulder-side delineation is better than center-side delineation.

- Female and elderly driver had a higher mental work load than young drivers and male drivers. The results suggest that both-side delineation can assist elderly driver and female drivers on expressways under low visibility conditions.

DISCUSSION AND CONCLUSIONS, CONT.

- Expressways in Hokkaido have been employed center-side delineation since 1980, because the cost of center-side delineation is the cheaper than both-sides, and shoulder-side delineations.
- However, the present study indicates that both-sides delineation is the most desirable, and shoulder-side delineation is the second desirable in terms of reducing driver mental work load and improving driver subjective visibility assessment.
- These conclusions are based on simulation study. We should confirm the cost-effectiveness of shoulder-side and both-sides delineators under field conditions.

THANK YOU FOR YOUR KIND ATTENTION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